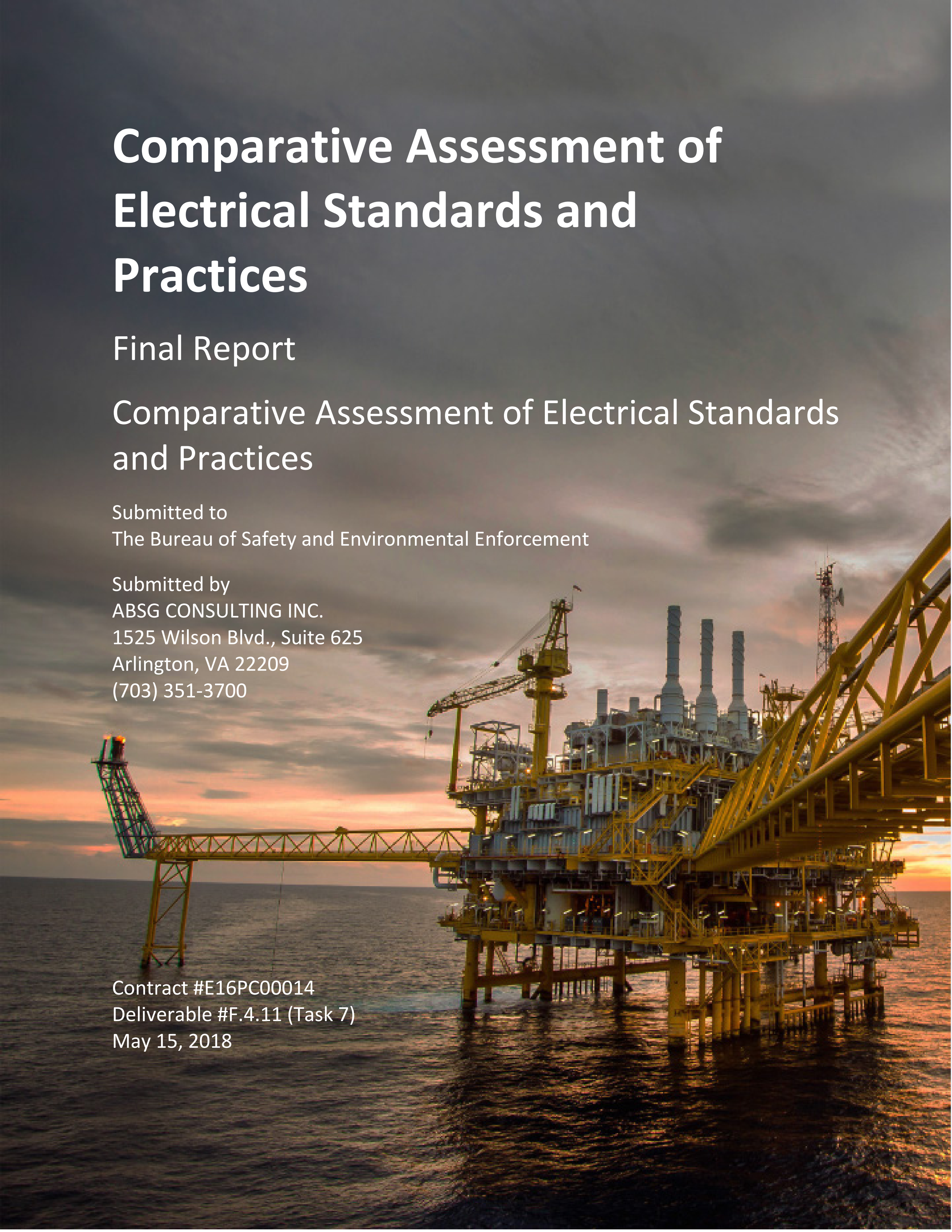

Comparative Assessment of Electrical Standards and Practices

Final Report

Comparative Assessment of Electrical Standards and Practices

Submitted to
The Bureau of Safety and Environmental Enforcement

Submitted by
ABSG CONSULTING INC.
1525 Wilson Blvd., Suite 625
Arlington, VA 22209
(703) 351-3700

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Executive Summary

Purpose of the Project

The purpose of this report is to provide a comprehensive overview of the activities performed during this project, including a discussion of the findings and recommendations. On September 16, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) initiated the Comparative Assessment of Electrical Standards and Practices with the issuance of a contract (#E16PC00014) to ABSG Consulting, Inc. (ABSG). BSEE currently incorporates various industry standards into regulation by reference (Title 30 Code of Federal Regulation, 250.198) and conducts inspections of offshore oil and gas facilities to ensure compliance with regulations and incorporated standards. With more facilities and components being manufactured overseas to international standards, determining equivalencies between the domestic standards incorporated into the regulations and international standards has become more challenging, especially in the area of electrical standards. The purpose of this study was to conduct a gap analysis to compare selected domestic electrical standards to selected international electrical standards and to develop exhibits that BSEE inspectors could use to determine whether operators are in compliance with these standards. Through this comparative gap analysis, BSEE was seeking to determine if some of the existing international electrical standards are equivalent to the standards currently incorporated into regulation, exceed the current standards or if they do not meet the current standards. Following this introduction, this report is organized into three major sections and includes a series of Appendices

What We Did

To conduct the analysis, ABSG developed a Standards Analysis Template to facilitate the comparative assessment. The Standards Analysis Template was used to map the domestic baseline standards to the comparable sections of the international standards.

During Tasks 1, 2 add 3, a gap analysis was conducted to compare the International Electrotechnical Commission (IEC and IEC Ex) series of standards to standards the *National Electric Code* (*NEC*), various standards issued by the American Petroleum Institute (API) and standards issued by the American National Standards Institute (ANSI). Tasks 4 consisted of a gap analysis among a number of standards to determine if the elements and standards met, exceeded or did not meet the other. Task 5 involved demonstrating how BSEE's field and office personnel could use each of the IEC, *NEC*, ANSI and various API standards to determine whether operators are in compliance. Finally, Task 6 involved a comparative assessment to determine the similarities and differences between how the U.S. Occupational Safety and Health Administration (OSHA) accredits Nationally Recognized Testing Laboratories (NRTL) and how international authorities accredit independent testing laboratories. Appendix A contains abstracts of each of the standards compared as part of the electrical standards comparative assessment to provide the reader with a general understanding of the scope of each of the standards.

What We Found

Given the large number of standards analyzed during the course of this project it is difficult to come to an overall conclusion from the comparative assessments that were conducted. Many of the international standards analyzed were equivalent to the United States standards. Other international standards either exceeded or did not meet the domestic standards. Section 3 provides a summary of the findings and conclusions for each of the standards analyzed.

We also found gaps in some of the BSEE PINCs where portions of the API standards that are currently incorporated by reference into regulations were not included in the PINCs. We also identified other gaps where new PINCs could be developed or where an audit protocol could help BSEE inspectors better determine compliance with these standards.

Comparative Analysis of Standards

IEC vs. *NEC* (Task 1)

A comparative analysis between the IEC 60079 series and the *NEC* found similarities and differences in several areas. Similarities exist in the area of definitions and zone method classification, and protection of equipment. The definitions and basis for the Zone method classification in *NEC* Article 505 and IEC 60079 series of standards are very similar. The IEC requires enclosures to be against incoming solid foreign objects as well as against the harmful effects of water ingress, which is comparable to the requirements in the *NEC*. Neither the *NEC* nor the IEC contains any requirements for submarine cables.

Differences between the two standards were found in the areas of protection techniques, marking, hazardous area classification, wiring methods, and surge protection. The IEC does not identify some of the protection techniques contained in the *NEC*, such as explosion proof equipment. In addition, IEC does not require the equipment to be marked with Class or type of Zone such as Zone 0, Zone 1 or Zone 2. The *NEC* doesn't contain any guidance or requirements regarding the criteria for the gas dispersion models, whereas the IEC describes different methods that can be used to classify a hazardous area. The requirements in the *NEC* are specific with regard to type of the wiring permitted in different types of hazardous locations. Wiring methods covered by the IEC standard are general and don’t provide as much detail as in the *NEC*. The *NEC* contains requirements about the installation of surge protection devices in hazardous areas whereas the IEC does not contain many requirements about surge arresters, except for protection against lightening induced surges.

IEC vs. API RP 14F and API RP 14FZ (Task 2)

A comparative analysis between the IEC 61892 series and API RP 14F and API RP 14FZ found similarities and differences in several areas. Similarities exists in the general provisions, electrical equipment for hazardous locations, emergency power systems, electrical distribution systems and, electrical equipment, special systems for offshore installation and system checkout requirements. API RP 14F and

14Z, as well as the IEC all provide general design guidance for electrical systems. API RP 14FZ and the IEC both provide similar guidance for selection of electrical equipment in hazardous locations designated as Class I, Zone 1 or Zone 2. For floating installations, API RP14F and API RP 14 FZ require an emergency power system consisting of an emergency generator that is sized to supply 100% of the connected loads that are essential for safety and can supply power continuously for 18 hours. IEC 61892 has similar requirements for emergency power systems. Wiring methods and circuit protection described in the IEC 61892 are comparable to those indicated in API RP14F and API RP 14 FZ. Additionally, both API and IEC standard provides similar requirements for selection of cables, voltage drop consideration and circuit protection. API RP 14F, API RP 14FZ and the IEC provide similar guidance for selection, control and protection for electric motors, transformers, normal and emergency lightings, and provides general guidance regarding the use of direct current (DC) power systems. API RP 14F and API RP 14FZ introduces safety systems typically required for offshore production facilities such as Fire and Gas detection, Platform safety controls, Navigation aids, Communication etc. IEC 61892 also includes requirements for various systems. API RP 14F, API RP 14FZ and the IEC all provide similar requirements for checking out electrical, control and instrumentation systems and equipment before putting them in operation.

Differences exist in the use of explosion proof equipment, marking of equipment, electrical power generating stations, prime movers and generators, switchboards, and certain special considerations. API RP 14F allows explosion-proof equipment to be used in Division 1 and Division 2 locations. There is no IEC standard for explosion-proof equipment. IEC 61892 requirements meet the recommended practices in API RP 14FZ but not API RP 14F for the use of explosion proof equipment. Additionally, the IEC 61892 requirements do not meet the recommended practices in API RP 14F and API RP 14FZ for Marking of Electrical Equipment. API RP 14F and API RP 14FZ provide general guidance for sizing the prime mover and generator and typical protections for the prime mover as well as the generator. IEC 61892 also has requirements for the design of electrical power system as well as electrical equipment, however, it does not provide guidance for protection of the prime mover. API RP 14F and API RP 14FZ provides general guidance for sizing, locations of air intakes and exhaust, typical control functions and automatic shutdown conditions for the prime mover. IEC 61892 does not meet the recommended practices contained in API RP14F and API 14 FZ for protection requirements for prime movers. API RP14F and API RP 14 FZ do not have the requirements for dividing the main bus on switchboards as described in IEC standards. API RP 14F and API RP 14FZ recommend additional considerations for electrical installations such as construction practices, instrumentation, lockout tagout procedures, portable electronic devices. The IEC does not contain similar requirements.

IEC vs. API RP 500 and API RP 505 (Task 2)

A comparative analysis between the IEC 60079 series and API RP 500 and API RP 505 found the most apparent difference is that the API RP's cover the option of Classification into Divisions or into Zones, but IEC 60079-10-1 uses Zones exclusively. API RP 500 incorporates the definitions of Class I, Division 1 and Division 2 from the *NEC* Article 500. API RP 505 incorporates the definition of Class I, Zone 0, Zone

1, and Zone 2 from IEC 60079-10-1. IEC 60079-10-1 is a generic standard for classifying hazardous areas. The focus of this standard is the methods, with examples and calculations, for determining the hazardous areas for many arrangements in unspecified installations. Given the different types of facilities handling hydrocarbons, API RP 500/505 presents applications that are common to several facility types as well as giving specific guidance for each type of facility (i.e., MODU, FPSO, TLP, and others).

IEC vs. ANSI/UL (Task 3)

A comparative analysis between the IEC 60079 series and the various ANSI/UL standards was conducted to determine similarities and difference in requirements electrical equipment used in hazardous (classified) locations including;

- *Electric Motors and Generators*
- *Electric Heaters*
- *Luminaires*
- *Intrinsically Safe Apparatus and Associated Apparatus*
- *Explosion-Proof and Dust-Ignition-Proof Electrical Equipment*
- *Cables and Cable-Fittings*

Similarities and differences were noted among requirements for construction, performance testing, and marking. The biggest difference was that the IEC standards do not require that compliance with industrial standards be verified, whereas UL standards for ordinary locations have requirements that equipment must be verified by a testing laboratory.

IEC 60079-0 vs. ANSI/ISA 60079 series (Task 4)

A comparative assessment of ANSI/ISA 60079 series of standards and the IEC 60079 series of standards was conducted to identify areas of the IEC that either met, exceeded or did not meet the ANSI/ISA series of standards. During the assessment, 15 different IEC standards in the 60079 series were compared to comparable ANSI/ISA standards. The areas where major differences were noted is discussed below. A summary of these major differences is included in Section 3 of this report with detailed discussion found in the Task 4 report in Appendix E. Task 4 Report: Other Gap Analysis.

National Differences

The ANSI/ISA 60079 series are identical to the IEC 60079 series except for five categories of U.S. National Differences that add, delete, or modify the IEC requirements. These categories include;

- Basic safety principles and requirements
- Safety practices
- Component standards
- Editorial comments or corrections

- National regulatory requirements

Other Differences

In addition, major differences were noted between the ANSI/ISA 60079 series of standards and the IEC 60079 series. These differences were in the following areas;

- Equipment Protection (IEC 60079 -0,-1,-2,-5,-6,-7,-11,-15,-18,and -25)
- Hazardous Areas (IEC 60079 -10)
- Installation Practices (IEC 60079 -26,-27)
- Gas Detection Devices (IEC 60079 -29-1., -29-2)

IEC 60079 vs. FM Series (Task 4)

A comparative assessment of the FM standards with IEC 60079 series of standards was conducted to determine similarities and difference in requirements.

- *Electrical equipment installed in hazardous (classified) locations.*
- *Intrinsically Safe Apparatus and Associated Apparatus*
- *Nonincendive Electrical Equipment*
- *Explosion-proof Electrical Equipment*
- *Purged and Pressurized Electrical Equipment*

The FM Series and the IEC differ on their approach to approval and certification, the FM's Basis for Approval includes two aspects;

1. Verifying products meeting the performance requirements as specified in the standard(s) and
2. Evaluating product manufacturers through surveillance audit programs. Although the IEC does establish standards for quality systems, testing laboratories, certifying body qualification, it does not provide any attestation of conformity. This standard series defines manufacturers' responsibilities for the products, such as type tests, routine tests, marking and instructions, etc. Manufacturer evaluation is not included in the scope.

A summary of the major differences between the IEC 60079 series and the FM Series of standards is contained in Section 3. Detailed analysis is contained in the Task 4 report in Appendix E.

Listing, Marking and Documentation of Equipment Installed in Hazardous Locations (AEx vs EEx) (Task 4)

A comparative assessment of *NEC* Article 505, ANSI/ISA and UL 60079 series of standards and IEC 61892-1, IEC 61892-7 and IEC 60079 series of standards was conducted to identify major differences. The majority of the differences involved marking requirements as summarized in Section 3. For examples two major differences are:

- *NEC* 505, ISA and UL 60079 require AEx marking vs IEC 60079 requires symbol EEx.

- *NEC* 505, ISA and UL 60079 require that Class and Zone of equipment be identified in the marking.

Detailed findings are contained in Section 3.7 and in the Task 4 report in Appendix E.

Test Standard in NRTLS vs. IEC (Task 4)

This section contains a summary of the finding and conclusions from the Task 4 comparative assessment of the test standards in the (NRTLs) and the IEC. Detailed findings are contained in the Task 4 report in Appendix E.

A comparative analysis was conducted among the test standards in the Nationally Recognized Testing Laboratories NRTLs and the IEC standards for the electrical equipment for use in classified locations. One major difference identified from the assessment is regarding the requirement for verification of equipment for ordinary location standards.

- In the IEC 60079 series of standards ordinary location requirements are referenced so that the equipment is constructed in accordance with the applicable safety requirements in these industry standards. However, a clarification is given that it is not a requirement in IEC 60079 series that the compliance with these industrial standards be verified.
- In the U.S. standards, manufacturers must comply with the applicable requirements for similar equipment for use in ordinary (unclassified) locations in addition to the hazardous area requirements. U.S. standard ISA 60079-0 states that the equipment listed by NRTLs is considered to meet the applicable requirements found in the ordinary location standards.

Hazardous Location Standards in IRF member countries vs. United States (Task 4)

Research was done to identify the various electrical standards used by the offshore regulators in the International Regulators' Forum (IRF) member countries. A summary of the findings from this research is found below. Detailed findings are contained in the Task 4 report in Appendix E.

- Australia and New Zealand - IEC 60079 series standards are adopted with national variations, which are known as AS/NZS 60079 series standards
- Brazil - Brazilian Ex NBR IEC standards are fully harmonized with IEC 60079 Series
- Canada - Canada Oil and Gas Installations Regulations, SOR/96-118 refers to API RP 500 for the classification of hazardous areas with respect to hazards caused by combustible gases on offshore platforms
- Denmark and The Netherlands - Allows the use of IEC and ATEX standards for fixed offshore installations
- Mexico - Mexico adopted the NEC 2011 in November 2012 with the effective date of May 30, 2013. Hence, for hazardous locations (special environments), NEC articles 500, 501, 504 and 505 should be applicable.

- Norway - Allows the use of various industry standards such as NORSOK, API or other normative documents with supplementary addendums provided in the guidelines. NORSOK Standard E-001 for electrical system is mainly based on the IEC 61892.
- United Kingdom - For electrical equipment in hazardous areas, internationally recognized standards such as IEC, IECEx, NEC, API 14/14FZ/500/505 and the ANSI/UL are accepted.

Gaps in PINCs

Analysis of the current PINCs identified some recommended modifications based on the information in API RP 14F, 14FZ, 500 and 505. Some of the information from these standards was not contained or referenced in four of the existing Electrical PINCs. As such, modifications to the following PINCs is recommended;

- F-101
- F-108
- P-154
- P-173

Further analysis of the standards currently also incorporated into regulation by reference also identified gaps among the current PINCs. To close these gaps, 26 new PINCs could be developed. Section 3.10, and Appendix F, provide details of the analysis.

Audit Protocols

This project also involved the development of an audit protocol for inspectors to use to determine if operations are in compliance with standards. The IEC/ISA/UL harmonized standards, as well as the NEC, are not incorporated into BSEE's regulations. As such, it was determined that compliance should be best determine by use of an audit checklist.

A single combined checklist was generated instead of separate checklists for each standard in order to expedite the audit process and reduce redundancy as several inspection items are addressed in multiple standards. The use of an audit checklist could certainly help BSEE determine if operators are in compliance with the standards as they conduct offshore operations. However, since the standards included in the checklist are not incorporated by reference into BSEE's regulation, BSEE would need to determine its regulatory authority to enforce compliance with these standards.

United States vs. International Accreditation Practices

Another objective of the project was to assess the similarities and differences between how the United States accredits NRTLs and how international authorities accredit independent laboratories. Based upon the analysis, the following conclusions can be drawn:

1. NRTL applications and appeals processes involve the public at an early stage in contrast to both the EU and IECEx whose processes are all internal until the final decision. For established NB, ExCBs and ExTLs this difference will not affect the quality of conformity assessments or accredited products.
2. Renewal of NRTL recognition by self-certification against their letter of recognition is a weakness of the OSHA NRTL program in comparison to the EU and IECEx. This issue has been clarified in the draft NRTL directive and thus will close the perceived gap.
3. NRTL requirements for test facilities are not fully met for the EU and IECEx, specifically general security, fire protection and personnel safety. These aspects are typically covered by national (or regional (e.g. EU)) regulations but this difference has no significant effect on quality of conformity assessments or accredited products.
4. Independence of assessors is required in all cases but the EU and IECEx may not meet all of the NRTL requirements. The level of independence required is currently considered sufficient to ensure integrity of testing and assessment is maintained but the NRTL, EU and IECEx requirements will become fully aligned when the draft NRTL directive is enacted.
5. ATEX does not provide a sufficient framework to be considered equivalent to the NRTL program for the following major reasons:
    a. Manufacturers can self-certify some low risk products
    b. ATEX requires products to be either tested or made under an assessed quality management system but not both
6. The IECEx Certified Equipment Scheme is broadly comparable to the NRTL program. ExCBs and ExTLs can therefore be equivalent to the corresponding parts of a NRTL (ExCB for certification and ExTL for testing). However, there remain some differences which are likely to prohibit use of IECEx certification directly in the US without changes to the law (particularly labelling and markings).

A discussion of the key points surrounding the analysis, along with detailed finding, are contained in the Section 3.11 and in the Task 6 report in Appendix G.

Recommendations

From our findings and conclusions, recommendations were developed to help make BSEE's electrical-related regulations easier to follow, easier to enforce and more inclusive of international approaches, where appropriate. The intent of these recommendations is to promote safer operations on the OCS, better protection of the environment and a reduction in injuries, loss of life and property. This report provides recommendations in five areas.

Changes to the Potential Incidents of Noncompliance (PINC)

This assessment concluded that the current list of PINCs contains gaps in BSEE's methods of ensuring compliance with each of the standards analyzed in Tasks 1 through 4 of this project. BSEE should review the recommended changes to the PINCs discussed in Section 3.10 and Appendix F. These include revisions to existing PINCs as well as the addition of new PINCs to better evaluate compliance with the standards currently incorporated into BSEE's regulations.

Implementation of an Audit Protocol

Neither the IEC, *NEC* nor ISA/UL harmonized standards are currently incorporated by reference into BSEE's regulations. To assess compliance with these standards, BSEE could implement an audit protocol by using the Audit Checklist discussed above in Section 3.10 and Appendix F. This checklist will provide inspectors with the necessary areas of focus in order to ensure BSEE facilities conduct offshore operations in a manner that is compliant with the various international electrical standards that extend beyond current regulation. BSEE should also review its authority to enforce these standards and provide the appropriate enforcement guidance to inspectors and engineers.

Personnel Training

Paramount to the successful implementation of the recommended changes to the PINCs and audit protocol, as well as an improved understanding of the domestic and international electrical standards, is training. Inspections of electrical components and the engineering review of electrical systems during plan review and approval require extensive knowledge of the applicable regulations and standards to adequately ensure safety for personnel and equipment.

BSEE should provide training to inspectors and engineers on the all the U.S. and international standards included in this project so that they are familiar with the various provisions in these standards. For example, training scenarios could be developed that describe the current state of a electrical system, component or piece of equipment on an offshore facility. Participants in the training would use the PINCs and/or the audit checklist to discuss the given scenario and determine if the electrical component is in compliance with the relevant regulation and standard. Based on their conclusion, the participants would determine which enforcement option would be appropriate.

Reference Materials

BSEE should obtain copies of the all the U.S. and international standards referenced in this project for use by engineers and inspectors during training and for use on the job. Additionally, BSEE should provide inspectors and engineers with a copy of all the reports developed during this project so they can become familiar with the differences among the U.S. and international standards.

Changes to Regulations

Since the federal regulations represent minimum requirements, BSEE may want to consider incorporating clauses in the various standards not currently incorporated into regulations that exceed the comparable clauses of the standards that are currently incorporated into the regulations. The Task 5 report, contained in Appendix F, includes a recommended approach for how BSEE could incorporate some of the standards included in this project into regulation.

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1. Introduction

1.1 Purpose of the Report

The purpose of this report is to provide a comprehensive overview of the activities performed during this project, including a discussion of the findings and recommendations. This report will provide the reader with an understanding of the scope of each of the electrical standards assessed, an understanding of the differences between the standards compared, and will present exhibits that BSEE inspectors can use to determine if operators are in compliance with these standards during offshore operations. This report also presents a series of recommendations for BSEE to consider.

1.2 Scope of the Project

On September 16, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) initiated the Comparative Assessment of Electrical Standards and Practices with the issuance of a contract (#E16PC00014) to ABSG Consulting, Inc. (ABSG). BSEE currently incorporates various industry standards into regulation by reference (Title 30 Code of Federal Regulation, 250.198) and conducts inspections of offshore oil and gas facilities to ensure compliance with regulations and incorporated standards. With more facilities and components being manufactured overseas to international standards, determining equivalencies between the domestic standards incorporated into the regulations and international standards has become more challenging, especially in the area of electrical standards. The purpose of this study was to conduct a gap analysis to compare selected domestic electrical standards to selected international electrical standards and to develop exhibits that BSEE inspectors could use to determine whether operators are in compliance with these standards. As part of this study the following tasks were conducted.

- Task 1 – Gap Analysis - IEC standards vs. *NEC*
- Task 2 – Gap Analysis - IEC vs. API standards
- Task 3 – Gap Analysis - IEC vs. ANSI/UL standards
- Task 4 – Other gap analysis assessments
- Task 5 – Exhibit of BSEE Personnel Using Standards for Ensuring Compliance
- Task 6 – Gap Analysis United States vs International Accreditation Practices

Through this comparative gap analysis, BSEE was seeking to determine if some of the existing international electrical standards are equivalent to the standards currently incorporated into regulation, exceed the current standards or if they do not meet the current standards. BSEE may use the results of this analysis to inform the policies and regulations associated with the electrical-related standards incorporated by reference into regulation. The ultimate goal of improved regulations is safer operations on the OCS, resulting in better protection of the environment and a reduction in the loss of life and property.

1.3 Organization of the Report

Following this introduction, this report is organized into three major sections and includes a series of Appendices, as outlined in **Table 1**.

Table 1: Organization of the Report

Section	Contents
Section 2 – Overview of Activities Performed	This section provides the reader with an overview of the approach and activities performed to conduct the comparative assessment of the electrical standards. It also provides an overview of the approach used to develop the exhibits for BSEE personnel to use as they conduct compliance activities of offshore oil and gas activities. Section 3 also provides abstracts of all of the electrical standards included in the scope of work for this project. These abstracts will assist the reader in gaining a general understanding of the contents of each standard.
Section 3 – Findings and Conclusions	This section provides summary of the findings and conclusions from each of the gap assessment conducted. Detailed analysis and conclusions for these assessments are contained in the various appendices, which contain the full comparative assessment reports.
Section 4 – Recommendations	This section contains a summary of the recommendations for BSEE to consider in six areas.
Appendices	This report also includes seven appendices that contain the full task reports that were developed throughout the project. Appendix A contains abstracts of the U.S. and IEC standards that were analyzed as part of this project. These abstracts provide the reader with a general understanding and awareness of the scope of each of the standards. The reports contained in Appendices B, C, D and E are structured to summarize the results of the comparative assessments for selected electrical standards. Each report contains sections that provide a brief overview of the standard's subject area, a table highlighting the assessment results followed by analysis where there are differences between the baseline United States standard and the international standard. Each report also includes their own appendices that provide the detailed results of the comparative assessment. Appendix F contains the Task 5 report, which includes exhibits of how BSEE personnel can use the standards to determine compliance. These exhibits included recommended changes to list of Potential Incidents of Noncompliance (PINC) and a proposed audit protocol for BSEE field and office personnel.

Section	Contents
	Appendix G contains the results of the comparison between the accreditation practices for independent testing laboratories in the United States and international countries.

2. Overview of Activities Performed

2.1 Approach to Conducting the Gap Analysis

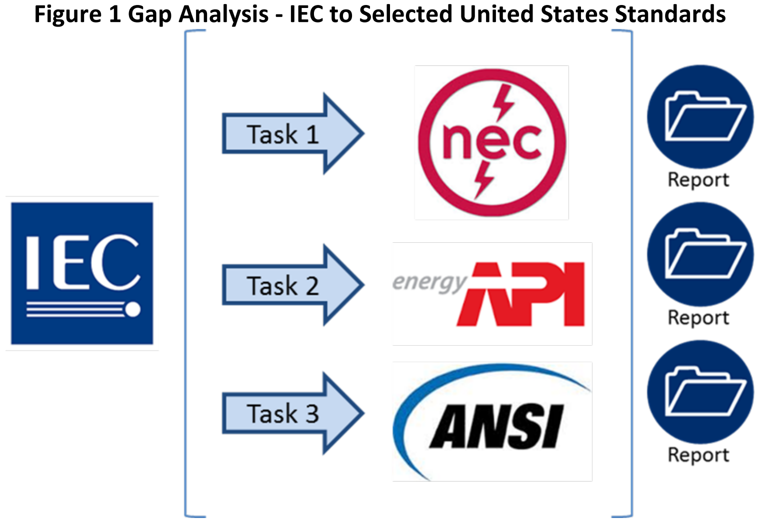
The purpose of the gap analysis was to determine if a series of selected international electrical standards either meet, exceeded or did not meet the requirements contained in a similar set of standards issued by Standards Development Organizations in the United States. To conduct the analysis, ABSG developed a Standards Analysis Template to facilitate the comparative assessment. The Standards Analysis Template was used to map the domestic baseline standards to the comparable sections of the international standards. The Standards Analysis Template incorporated an Impact Type criteria, (**Table 2**) which allowed for a side-by-side comparison of each section of the domestic baseline standards to the comparable section of the international standards. Lastly, the Standards Analysis Template included an analysis section for the subject matter expert (SME) to provide comments on the impact category that was selected. The comments include a justification of each impact type designation (meets, exceeds, or does not meet), descriptions of similar provisions, and additional requirements or shortfalls. The completed analysis templates are provided in the appendices to each report.

Table 2: Impact Type Criteria

Impact Category	Description
Type 1 - Exceeds	The International Electrotechnical Commission standards exceed the standards currently used by BSEE
Type 2 - Meets	The International Electrotechnical Commission standards meet the standards currently used by BSEE
Type 3 - Does Not Meet	The International Electrotechnical Commission standards does not meet the standards currently used by BSEE

During Tasks 1, 2 add 3, a gap analysis was conducted compare the International Electrotechnical Commission (IEC and IEC Ex) series of standards to standards the *National Electric Code* (*NEC*), various standards issued by the American Petroleum Institute (API) and standards issued by the American National Standards Institute (ANSI). **See Figure 1**. The results of each task were documented in reports, which are included in the Appendix B, C and D of this final report. These reports include the results of the comparative assessments, summary conclusions and the completed analysis templates.

Figure 1 Gap Analysis - IEC to Selected United States Standards



Tasks 4 consisted of a gap analysis among a number of standards to determine if the elements and standards met, exceeded or did not meet the other. In task 4, special emphasis was made on the following topics, as illustrated in **Figure 2**;

- ANSI/ISA 60079 series compared to the IEC 60079 series of standards
- Listing, marking and documentation of equipment installed in hazardous locations
- Factory Mutual (FM) approval standards compared to the IEC 60079 series of standards
- Test standards in Nationally Recognized Testing Laboratories (NRTL)
- Standards used in the International Regulators' Forum (IRF) member countries to various U.S. and international standards.

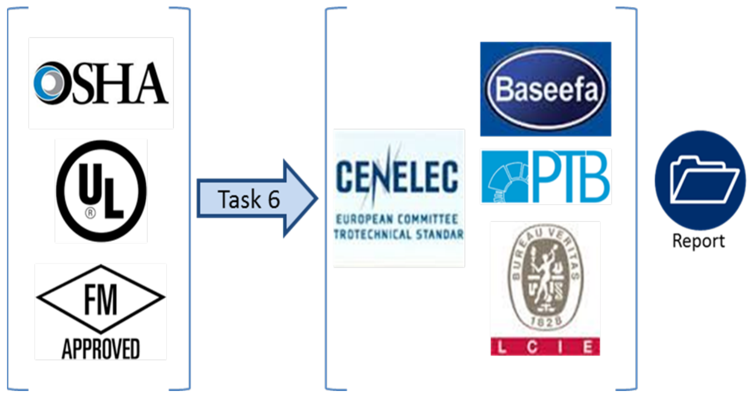
Figure 2 Other Gap Analysis

The results of this gap analysis are contained in a report in Appendix E. The report includes the results of the comparative assessments, summary conclusions and the completed analysis templates.

Finally, Task 6 involved a comparative assessment to determine the similarities and differences between how the U.S. Occupational Safety and Health Administration (OSHA) accredits Nationally Recognized Testing Laboratories (NRTL) and how international authorities accredit independent testing laboratories. **See Figure 3**. This task involved considering how the European Committee for Electrotechnical Standardization (CENELEC) accredits independent testing laboratories, including the;

- British Approval Service for Electrical Equipment in Flammable Atmospheres (BASEEFA)
- Physikalisch-Technische Bundesanstalt (PTB) in Germany and the
- Laboratorie Central des Industries Electriques (LCIE) in France

Figure 3 United States vs. International Accreditation Practices

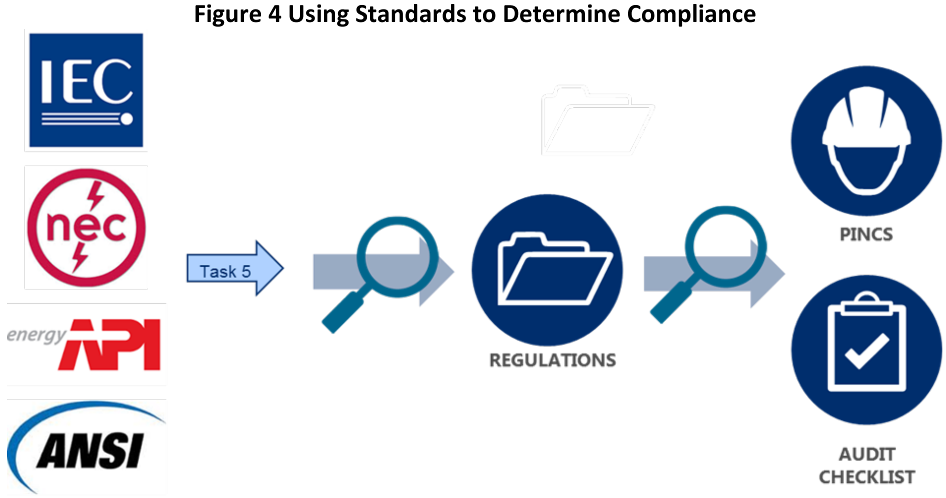


The results of this gap analysis are contained in a report in Appendix G. The report includes the results of the comparative assessments, summary conclusions and the completed analysis templates.

2.2 Approach to Developing Compliance Exhibits

Task 5 involved demonstrating how BSEE's field and office personnel could use each of the IEC, *NEC*, ANSI and various API standard to determine whether operators are in compliance. See **Figure 4**. This task focused on areas including installation and maintenance of equipment, safe work practices and operating procedures. During this task, the IEC, *NEC*, ANSI and API standards were compared to existing regulations in Title 30, Code of Federal Regulations, Part 250 to determine BSEE's regulatory authority. Next, the existing list of electrical-related PINCs were reviewed to determine if changes to PINCs were needed or if new PINCs needed to be developed. For standards not incorporated into regulation by reference, audit protocols and an audit checklist were developed for use by BSEE's field and office personnel.

Figure 4 Using Standards to Determine Compliance



Appendix F includes the Task 5 report, which contains recommended changes to existing PINCs as well as a list of recommended new PINCs. The Task 5 report also contains a recommended audit checklist.

2.3 Abstracts of Selected Electrical Standards

As discussed above, this project involved conducting a comparative assessment of various U.S. and IEC standards. Appendix A contains abstracts of each of the standards compared as part of the electrical standards comparative assessment to provide the reader with a general understanding of the scope of each of the standards. The following tables provide the list of U.S. standards and the associated IEC standard used in the comparative assessment throughout this project. **Table 3** provides a list of the baseline standards that were compared to various IEC standards.

Table 3: Baseline and IEC standards used for comparative assessments

Baseline Standards	IEC Standards
Task 1 *NFPA 70®: National Electrical Code® (NEC)*	IEC 60079-0 *Explosive atmospheres - Part 0: Equipment – General requirements* (Ed. 6.0: 2011-06) IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* IEC 60079-7 *Explosive atmospheres – Part 7: Equipment protection by increased safety "e"* IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* IEC 60079-11 *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"* IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection* IEC 60079-25 *Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems*
Task 2 API RP 14F - *Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations* (Fifth edition, July 2008, Reaffirmed, April 2013) API RP 14FZ - *Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1 and Zone 2 Locations 1 and Division 2 Locations* (First edition, September 2001, Reaffirmed March 2007)	IEC 61892, *Mobile and fixed offshore units – Electrical installations:* IEC 61892-*1 Part 1: General requirements and conditions* (Ed. 3.0: 2015-07) IEC 61892-2, *Part 2: System design*(Ed. 2.0 2012-03) IEC 61892-3, *Part 3: Equipment* (Ed. 3.0 2012-03) IEC 61892-4, *Part 4: Cables* (Ed. 1.0 2007-06) IEC 61892-5, *Part 5: Mobile Units* (Ed. 3.0 2014-11) IEC 61892-6, *Part 6: Installation* (Ed. 3.0 2013-12) IEC 61892-7, *Part 7: Hazardous Areas* (Ed. 3.0 2014-12)

Baseline Standards	IEC Standards
Task 2 API RP 500 - *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2,* (Second edition, November 1997, Reaffirmed: November 2002) API RP 505 - *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2* (First edition, November 1997, Reaffirmed August 2013)	IEC 60079-0 *Explosive atmospheres - Part 0: Equipment – General requirements* (Ed. 6.0: 2011-06) IEC 60079-10-1 *Explosive atmospheres - Part 10-1: Classification of areas – Explosive gas atmospheres* (Ed. 2.0: 2015-09)
Task 3 UL 674 Ed. 5 May 31, 2011 *Standard for Safety for Electric Motors and Generators for Use in Hazardous (Classified) Locations* (Revised on May 19, 2017)	IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*
Task 3 UL 823 Ed. 9 October 20, 2006, *Standard for Safety for Electric Heaters for Use in Hazardous (Classified) Locations* (Reaffirmed on April 22, 2016)	IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

Baseline Standards	IEC Standards
Task 3 UL 844 Ed. 13 June 29, 2012, *Standard for Luminaires for Use in Hazardous (Classified) Locations* (including revisions through March 11, 2016)	IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*
Task 3 UL 913 Ed. 8 December 06, 2013, *Standard for Safety for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations* (including revisions through October 16, 2015)	*IEC 60079-0 Explosive atmospheres – Part 0: Equipment – General requirements* *IEC 60079-11 Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*
Task 3 UL 1203 Ed. 5 November 22, 2013, *Standard for Safety for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations* (including revisions through October 16, 2015)	IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*
Task 3 UL 2225 Ed. 4 September 30, 2013, *Standard for Safety for Cables and Cable-Fittings for Use In Hazardous (Classified) Locations* (including revisions through March 24, 2017)	IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* IEC 60079-7 *Explosive atmospheres – Part 7: Equipment protection by increased safety "e"*
Task 4 FM 3600: *Approval Standard for Electrical Equipment for Use In Hazardous (Classified) Locations - General Requirements* (2001-12)	IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General Requirements* (Ed. 6, 2011-06)

Baseline Standards	IEC Standards
Task 4 FM 3610: *Approval Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II & III, Division 1, Hazardous (Classified) Locations* (2015-12)	IEC 60079-11 *Explosive atmospheres – Part 11: Equipment Protection by Intrinsic Safety "i"* (Ed. 6, 2011-06)
Task 4 FM 3611: *Approval Standard for Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations* (2016-12)	IEC 60079-15 *Explosive atmospheres – Part 15: Equipment Protection by Type of Protection "n"* (Ed. 4, 2010-01)
Task 4 FM 3615 *Approval Standard for Explosionproof Electrical Equipment General Requirements* (2006-08)	IEC 60079-1 *Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"* (Ed. 7, 2014-06)
Task 4 FM 3620: *Purged and Pressurized Electrical Equipment for Hazardous (Classified) Location* (2014-12)	IEC 60079-2 *Explosive Atmospheres Part 2: Equipment Protection by Pressurized Enclosures "p"* (Ed. 6, 2014-07)
Task 6 OSHA Regulations, Standards 29 CFR, 1910.7 *Definition and requirements for a nationally recognized testing laboratory.* (including Appendix A) OSHA Instruction (Directive) CPL 01-00-003 (1999) *NRTL Program Policies, Procedures, and Guidelines* *OSHA NRTL Program - Application Guidelines,* October 2000	ISO/IEC 17011:2004(E) *Conformity assessment – General requirements for accreditation bodies accrediting conformity assessment bodies* ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories* ISO/IEC 17065:2012 *Conformity assessment – Requirements for bodies certifying products, processes and services*

Table 4 contains a list of the ISA/UL 60079 standards compared to IEC 60079 standards that were assessed.

Table 4: ISA/UL 60079 standards compared to IEC 60079 standards (Task 4)

U.S. Standard	U.S. Title	IEC Standard
ANSI/ISA-60079-0 (12.00.01) Ed. 6, 2013	*Explosive Atmospheres - Part 0: Equipment - General Requirements*	IEC 60079-0 Ed. 6, 2011-06

U.S. Standard	U.S. Title	IEC Standard
UL-60079-1, Ed. 7, September 18, 2015	*Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"*	IEC 60079-1 Ed. 7, 2014-06
UL-60079-2, Ed. 6, June 2, 2017	*Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures "p"*	IEC 60079-2 Ed. 6, 2014-07
ANSI/UL 60079-5, Ed. 4, April 29, 2016	*Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"*	IEC 60079-5 Ed. 4, 2015-02
ANSI/UL 60079-6 Ed. 4, April 29, 2016	*Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"*	IEC 60079-6 Ed. 4, 2015-02
UL-60079-7, Ed. 5, February 24, 2017	*Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"*	IEC 60079-7 Ed. 5, 2015-06
ANSI/ISA-60079-10-1, Ed. 5, February 24, 2017 (12.24.01) Ed. 1, 2014	*Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres*	IEC 60079-10-1 Ed. 2, 2015-09
ANSI/ISA-60079-11 (12.02.01) Ed. 6.2, 2014	*Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"*	IEC 60079-11 Ed. 6, 2011-06
ANSI/ISA-60079-15 (12.12.02) Ed. 4, 2012	*Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"*	IEC 60079-15 Ed. 4, 2010-01
ANSI/UL 60079-18 Ed. 4 December 14, 2015	*Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"*	IEC 60079-18 Ed. 4, 2014-12
ANSI/ISA-60079-25 (12.02.05)-2011	*Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems*	IEC 60079-25 Ed. 2, 2010-02
ANSI/UL 60079-26 Ed. 3, April 21, 2017	*Explosive Atmospheres - Part 26: Electrical Apparatus for Use in Class I, Zone 0 Hazardous (Classified) Locations*	IEC 60079-26 Ed. 3, 2014-10
ANSI/ISA-60079-27 (12.02.04)Ed. 1, 2006	*Explosive Atmospheres – Part 27: Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)*	IEC 60079-27 Ed. 1, 2005-04
ANSI/ISA-60079-29-1 (12.13.01) Ed. 1, 2013	*Explosive Atmospheres - Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases*	IEC 60079-29-1 Ed. 1 2007-08
ANSI/ISA-60079-29-2 (12.13.02)-2012	*Explosive Atmospheres - Part 29-2: Gas Detectors - Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen*	IEC 60079-29-2 Ed. 2, 2015-03

3. Findings and Conclusions

Given the large number of standards analyzed during the course of this project it is difficult to come to an overall conclusion from the comparative assessments that were conducted. As such, Section 3 provides a summary of the findings and conclusions for each of the standards analyzed. Detailed analysis and conclusions are contained in the individual Task reports found in the appendices to this report, as shown in **Table 5**.

Table 5: Detailed Findings and Conclusions for Comparative Assessments and Exhibits

Comparative Assessment and Exhibits	Location of Findings and Conclusions
IEC vs. *NEC*	Appendix B
IEC vs. API 14F, API 14FZ, API 500 and API 505	Appendix C
IEC vs. ANSI/UL	Appendix D
IEC 61892 vs. ANSI/ISA 60079 & ANSI/NFPA 70 IEC 60079-0 vs. ANSI/ISA 60079 series IEC 60079 vs. FM Series Test Standard in NRTLS vs. IEC Hazardous Location Standards in IRF member countries vs. United States	Appendix E
Exhibit of BSEE Personnel Using Standards for Ensuring Compliance	Appendix F
United States vs. International Accreditation Practices	Appendix G

3.1 IEC vs. *NEC* (Task 1)

This section contains a summary of findings and conclusions from the Task 1 comparative assessment of the *NEC* vs IEC 60079-10-1. Detailed findings are contained in the Task 1 report in Appendix B. Task 1 Report: IEC vs *NEC* Gap Analysis

In general, the definitions and basis for the Zone method classification in *NEC* Article 505 and IEC 60079 series of standards are very similar. The Division method in *NEC* Article 500 is not covered by the IEC 60079 series of standards, however it is comparable to the *NEC* Zone method. Division 2 is equivalent to Zone 2, while Division 1 is either Zone 0 or Zone 1. Zone 0 is reserved for areas with continuous presence of flammable gas/vapor, which falls into Division 1 category since there is no separate category as Division 0. The gas groups A and B from the Division method are equivalent to gas group IIC in Zone method. Also, Gas group C is equal to group IIB and gas group D is equal to IIA.

IEC 60079 does not identify some of the protection techniques contained in the *NEC*, such as explosion proof equipment. Part 1 of the IEC 60079 discusses explosive atmosphere and contains provisions for equipment protection by flameproof enclosures. This part of the IEC provides requirements on flameproof enclosures, which is comparable to explosion proof enclosure described in the *NEC*.

However, there are differences between explosion proof enclosures used in *NEC* Article 500 and flameproof enclosures used in IEC 60079-1. The explosion proof enclosures in *NEC* Article 500 are individually factory tested to four times the maximum pressure that is released in an explosion, whereas the flameproof enclosures are referenced in IEC 60079-1 are tested to 1.5 times the maximum pressure that is released in an explosion.

IEC standard does not require the equipment to be marked with Class I. However, class marking can be identified based on group type indicated on the equipment label. In addition, IEC 60079 does not require the equipment to be marked with type of Zone such as Zone 0, Zone 1 or Zone 2. However, zone classification can be identified based on the type of protection used for the equipment. For example, protection type code 'ia' is suitable for installation in Zone 0, whereas protection type code 'ib' is suitable for installation in Zone 1.

NEC doesn't contain any guidance or requirements regarding the criteria for the gas dispersion models. However, a national standard such as NFPA 59A*, Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, refers to a model described in *GRI Report 0242*. IEC 60079-10-1 describes different methods that can be used to classify a hazardous area. Three methods are called simplified methods, classification by sources of release and combination methods. Any of these methods can be considered based on the physical factors and practical application of it.

3.1.1 Wiring methods

The requirements in the *NEC* are specific with regard to type of the wiring permitted in different types of hazardous locations. Wiring methods covered by the IEC standard are general and don't provide as much detail as in the *NEC*. IEC 60079-14 provides some information about grounding. For example, the conduit system is allowed to be used as a protective earthing conductor (Equipment grounding conductor) provided that the threaded junction is suitable to carry the fault current. The *NEC* requires a separate equipment grounding conductor or equipment bonding jumper whereas the IEC allows the conduit system to be used as the equipment grounding conductor.

3.1.2 Surge protection

NEC Article 501.35 Surge Protection, contains some requirements about the surge protection devices installation in hazardous area. For Class I, Division 1 locations, surge arresters, surge-protective devices and capacitors shall be installed in enclosure identified for Class I, Division 1 location. Also, surge protective capacitors shall be of a type designed for specific duty. For Class I, Division 2 locations, surge arresters and surge-protective devices shall be non-arcing, such as metal-oxide varistor (MOV) sealed type. Enclosures shall be permitted to be of the general-purpose type. In general, IEC 60079 series does not contain many requirements about the surge arresters except in Annex F of IEC 60079 part 25. Annex F provides information on use of surge arrester protect against lightning induced surges.

3.1.3 Protecting equipment from ingress of solid foreign objects

IEC 60529 *Degrees of Protection Provided by Enclosures (IP Code)*, defines the degree of protection provided by an enclosure. The enclosure rating is indicated by the IP Code. The enclosures are to protect against the incoming solid foreign objects as well as against the harmful effects of ingress water. The enclosure ratings in IEC is provided with the combination of two digits, i.e. IP22. First digit indicates the level of protection against the solid objects and the second digit indicates the level of protection against water.

The degree of protection provided by an enclosure that is identified by IP rating is comparable to the enclosure type number identified in *NEC* Table 110.28. For example, an enclosure with IP 22 rating is comparable to Type 2 enclosures indicated in the *NEC*. For most part the degree of protection provided by an enclosure with IP code is comparable to the type rating of the enclosure identified in *NEC*. However, there are enclosures with enclosure type rating 4X and 7, for which there are no equivalent enclosures identified by IP rating.

3.1.4 Design criteria for submarine cables used for subsea production equipment.

The *NEC* does not contain any requirements for the submarine cables. *NEC* Article 340 Underground Feeder and Branch-Circuit Cable: Type UF, provides the information on the use, installation and construction specifications for underground cables and branch-circuit cables and does not provide any information on submarine cables. Similarly, there is no specific IEC standard that provides requirements for submarine cables. The API SPEC 17E*, Specification for Subsea Umbilicals* and IEEE 1120*, IEEE Guide for the Planning, Design, Installation, and Repair of Submarine Power Cable Systems* provide design criteria for submarine cables.

3.2 IEC vs. API RP 14F and API RP 14FZ (Task 2)

This section contains a summary of the findings and conclusions from the Task 2 comparative assessment of API RP 14F and API RP 14FZ vs IEC 61892. Detailed findings are contained in the Task 2 report in Appendix C. Task 2 Report: IEC vs. API Gap Analysis.

API RP 14F, titled "Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Division 1 and Division 2 Locations," contains recommended practices for electrical systems on offshore petroleum facilities. This RP identifies features of offshore electrical systems and recommends generally accepted practices for electrical design and installation in the offshore industry. Area classification for locations are defined in Article 500 of the U.S. *NEC*.

API RP 14FZ, titled “Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1 and Zone 2 Locations," contains recommended practices for electrical systems on offshore petroleum facilities. This

RP identifies features of offshore electrical systems and recommends generally accepted practices for electrical design and installation in the offshore industry. Area classification for locations are defined in *NEC* Article 505.

The comparable IEC standard to API RP 14F and API RP 14 FZ is the IEC 61892 standard. This standard provides guidance for the design and installation of electrical systems for the offshore petroleum industry. IEC 61892 is a seven (7) parts standard intended to provide safe practices for the design and installation of electrical systems for offshore units. The standard can be applied to pipeline, pumping or 'pigging' stations, compressor stations and exposed location single buoy moorings, used in the offshore petroleum industry for drilling, processing and storage purposes drilling units and production platforms. This standard has a common title of "*Mobile and fixed offshore units – Electrical installations*" for all 7 parts. Each part has a unique title as follows:

Part 1: General requirements and conditions
Part 2: System Design
Part 3: Equipment
Part 4: Cables
Part 5: Mobile units
Part 6: Installation
Part 7: Hazardous Areas

The IEC classifies hazardous areas as either zone 0, zone 1 or zone 2 in IEC 60079-10-1. These area classifications are equivalent to Class I, Zone 0, Zone 1 and Zone 2 defined by the U.S. National Electrical Code Article 505. API RP 14F was written for electrical installations on offshore facilities where areas are classified by the division method and the IEC standards only recognize the zone method of area classification, making it difficult to make a direct comparison between the two approaches. In these cases, the requirements in the IEC standard were compared with those in the API standard to determine if an equivalent level of safety can be achieved by following the IEC standard.

The scope of the comparative assessment between the API RP 14F and API RP 14FZ with the IEC Standard 61892 included the topics such as General provisions, Electrical equipment for hazardous (classified) locations, Electrical power generating stations, Electrical distribution systems, Electrical equipment, Special systems, Special considerations, System checkout.

3.2.1 General Provisions

Both API RP 14F and 14Z provide general design guidance for electrical systems but refer to the *NEC* for detailed requirements with only a few deviations specifically stated in the RPs. These RPs also refer to the 46 CFR Chapter I, Subchapter J for systems that are regulated by the USCG and BSEE. Electrical equipment design and construction typically refer to other recognized industry standards such as ANSI, IEEE, API, etc.

IEC 61892 also refers to other IEC or international standards for detailed requirements for some specific systems or equipment. Since it is intended to be an international standard, it does not refer to any standards such as UL, ANSI, etc. specifically used by a single country or countries in a region.

3.2.2 Electrical Equipment for Hazardous (Classified) Locations

API 14 F provides guidance for selection of electrical equipment in hazardous locations designated as Class I, Division 1 or Division 2. Different types of protection techniques such as explosion-proof, hermetically sealed, intrinsically safe, non-incendive and purged enclosures are included. Reference is made *to UL913* for intrinsically safe *and NFPA 496* for purged enclosures. Although *NEC* is applicable for electrical installations on offshore facilities, API RP 14F does not permit isolating switches for a transformer to be installed within general purpose enclosure located in Division 2 area. This is a deviation from the NEC.

API RP 14FZ provides guidance for selection of electrical equipment in hazardous locations designated as Class I, Zone 1 or Zone 2. Additional protection techniques such as flameproof, increased safety, oil immersion, etc. are introduced along with the ISA standards specified for these protection techniques. Also, reference is made to NFPA 496 and IEC 60079-2 for purged enclosures and UL 913 and IEC 60079-11 for intrinsic safety system requirements.

IEC 61892 part 7 provides guidance for the selection of electrical equipment in hazardous areas. To determine which type of protection technique is acceptable for a particular hazardous area, IEC 60079-14 should be consulted as this standard has tables listing the acceptable protection methods for Zone 0, 1 and 2. IEC 61892-7 permits only equipment certified to IEC 60079 to be installed in hazardous areas and such equipment must have a certificate issued by a recognized certifying body.

API RP 14F and API RP 14FZ requires high temperature devices (operating temperature exceeds 80% of the auto ignition temperature of the flammable gas involved) that have not been certified by a nationally recognized testing laboratory (NRTL) for a specific temperature rating to be installed inside explosion-proof, flameproof or purged enclosures. IEC 61892 part 7 requires all equipment installed in hazardous locations to be certified according to IEC 60079, and the certified equipment will be marked showing the temperature code assigned to the equipment.

API RP 14F allows explosion-proof equipment to be used in Division 1 and Division 2 locations. There is no IEC standard for explosion-proof equipment. The only IEC standard that is comparable is the IEC 60079-1 for flameproof equipment. Equipment certified to this IEC standard is approved for Zone 1 and Zone 2 locations. The testing requirements for the explosion-proof equipment are higher than the testing requirements for the flame-proof equipment. IEC 61892 requirements meet the recommended practices in API RP 14FZ but not API RP 14F for this subject.

API RP 14F, marking of Division equipment is required to show the class and division, gas group and operating temperature or temperature range. API RP 14FZ requires marking for zone equipment to show class and zone, the symbol AEx, the protection technique, gas group and temperature code. IEC certified equipment will have marking showing Ex symbol, protection technique, gas group and temperature code. The area classification and zone is not required by IEC for marking of equipment. IEC 61892 requirements do not meet the recommended practices in API RP 14F and API RP 14FZ for Marking of Electrical Equipment.

3.2.3 Electrical Power Generating Stations

API RP 14F and API RP 14FZ provide general guidance for sizing the prime mover and generator and typical protections for the prime mover as well as the generator. Basic design requirements and construction standards for electrical switchboards are also included. For floating facilities, additional requirements are contained in U.S. Coast Guard regulations in Title 46 Code of Federal Regulations, Subpart 58.10. The USCG regulations and class rules for floating facilities require an independent emergency generator and switchboard.

IEC 61892 also has requirements for the design of electrical power system as well as electrical equipment in Part 2 and Part 3 of the series, respectively. However, it does not provide guidance for protection of the prime mover. IEC 61892 requires at least two (2) generators for the main power system and also an independent emergency power generator and switchboard.

3.2.4 Prime Movers and Generators

API RP 14F and API RP 14FZ require generators to be designed to perform in accordance with *National Electrical Manufacturers Association – Motors and Generators* (NEMA MG1), while the IEC standard requires generators to comply with IEC 60034-1. The National Electrical Manufacturers Association Motors and Generators (NEMA MG1) and the IEC 60034 have the similar performance requirements. API RP 14F and API RP 14FZ provides general guidance for sizing, locations of air intakes and exhaust, typical control functions and automatic shutdown conditions for the prime mover. IEC 61892 does not meet the recommended practices contained in API RP14F and API 14 FZ for protection requirements for prime movers.

3.2.5 Switchboards

API RP 14F and API RP 14FZ require low voltage switchboards to be dead front type meeting UL 891; ANSI/IEEE C37.20.1 and ANSI/IEEE C37.20.2. The IEC standard requires switchgear and control-gear to comply with *IEC 61439-1* and IEC 62271. API RP14F and API RP 14 FZ do not have the requirements for dividing the main bus as described in IEC standards. IEC 61892 requirements for switchboards exceed the recommended practices contained in API RP14F and API RP 14 FZ

3.2.6 Emergency Power System

For floating installations, API RP14F and API RP 14 FZ require an emergency power system consisting of an emergency generator that is sized to supply 100% of the connected loads that are essential for safety and can supply power continuously for 18 hours. IEC 61892 has similar requirements for an emergency power system, however, it also offers an alternative arrangement without a specific emergency power source provided the main source of power is located in two or more spaces which have their own completely independent systems, including power distribution and control systems, such that a fire or other casualty in any one space will not affect the power distribution from the other spaces. IEC 61892 requirements for Emergency Power System meets the recommended practices contained in API RP14F and API RP 14 FZ.

3.2.7 Electrical Distribution Systems

Wiring methods and circuit protection described in the IEC 61892 are comparable to those indicated in API RP14F and API RP 14 FZ. Additionally, both API and IEC standard provides similar requirements for selection of cables, voltage drop consideration and circuit protection. For working space around electrical equipment, both API RP 14F and API RP 14FZ refer to NEC Article 110 Requirements for Electrical Installations for minimum clear working space. The required depth of working space varies depending on the voltage class of the equipment. The NEC requires greater working space depth for higher voltage class equipment. The IEC standard does not have similar requirements.

3.2.8 Electrical Equipment

API RP 14F and API RP 14FZ provide guidance for selection, control and protection for electric motors, transformers, normal and emergency lightings, and provides general guidance regarding the use of direct current (DC) power systems. Specific standards are included for electric motors and transformer. IEC 61892 provides construction standards for many types of electrical equipment. Part 2, Clause 11 of the IEC standard explains the differences between general lighting, emergency lighting and escape lighting. Minimum illumination levels required for different types of areas are also provided. Based on the assessments, it is concluded that the IEC 61892 meets the API RP 14F and API RP 14FZ requirements for electrical equipment.

3.2.9 Special Considerations

API RP 14F and API RP 14FZ recommend additional considerations to be taken in the selection of materials for electrical installations such as construction practices, instrumentation, lockout tagout procedures, portable electronic devices etc. IEC 61892 does not include a dedicated section for the listed considerations although the considerations are addressed throughout Parts 1, 3, 6 and 7 of IEC 61892. Based on the analysis, IEC 61892 meets the considerations of API RP 14F and API RP 14FZ.

3.2.10 Special Systems

API RP 14F and API RP 14FZ introduces safety systems typically required for offshore production facilities such as Fire and Gas detection, Platform safety controls, Navigation aids, Communication etc. IEC 61892 also includes requirements for various systems. Safety critical systems are required to have a high degree of availability. For some of the systems such as navigation aids, oil-immersion heaters, power operated winches for survival craft, power-operated watertight doors, hull mechanical system controls, general alarm system, and cathodic protection system IEC 61892 requirements do not meet the recommended practices contained in API RP14F and API 14 FZ

API RP 14F and API RP 14FZ recommends a minimum 6 air changes per hour for cargo handling rooms. IEC 61892 references to the IEC standard 60092-502 which requires minimum of 20 air changes per hour ventilation requirement. Therefore, the IEC requirements for cargo handling rooms exceeds the recommended practices contained in API RP14F and API 14 FZ.

3.2.11 System Checkout

API RP 14F and API RP 14FZ provide the minimum requirements for checking out electrical, control and instrumentation systems and equipment before putting them in operation. IEC 61892 also provides inspection and testing requirements for electrical systems and equipment after installation is completed. Based on the comparative assessment, IEC61892 meets the requirements in the API RP 14F and API RP 14FZ for system checkout procedures.

3.3 IEC vs. API RP 500 and API RP 505 (Task 2)

This section contains a summary of the findings and conclusions from the Task 2 comparative assessment of API RP 500 and API RP 505 vs IEC 60079-10-1. Detailed findings are contained in the Task 2 report in Appendix C.

API RP 500, titled “Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2," contains recommended practices for classifying locations Class I, Division l and Class I, Division 2 at petroleum facilities for the selection and installation of electrical equipment.

API RP 505, titled "Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2," contains recommended practices for classifying locations Class I, Zone 0, Zone 1, and Zone 2 locations at petroleum facilities for the selection and installation of electrical equipment.

The comparable IEC standard to API RP 500 and API RP 505 is the IEC 60079-10-1 standard. The IEC 60079-10-1 standard provides guidance for classification of areas where flammable gas or vapor hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas. IEC standard 60079-10-1 is not specifically written for petroleum facilities, however, it does pertain to the classification of areas where there are risks of ignition due to presence of flammable gas, liquid or vapor. Both API RP 500/API RP 505 and IEC 60079-10 describe classification of hazardous areas according to the probability that a flammable gas may be present in different areas.

The scope of the comparative assessment between the API RP 500 and API RP 505 with the IEC Standard 60079-10-1 included the topics such as General provisions, Basic conditions for fire/explosion and flammable/combustible liquids, gases and vapors Classification criteria, Extent of a classified location, Degree and extent of classified locations.

The most apparent difference between API and IEC 60079-10-1 is that the API RP's cover the option of Classification into Divisions or into Zones, but IEC 60079-10-1 uses Zones exclusively. API RP 500 incorporates the definitions of Class I, Division 1 and Division 2 from the *NEC* Article 500. API RP 505 incorporates the definition of Class I, Zone 0, Zone 1, and Zone 2 from IEC 60079-10-1.

API RP 500, API RP 505 and IEC 60079-10-1 approach the classification of hazardous areas from a point source approach where each potential source of gas release is evaluated with consideration for the type of source of release. The type of zone, extent of zone can be determined based on release rate of gas, lower explosive limit (LEL), ventilation, relative density of the gas or vapor, climate or weather, and topography or arrangements. Further, both API RP 500/505 and IEC 60079-10-1 give schematic examples of hazardous area classifications around different types of sources of release and different arrangements. Typical examples given in the API RPs make classifying of locations simple without performing calculations.

IEC 60079-10-1 is a generic standard for classifying hazardous areas. The focus of this standard is the methods, with examples and calculations, for determining the hazardous areas for many arrangements in unspecified installations. Given the different types of facilities handling hydrocarbons, API RP 500/505 presents applications that are common to several facility types as well as giving specific guidance for each type of facility (i.e., MODU, FPSO, TLP, and others). API RP 500/505 presents hazardous area classification specifications and schematic graphics associated with the most common possible sources or gas release such as vents, flanges, valves, drains, sumps, etc. on specific types of installations. For areas not addressed specifically, API RP 500/505 gives the option of classifying areas based on a point source method and calculations derived from IEC 60079-10.

3.4 IEC vs. ANSI/UL (Task 3)

This section contains a summary of the findings and conclusions from the Task 3 comparative assessment of ANSI/UL Standards 674, 823, 844, 913, 1203, and 2225 with the latest editions of the IEC 60079 Series standards. Detailed findings are contained in the Task 3 report in Appendix D. Task 3 Report: IEC vs. ANSI/UL Gap Analysis.

3.4.1 UL 674 vs. IEC 60079 series

UL 674 *Standard for Safety for Electric Motors and Generators for Use in Hazardous (Classified) Locations* provides requirements for the construction, performance and marking of electrical motors and generators or other rotating machinery with the type of protection explosion-proof or dust-ignition-proof, intended for use in explosive atmospheres. Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-14 and IEC 60079-10-1. Comparative assessment was conducted between the UL 674 standard IEC 60079 standards on the general provisions, construction standards, performance tests and marking requirements. The major differences between UL 674 and IEC 60079 are summarized in this section.

UL 674 applies to electric motors and generators or submersible and nonsubmersible sewage pumps and systems as well as other rotating machinery installed in Class I, Division 1, Group B, C & D (equivalent to Class I, Zone 1, Group IIA and IIB, IIB+H2). The UL standard only addresses types of protection explosion-proof or dust-ignition-proof for the equipment aforementioned. Requirements for all types of protection for various electrical equipment are contained in the IEC 60079 series.

The normal ambient conditions defined in UL 674 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, higher than 40 °C in UL 674.

The Division system for hazardous area classification employed in UL 674 is not used in IEC 60079 series. The detailed equivalency analysis between the Division system and Zone System can be found in the Task 1 Report (Appendix B).

UL 674 does not employ any IEC standard for base requirements. Normative references in UL 674 are U.S., Canada and Mexico standards.

Both UL 674 and IEC 60079-0 standards require that electrical equipment and components in hazardous (classified) locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However, IEC standards do not require that compliance with the industrial standards be verified, whereas UL standards for ordinary locations have requirements on equipment be verified by the testing lab.

Construction

The motor enclosures are made of metal materials, and zinc alloys as well as magnesium and its alloys are not allowed per UL 674. Enclosure strength can be determined by tests per UL and IEC. In UL 674, the ability of a motor enclosure to withstand internal explosion pressure can also be determined by calculations.

Both UL and IEC provide the dimensional (joint width and gap) requirements for joints in enclosure based on gas groups and joint types (non-threaded joint or thread joint). For non-threaded joint of enclosure, UL requirements are more conservative, except minimum required joint width in IEC and UL are the same in Group (C, D / IIA, IIB) locations. National Pipe Thread (NPT) and Cylindrical Thread joints are used in IEC for all gas groups. In UL 674, NPT is used for gas groups (B, C, D), but cylindrical threads are only mentioned in the section for the enclosure in Group B location only.

Regarding the requirements for bolts in joint width, it was noted that both UL 674 and IEC 60079-1 have requirements. However, the required minimum flame path length (from inside or outside of enclosure to the nearest edge of bolt hole) in IEC is less than in UL under the same joint width ranges.

Minimum length of joint and clearance (gap) for motor shaft opening depend on gas groups, shaft joint types (straight or labyrinth) and bearing types (sleeve or ball). For the same length of joints as well as same joint types and bearing types, the maximum allowable clearance (gap) for Group C & D locations in UL is less than equivalency Group IIA & IIB locations in IEC, thus UL 674 is more stringent. The shaft opening for Group B locations is not covered in UL.

Performance Tests

Regarding the performance test requirements in UL 674 and IEC 60079 standard, several differences were noted. The temperature tests on sine wave power for single speed or multi-speed motors and for variable-frequency inverter-driver motors in UL 674 are more stringent than IEC 60079 series of standards. It was also noted that UL 674 exceeds the IEC standard requirements for the secureness test on conduit hubs and sealing compound test. Comparisons of electrical resistance test and earth continuity test between UL and IEC show that IEC 60079-0 exceeds the requirement in UL 674.

Marking

In general, the marking in both UL 674 and IEC standards are providing similar information. The IEC marking doesn't indicate Zone whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in the IEC are not employed by UL. Although it may be considered that IEC does not meet UL for marking due to difference between the standards, it should have no negative affect on the safety level of equipment operation.

Conclusion

In addition to the major differences identified above, Section 3 of the Task 3 report in Appendix D covers each of the gap assessments conducted between UL 674 and IEC 60079. Based on the comparative assessments, various sections of the IEC 60079 series meet, exceed, or do not meet the requirements of UL 674 as listed in Section 3.5 of Appendix D.

3.4.2 UL 823 vs. IEC 60079 Series

UL 823 *Standard for Safety for Electric Heaters for Use In Hazardous (Classified) Locations* provides requirements for the construction, performance and marking of portable and fixed electrical heaters with the type of protection explosion-proof or dust-ignition-proof and dust-tight, intended for use in explosive atmospheres. Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-10-1 and IEC 60079-14. The scope of the comparative assessment between the UL 823 with IEC Standard 60079 includes the requirements for general provisions, construction, Performance tests for heaters for Class I, Division 2 locations, manufacturing and production tests and marking. The major differences between UL 823 and IEC 60079 series are summarized in this section.

General

UL 823 covers fixed and portable electric heaters installed in Class I, Division 1 & 2, Group A, B, C & D. The UL standard only addresses types of protection explosion-proof or dust-ignition-proof and dust-tight and is applicable to electric air heaters, hot-water or steam radiators, electric hot plates and paint heaters rated 600 volts or less. All types of protection are contained in the IEC 60079 series.

The normal ambient conditions defined in UL 823 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but no maximum temperature is specified in UL 823.

Both UL and IEC standards require that electrical heaters and components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However, IEC 60079-0 does not require compliance with industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing lab.

Both IEC and UL standards have requirements on protecting equipment. IP rating in IEC is not employed by UL, but most of the IP code is comparable to the type rating of the enclosure in UL. UL 823 requires heaters with Type 7 enclosures to meet the applicable requirements for indoor Class I locations. Such enclosure type is not found in IEC 60079.

The Division System for hazardous area classification employed in UL 823 is not used in the IEC 60079 series. The detailed equivalency analysis between Division System and Zone System can be found in Task 1 Report (Appendix B).

Construction

The heater enclosure housing can be made of metal materials or nonmetallic materials. UL 823 may be considered more stringent than IEC 60079 due to no allowance on zinc alloys and magnesium and its alloys as well as low copper content of alloy permitted in UL 823. Both UL 823 and IEC 60079 require nonmetallic enclosures to satisfy the non-metallic materials tests. The chemical compatibility test in UL 823 cannot be satisfied by IEC 60079 (refer to Performance Tests).

IEC 60079-1 does not meet UL 823 for the requirements of non-threaded joint and shaft opening. Bolts in joint width are accepted with conditions in UL, which is not required by IEC. Where the bolt in joint width is provided, the required minimum width of joint and/or minimum flame path length (distance from inside of enclosure to nearest edge of bolt hole) in IEC 60079-1 is less than UL 823.

Bonding and grounding requirements in IEC 60079-1 and UL 823 are similar, except that minimum cross-sectional area of earthing conductor are specified based on phase conductors in the IEC standard, which are not found in UL 823. Thus it is considered that IEC 60079-1 exceeds the requirements of UL 823 for bonding and grounding.

Performance Tests

With regard to performance tests, it is noted that IEC 60079 exceeds the requirements for temperature test used to determine the maximum surface temperature and electrical resistance test. Explosion tests, hydrostatic pressure test, accelerated-aging test on bushing and drop test in UL can be satisfied by IEC. For other performance tests, including non-metallic enclosure material test and secureness of conduit hub test, etc., the requirements in UL 844 are more stringent than IEC 60079 standard requirements.

Heaters for Class I, Division 2 Locations and Manufacturing and Production Tests

UL 823 also includes requirements on heaters for use in Class I, Division 2 locations and heater production-line tests. The comparisons of these aspects between UL 823 and IEC 60079 can be covered by the related sections for the installations in Class 1, Division 1 locations, as applicable. The enclosure for an arcing or sparking part in Division 2 locations shall meet the requirements for an enclosure in Division 1 locations per UL 823. The air-leakage test for heater element sheath is not found in IEC 60079.

Marking

In general the marking in both UL 823 and IEC 60079 series are providing similar information. IEC marking doesn't indicate Zone whereas UL marking requires the Zone 0, 1 or 2 provided on the label. Ex Symbols and equipment protection levels in IEC are not employed by UL. Although it may be considered that IEC does not meet UL for marking due to difference between the standards, it should have no negative affect on the safety level of equipment operation.

Conclusion

In addition to the major differences identified above, Section 4 of the Task 3 report in Appendix D covers each of the gap assessments conducted between UL 823 and IEC 60079 series. Based on the comparative assessments, various sections of the IEC 60079 series meet, exceed, or do not meet the requirements of UL 823 as listed in Section 4.7 of Appendix D.

3.4.3 UL 844 vs. IEC 60079 Series

UL 844 S*tandard for Luminaires for Use in Hazardous (Classified) Locations* provides requirements for the construction, performance and marking of fixed and portable luminaires for installation and use in hazardous (classified) locations. Based on the scope of UL 844, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-10-1 and IEC 60079-14. The scope of the comparative assessment between the UL 844 with IEC 60079 includes the requirements for General provisions, Luminaires for Class I, Division 1 locations, Luminaires for Class I, Division 2 locations, Portable Luminaires, manufacturing and Production Tests and Marking. The major differences between UL 844 and IEC 60079 are summarized in this section.

General

UL 844 covers fixed and portable luminaires installed in Class I, Division 1 & 2, Group A, B, C & D. Luminaires and all types of protection are contained in IEC 60079 series. The Division System for hazardous area classification employed in UL 844 is not used in IEC 60079 series. The detailed equivalency analysis between the Division System and Zone System can be found in Task 1 Report (Appendix B).

The ambient conditions defined in UL 844 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -25 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but no maximum temperature is specified in UL 844.

Both UL 844 and IEC 60079 series require that electrical luminaires and components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations. However, IEC does not require that compliance with industrial standards be verified, whereas UL standards for ordinary locations have requirements on equipment be verified by the testing lab.

IEC and UL have no objection to high-pressure sodium lamps used in hazardous areas. Low-pressure sodium lamps are not permitted for use in all hazardous areas in IEC, but only prohibited by UL for Division 1 hazardous locations. IEC 60079 exceeds UL 844 on the requirement of application of sodium lamps.

Both IEC and UL standards have requirements on protecting equipment. IP rating in IEC is not employed by UL, but most of the IP code is comparable to the type rating of the enclosures in UL. UL 844 requires luminaires with Type 7 enclosures to meet the applicable requirements for indoor Class I locations. Such enclosure type is not found in IEC 60079.

Luminaries for Class I, Division 1

Comparison of requirements of construction and performance tests of luminaires for Class I, Division 1 installations in UL 844 is done with IEC 60079-1 and 60079-0 and IEC 60079-14 requirements.

Construction

The luminaire enclosure housing can be made of metal materials or nonmetallic materials. UL 844 may be considered more stringent than IEC due to no allowance on zinc alloys and magnesium and its alloys as well as low copper content of alloy permitted in UL 844. Also, UL 844 has detailed requirements for surface porosity in castings materials of enclosures without limitation on a specific material, whereas only cast iron quality is required in IEC 60079-1. Both UL 844 and IEC require nonmetallic enclosures to satisfy the non-metallic materials tests. The chemical compatibility test in UL cannot be satisfied by IEC (refer to Performance Tests).

For non-threaded joints and shaft opening in enclosures of luminaires used in Class I, locations, comparisons with minimum width and maximum clearance permitted in UL 844 and IEC 60079-1 show that UL requirements are more stringent than IEC. UL 844 also requires a shaft opening in an enclosure shall be of the metal-to-metal type for Class I locations, whereas no specific opening type is required in IEC 60079-1. Bolts in joint width are accepted with conditions in UL 844, which is not required by IEC. Where the bolt in joint width is provided, the required minimum width of joint and/or minimum flame path length (distance from inside of enclosure to nearest edge of bolt hole) in IEC 60079-1 is less than UL 844.

Both UL 844 and IEC 60079-0 have requirements to ensure no danger of ignition due to electrostatic charges for nonmetallic external parts. IEC 60079-0 provides more methods than UL 844 to avoid a build-up of electrostatic charge on equipment.

Luminaires for wet locations shall be subjected to Thermal Shock Test per UL 844. IEC 60079-0 also has Thermal Shock Test for glass parts of luminaires, but the test requirements are less than UL (refer to Performance Test). NEMA enclosure ratings for luminaires at wet locations in UL are not employed by IEC.

IEC 60079-1 exceeds UL 844 for requirements on guards of luminaires and bonding and grounding, but it does not have the requirements similar in UL 844 for a fuse provided in a luminaire for Class I locations.

Performance Tests

With regard to performance tests, it is noted that IEC standard exceeds the requirements for temperature test used to determine the maximum surface temperature and electrical resistance test. Explosion tests and hydrostatic pressure test in IEC meet the requirements in UL. For other performance tests, including thermal shock test, secureness of conduit hub test, vibration test, non-metallic enclosure material test, sealing compounds test, etc., the requirements in UL 844 are more stringent than IEC 60079 standard requirements.

Luminaires for Class I, Division 2 locations, Portable Luminaires & Manufacturing and production Tests

UL 844 also includes requirements on luminaires in Class I, Division 2 locations, portable luminaries for indoor use in hazardous (classified) locations and luminaire production-line tests. The comparisons of these aspects between UL 844 and IEC 60079 can be covered by the related sections for the fixed installations in Class 1, Division 1 locations, as applicable. The enclosure for an arcing or sparking part in Division 2 locations shall meet the requirements for an enclosure in Division 1 locations per UL 844.

Marking

Both standards provide similar information on marking. IEC marking doesn't indicate Zone 0, 1 or 2 whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in IEC are not employed by UL. Although it may be considered that IEC does not meet UL for marking due to difference between the standards, it should have no negative affect on the safety level of equipment operation.

Conclusion

In addition to the major differences identified above, Section 5 of Task 3 report in Appendix D covers each of the gap assessment conducted between UL 844 and IEC 60079. Based on the comparative assessments, various sections of the IEC 60079 series meet, exceed, or do not meet the requirements of UL 844 as listed in Section 5.7 of Appendix D.

3.4.4 UL 913 vs. IEC 60079 Series

UL 913 *Standard for Safety for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and Ill, Division 1, Hazardous (Classified) Locations* provides requirements for the construction, testing and marking of electrical apparatus, or parts of such apparatus, having circuits that are not capable of causing ignition in Division 1 Hazardous (Classified) Locations as defined in *NEC* Article 500.

Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0 & IEC 60079-11. The scope of the comparative assessment between UL 913 with IEC 60079 includes general (construction and testing), marking and reference standards. The major differences for these aspects in UL 913 and IEC 60079 are summarized in this section.

UL 913 covers intrinsically safe apparatus and parts of apparatus for installation and use in Class I, Class II & III, Division 1 as well as Groups IIIA, IIIB & IIIC, Zone 20 locations in accordance with the requirements of the NEC. The requirements in UL 913 also apply to associated apparatus located outside of hazardous (classified) locations whose design and construction may influence the intrinsic safety of an electrical circuit within the hazardous (classified) locations. Apparatus and parts of apparatus, installation locations and type of protection in UL 913 are contained in IEC 60079 series.

The ambient conditions defined in UL 913 and IEC 60079-0 are similar. The ambient temperature range in IEC is given as –20 °C to +60 °C, while the ambient temperature range for UL 913 may be considered as –25 °C to +40 °C per marking requirements. Therefore, normal atmospheric conditions defined in UL 913 can be covered by IEC 60079-0.

UL 913 requires a component to meet standards for that component commonly used in electrical equipment. Both UL 913 and IEC 60079-0 standards require electrical equipment and components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However, IEC standards do not require that the compliance with the industrial standards be verified, whereas UL standards for ordinary location have requirements on components be verified by the testing lab.

General (Construction and Testing)

UL 913 requires intrinsically safe apparatus for Class I, Division 1, Group A, B, C & D shall comply with the applicable requirements in UL 60079-0 and UL 60079-11 for Group IIA, IIB, and IIC, level of protection "ia". UL 60079-0 and UL 60079-11 contain identical requirements, and identical publication dates as ANSI/ISA 60079-0 and ANSI/ISA 60079-11, respectively. Comparisons of ANSI/ISA 60079 Series with IEC 60079 Series are covered in Task 4 and the results of the comparative assessment of ISA 60079-0 to IEC-60079-0 and ISA 60079-11 to IEC 60079-11 in the Task 4 Report can be considered equivalent to the results of UL 913 compared with IEC 60079.

Marking

Both UL 913 and IEC 60079 require that terminals, terminal boxes, and plugs and receptacles, etc. for connection to intrinsically safe circuits shall be clearly identified and clearly distinguishable. Both standards also have similar marking requirements including warnings for batteries used to power apparatus.

In general, the marking in both standards provide similar information. Ex Symbols and equipment protection level in IEC are not included in UL 913. UL/ISA 60079 series use AEx. Intrinsically safe apparatus for Class I, Div. 1, Group A, B, C & D covered in UL 913 are required to meet UL/ISA-60079-0/-11. One major difference in marking between ISA 60079 and IEC 60079 is that the ISA standard requires marking to indicate Class and Division/Zone, whereas IEC 60079 does not. Although it may be considered that IEC does not meet UL for marking due to difference between the standards, it should have no negative affect on the safety level of equipment operation.

Reference Standards

The References in Appendix B of UL 913 are all UL Standards for Equipment for Ordinary Locations-and Hazardous Locations. References adopted by IEC are IEC and ISO standards, except ANSI/UL 746B & 746C in IEC 60079-0 and ANSI/UL 248-1 in IEC 60079-1, which are also listed in Appendix B of UL 913.

Conclusion

In addition to the major differences identified above, Section 6 of Task 3 report in Appendix D covers each of the gap assessment conducted between UL 913 and IEC 60079. The comparisons of construction and testing of intrinsically safe apparatus for Class I, Division 1 between UL 913 and IEC are referred to the Task 4 Report in Appendix E for results of the comparative assessment of ISA 60079-0 to IEC-60079-0 and ISA 60079-11 to IEC 60079-11. It is concluded that IEC 60079-0 does not meet the requirements in ANSI/ISA 60079-0 and IEC 60079-11 does not meet the requirements in ISA 60079-11 (Task 4 Report, Appendix E). Consequently IEC 60079 would not be considered to meet UL 913.

3.4.5 UL 1203 vs. IEC 60079 Series

UL 1203 *Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use In Hazardous (Classified) Locations* provides requirements for the construction, performance and marking of explosion-proof or dust-ignition-proof equipment for use in explosive atmospheres. Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-10-1and IEC 60079-14.

UL 1203 covers explosion-proof equipment installed in Class I, Division 1, Group A, B, C & D (equivalent to Class I, Zone 1, Group IIA, IIB & IIC). Equipment and types of protection in UL 1203 are contained in IEC 60079 series. The scope of the comparative assessment between the UL 1203 with the IEC Standard 60079 includes the topics-on general, explosion-proof equipment, manufacturing and production tests, marking, industrial control equipment, etc. The major differences for these aspects in UL 1203 and IEC 60079 are summarized in this section.

General

The Division System for hazardous area classification employed in UL 1203 is not used in IEC 60079 series. The detailed equivalency analysis between Division System and Zone System can be found in Task 1 Report (Appendix B).

The ambient conditions defined in UL 1203 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50°C is specified in UL, which is lower than -20°C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60°C, but no maximum temperature is specified in UL 1203.

Both UL and IEC standards indicate that electrical equipment and components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However, IEC 60079-0 does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary locations have requirements on equipment be verified by the testing lab.

Both IEC and UL standards have requirements on protecting equipment from ingress of liquid/solid foreign objects. IP rating in IEC is not employed by UL, but most of the IP code is comparable to the type rating of the enclosures in UL. Type 4X enclosure in UL 1203 is watertight corrosion-resistant enclosure. There are no equivalent enclosures identified by IP rating in IEC.

Explosion-proof Equipment

Construction

The luminaire enclosure housing can be made of metal materials or nonmetallic materials. UL 1203 may be considered more stringent than IEC from material aspect due to no allowance on zinc alloys and magnesium and its alloys as well as low copper content of alloy permitted in UL 1203. Also UL 1203 has detailed requirements for surface porosity in castings materials of enclosure without limitation on a specific material, whereas only cast iron quality is required in IEC 60079-1. Both UL 1203 and IEC require nonmetallic enclosure to satisfy the non-metallic materials tests. The chemical compatibility test in UL cannot be satisfied by IEC (refer to Performance Tests).

For non-threaded joints, including cylindrical joints in enclosures of luminaires used in Class I locations, minimum width and maximum clearance permitted in UL 1203 is more stringent than IEC 60079-1. Also UL 1203 has detailed requirements for surface porosity in castings materials of enclosure without limitation on a specific material, whereas IEC 60079-1 covers cast iron quality only. Bolts in joint width are accepted with conditions in UL 1203, which is not required by IEC. Where the bolt in joint width is provided, the required minimum width of joint and/or minimum flame path length (distance from inside of enclosure to nearest edge of bolt hole) in IEC 60079-1 is less than UL 1203.

A shaft opening in an enclosure shall be of the metal-to-metal, metal-to-polymeric, or polymeric-to-ceramic type per UL 1203, whereas no specific opening type is required in IEC 60079-1. Minimum length of joint and maximum allowable clearance (gap) for shaft opening in UL 1203 is more stringent than IEC 60079-1. Group A & B enclosure with shaft opening in UL is limited to a small volume, much less than enclosure volume specified for Group IIC in IEC. In addition, the joint path length and clearance (gap) of shaft openings in UL 1203 also depends on shaft speed (less or more than 100 rpm). Rotating speed (rpm) is not a parameter for consideration of opening requirements in IEC 60079-1.

For the supply connections requirements, NPT threaded connections per ANSI/ASME B1.20.1 are accepted by both IEC 60079-1 and UL 1203; however, for certain aspects such as conduit seals , bonding and grounding, the requirements in the IEC standard exceeds that of UL 1203 standard.

Performance Tests

With regard to the performance test, it is noted that IEC 60079 exceeds the requirements for temperature test used to determine the maximum surface temperature, tests for glass parts - Impact test and electrical resistance test. Explosion tests, hydrostatic pressure test, thermal-shock test, accelerated-aging test on bushing and drop test in IEC meet the requirements in UL. For other performance tests, including secureness of conduit hub test, non-metallic enclosure material tests, and chemical resistance tests on sealing and cementing compounds, etc., the requirements in UL 844 are more stringent than IEC 60079 requirements. Manufacturing and production tests including bonding test and hydrostatic pressure test can be covered by the related tests aforementioned.

Marking

In general, the marking in both standards are providing similar information as listed here. IEC 60079-0 marking doesn't indicate Class, Division or Zone, which are required by UL 1203. Ex Symbols and equipment protection level in IEC are not employed by UL. Although it may be considered that IEC does not meet UL for marking due to difference between the standards, it should have no negative affect on the safety level of equipment operation.

Other Requirements

UL 1203 includes more requirements for industrial control equipment, switches, circuit breakers, outlet boxes and fittings, receptacle-plug combinations and electrical operated valves, in addition to the applicable requirements for construction, testing and marking for explosion-proof equipment installed in Class I, Division 1 per this standard and the applicable requirements for similar components for use in unclassified locations. Most of these additional requirements cannot be met by IEC, except for the outlet boxes and fitting provisions.

Per UL 1203, tests on polymeric valve enclosure shall comply with the applicable requirements for explosion-proof equipment and additional requirements in this standard. A valve whose electrical enclosure has no internal volume is required to be hydrostatically tested at the pressure specified (from 600 psi to 6000 psi) depending on Groups and conduit size of fittings to the enclosures. The IEC 60079 series of standards do not have equivalent requirements.

Conclusion

In addition to the major differences identified above, Section 7 of Task 3 report in Appendix D covers each of the gap assessment conducted between UL 1203 and IEC 60079. Based on the comparative assessments, various sections of the IEC 60079 series meet, exceed, or do not meet the requirements of UL 1203 as listed in Section 7.13 of Appendix D.

3.4.6 UL 2225 vs. IEC 60079 Series

UL 2225 *Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations* contains requirements for the construction, performance and marking of cables and cable fittings intended for use in explosive atmospheres. Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-7. The scope of the comparative assessment between the UL 2225 with the IEC Standard 60079 includes the topics on general, cables, cable sealing fittings, AEx cable fittings and extra-hard usage cord connectors, marking. The major differences for these aspects in UL 2225 and IEC 60079 are summarized in this section.

General

UL 2225 covers MC-HL metal-clad cable, ITC-HL instrumentation tray cable and TC-ER-HL tray cable as well as explosion proof cable sealing fittings, increased safety "e" cable fittings and flameproof "d" cable sealing fittings for use in hazardous locations, including use on mobile offshore oil rig and drilling platforms, and other marine vessels.

For the cable fittings for use on mobile offshore oil rig and drilling platforms, and other marine vessels, evaluation for conformity to 46 CFR 111.105 “Hazardous Locations” & 111.60 “Wiring Materials and Methods” and other requirements in 46 CFR 110 to 113 (Subchapter J—Electrical Engineering)”, are also in the scope of UL 2225. IEC 60079 series contain requirements on all types of protection and hazardous locations included in UL 2225, except evaluation for conformity to 46 CFR.

The normal ambient conditions defined in UL 2225 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50°C is specified in UL, which is lower than -20°C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60°C, but no maximum temperature is specified in UL 2225.

Cables

UL 2225 focuses on the construction, test and marking requirements for the specific types of cables - *MC-HL metal-clad cable, ITC-HL instrumentation tray cable and TC-ER-HL tray cable* for use in Class I, Zone 1 hazardous locations. All cables shall comply with UL 1569 *Standard for Metal-Clad Cables*, UL 2250 *Standard for Instrumentation Tray Cable*, and UL 1277 *Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members*, as applicable, except where modified by this standard. The same specific types of cables are not covered by IEC 60079 series. In these subject areas, it is considered that the IEC does not meet the requirements of UL 2225.

Explosionproof Cable Sealing Fittings

Construction

UL 514B *Standard for Conduit, Tubing, and Cable Fittings* and UL 1203 *Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use In Hazardous (Classified) Locations* are required to be met per UL 2225. These two UL standards are not referenced in IEC 60079 series. In addition, cable sealing fittings to seal cables with optical fiber members shall be subjected to special investigation in accordance with UL 2225, and the same is not addressed by IEC.

Reference with UL 2225, the cable sealing fittings can be made of metal materials or nonmetallic materials with the same requirements as explosionproof equipment enclosure in UL 1203. IEC 60079 does not have the detailed material requirements on the cable fittings. Where a cable sealing fitting could be considered as a part of enclosure and constructed with the same material as flameproof enclosure in IEC 60079, it can be concluded that IEC 60079 does not meet the requirements of UL 2225 for materials based on the comparative assessment of UL 1203 with IEC.

UL 2225 applies UL 514B for bonding continuity requirements which is not referenced in IEC 60079-0. Comparisons show that UL 2225 requirements on non-threaded joints are more stringent than IEC 60079-1, similar as non-threaded joints in enclosure in UL 1203.

Performance

Cable sealing fittings for use in hazardous locations shall comply with all the performance requirements in UL 514B in addition to the requirements of UL 2225. UL 514B is not referenced in IEC. It is noted that explosion test, hydrostatic pressure test, resistance to impact test in IEC meet the requirements in UL. For other performance tests, including non-metallic enclosure material tests and tests on epoxy sealing compounds, etc., the requirements in UL 2225 are more stringent than IEC 60079 requirements. Tightening torque for conduit hubs specified in UL 2225 is more than torque on the conduit required for the test per IEC 60079-1.

Both enclosure types and Degree of Protection (IP) ratings are covered in UL 2225. The IP rating requirements in IEC is same as UL and also most of the IP code is comparable to the type rating of the enclosure in UL. However UL 2225 requires Type 7 enclosures to meet the applicable requirements for indoor Class I locations. Such enclosure type is not found in IEC 60079.

AEx Cable Fittings and Extra Hard Usage Cord Connectors

Construction

Flameproof "d" construction for AEx fittings and connectors are to follow the same requirements for explosionproof cable sealing fittings in UL 2225. Metal Increased Safety "e" fittings and connectors shall be NPT or metric threads compliant with threaded connection for explosionproof fittings in UL 2225; or in accordance with UL 514B.

Performance Test

Flameproof fitting or connector performance test for AEx fittings are referred to tests for explosionproof cable sealing fittings of UL 2225. Increased safety fitting or connector performance test includes aging test for elastomeric materials, resistance to impact test and test for degree of protection (IP). It may be considered that IEC 60079-1 meets UL 2225 requirements for this aspect based on the comparison results.

Marking

Marking in both standards are providing similar information. IEC 60079-0 marking doesn't indicate Class & Division and Zone which are required in UL 2225. Also Ex Symbols are used in IEC 60079-0, whereas AEx Symbols are used in UL 2225. Although it may be considered that IEC does not meet UL for marking due to difference between the standards, it should have no negative affect on the safety level of equipment operation.

Conclusion

In addition to the major differences identified above, Section 8 of Task 3 report in Appendix D covers each of the gap assessment conducted between UL 2225 and IEC 60079. Based on the comparative assessments, various sections of the IEC 60079 series meet, exceed, or do not meet the requirements of UL 2225 as listed in Section 8.6 of Appendix D.

3.5 IEC 60079-0 vs. ANSI/ISA 60079 series (Task 4)

This section contains a summary of findings and conclusions from the Task 4 comparative assessment of ANSI/ISA 60079 series of standards and the IEC 60079 series of standards. Detailed findings are contained in the Task 4 report in Appendix E. Task 4 Report: Other Gap Analysis.

The ANSI/ISA 60079 series are identical to the IEC 60079 series except for the U.S. National Differences. The nationalized versions of the standards have been previously co-published by ISA and UL. The ISA is no longer publishing nationalized versions of new revisions of the IEC 60079 series. Once a new IEC 60079 edition is published, UL will be publishing the standard as a UL only standard with U.S. National Differences. The most recent versions of the standards available at the time of the assessment were used for the comparison. Table 4 contains a list of the ISA/UL 60079 standards compared to IEC 60079 standards that were analyzed.

The ANSI/ISA and ANSI/UL 60079 series of standards adopt the IEC text with differences known as National Differences that may add, delete, or modify the IEC text. There are five categories of National differences that modify the text in the parent IEC standard based on:

- Basic safety principles and requirements
- Safety practices
- Component standards

- Editorial comments or corrections
- National regulatory requirements

The following general modifications are noted in the ANSI/ISA standards when compared with the IEC standards:

- When reference is made to any other IEC 60079 standards, it is required that the requirements in ISA 60079 standard be applied.
- Where references are made to hazardous areas, this is changed to the U.S. terms unclassified locations or hazardous (classified) locations.
- Where requirements call for the application of an “X” appended to the certificate number, this is replaced with a requirement to document this in the manufacturer’s instructions.

Each subsection below provides a summary of the analysis and comparative results for each of the standards in the series.

3.5.1 ANSI/ISA 60079-0 vs IEC 60079-0

ANSI/ISA (ISA) 60079-0 is the U.S. Nationalized version of IEC 60079-0 that provides the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres. Comparative assessment of IEC 60079-0 (Ed. 6) and ISA 60079-0 (Ed. 6) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. Following major differences are noted between the ISA and IEC 60079-0 standard.

- **A**dditional U.S. national standards for testing and acceptance of electrical equipment are included in the ISA standard. These additional standards are not included in the IEC.
- U.S. standards do not consider special protection type “s” as an option. Hence equipment with special protection "s" rating is not allowed per ISA 60079-0. However, the IEC standards allows manufacturer’s to designate equipment with Ex “s” to indicate special protection.
- IEC 60079-0 allows EPL to be used as part of risk assessment of an installation and reference is made to IEC 60079-14. In ISA standard, the reference to IEC 60079-14 is removed and it is indicated that the *NEC* does not recognize the concept of employing the concept of equipment protection level in risk assessment during classification of an installation.
- ISA 60079-0 requires testing for determining the surface temperature for smaller components, such as those commonly used in gas detection instruments where the temperature could rise due to internal catalytic or chemical reaction, which requires testing of the components for acceptability. The IEC does not contain the testing requirements for such small components.
- ISA standard requires that equipment listed by a Nationally Recognized Testing laboratory is considered to meet the applicable requirement of the safety standard for the equipment found in other U.S. standards. In IEC 60079-0 standard, there is not a requirement that compliance with industrial standards be verified by an independent testing laboratory. IEC 60079-0 only

requires that the equipment be constructed in accordance with applicable safety requirements of the relevant industry standard.
- ISA 60079-0 provides clarification that the certificate is to be issued by a NRTL. However, the IEC standard does not require the certificate to be issued by an independent laboratory. Rather, it provides the option that the certificate can be prepared by the manufacturer.
- The non-metallic walled enclosure construction is not permitted by U.S. standard; however, it is allowed by IEC standard.
- An additional clarifying requirement is included in the ISA 60079-0 for Plugs and Socket installation. This clarification aligns the requirements with *NEC* wiring methods
- ISA 60079-0 includes a specific note that the use of spiral-wound Lithium-cobalt-oxide cells and is not recommended in electrical equipment. This is due to potential thermal runaway hazards resulting from internal short circuits.

Based on the national differences identified, it is concluded that the requirements in IEC 60079-0 do not meet the requirements in ANSI/ISA 60079-0.

3.5.2 ANSI/UL 60079-1 vs IEC 60079-1

ANSI/UL 60079-1 is the U.S. Nationalized version of IEC 60079-1 standard contains specific requirements for the construction and testing of electrical equipment with the type of protection flameproof enclosure “d”, intended for use in explosive gas atmospheres. Comparative assessment of IEC 60079-1 (Ed. 7) and UL 60079-1 (Ed. 7) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. Following major differences are noted between the UL and IEC 60079-1 standard.

- Additional U.S. national standards for electrical equipment are included in the UL standard. These additional standards are not included in the IEC.
- Taper-threaded joint requirements in UL 60079-1 standard is modified to account for the changes required on the equipment to conform to the *NEC* thread engagement requirements.
- UL standard is modified and requires that the copper content of the alloy shall be limited to 30% whereas for IEC the cooper content acceptable is 60%. UL has more stringent material requirement than IEC standard.
- UL 60079-1 provides additional guidance and requirements regarding National Pipe Thread (NPT) and National Standard Pipe Straight (NPS) threaded entries. Requirements added in UL is to include the *NEC* requirements. Equipment certified to IEC Standard is not required to follow these *NEC* requirements, and these additional texts are not applicable for such equipment.
- UL standard requires that all cable glands, whether integral or separate must meet the requirement in UL 60079-1 Annex C. The UL 60079-1 Annex C requires that cable glands is to conform to the requirements in UL 2225 *Standard for Safety Cables and Cable Fittings for Use in Hazardous Locations*.

- The UL 60079-1 standard has included the exception that the test of ability of the enclosure to withstand pressure is required only for equipment marked with a name plate circuit breaker interruption rating greater than 10,000 rms symmetrical amperes. However, the IEC 60079-1 standard requires this test be conducted regardless of the circuit breaker rating.

Based on the national differences, it is concluded that the requirements in IEC 60079-1 does not meet the requirements in UL 60079-1.

3.5.3 ANSI/UL 60079-2 vs IEC 60079-2

ANSI/UL 60079-2 is the U.S. Nationalized version of IEC 60079-2 standard contains specific requirements for the construction and testing of electrical equipment with the type of protection Pressurized Enclosures "p", intended for use in explosive gas atmospheres. Comparative assessment of IEC 60079-2 (Ed. 6) and UL 60079-2 (Ed. 6) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL standard. Following major difference is noted between the UL and IEC 60079-2 standard.

- Additional reference to the *NEC* is included in UL Standard.
- For type of protection “pzc”, UL 60079-2 standard requirement for automatic safety device for non-metallic enclosures is less stringent than IEC 60079-2. Based on UL standard, non-metallic enclosures that have not undergone thermal endurance test is allowed to have indicator instead of automatic safety devices and the same is not allowed as per IEC standard.

Based on the national differences identified, it is concluded that the requirements in IEC 60079-2 does not meet the requirements in UL 60079-2.

3.5.4 ANSI/UL 60079-5 vs IEC 60079-5

ANSI/UL 60079-5 is the U.S. Nationalized version of IEC 60079-5 standard contains specific requirements for the construction and testing of electrical equipment with the type of protection Powder Filling "q", intended for use in explosive gas atmospheres. Comparative assessment of IEC 60079-5 (Ed. 4) and UL 60079-5 (Ed. 4) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. Following major difference are noted between the UL and IEC 60079-5 standard.

- UL 60079-5 requires that a flameproof "d" cable gland that complies with UL 2225 be provided for the powder filled electrical equipment. The UL standard also states that an increased safety "e" cable gland may not provide adequate pressure sealing of the powder filled "q" enclosure. Similar requirements are not included in IEC standard.
- Both IEC and UL 60079-5 require that the powder filled containers shall not be damaged and that the temperature class shall not be exceeded in the case of malfunctions such as caused by overvoltage or overcurrent. It is required by UL standard that overloads be tested to applicable

U.S. standards. The IEC standard indicates that if there are no product standards, the overloads to be considered are those specified by the manufacturer.

Based on the national differences identified, it is concluded that the requirements in IEC 60079-5 does not meet the requirements in UL 60079-5.

3.5.5 ANSI/UL 60079-6 vs IEC 60079-6

ANSI/UL 60079-6 is the U.S. Nationalized version of IEC 60079-6 standard contains specific requirements for the construction and testing of electrical equipment with the type of protection Oil Immersion "o", intended for use in explosive gas atmospheres. Comparative assessment of IEC 60079-6 (Ed. 4) and UL 60079-6 (Ed. 4) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. Following major difference are noted between the UL and IEC 60079-6 standard.

- In IEC 60079-6, it is required that switching devices protected by liquid immersion Level of Protection “ob” be suitable for a prospective short circuit current of 32 kA, unless marked with a lower value. UL 60079-6 has included a national difference to this requirement by adding a note stating that NEC limits the use of the increased safety termination to 10 kA available short circuit current.
- With regard to the requirement for selection and erection of equipment with protection type ‘o”, UL 60079-6 refers to the NEC for selection and installation of equipment, whereas IEC 60079-6 refers to IEC 60079-14. It is also to be noted that ISA 60079-10-1 states that IEC 60079-14 has not been adopted in the U.S.

Based on the national differences identified, it is concluded that the requirements in IEC 60079-6 does not meet the requirements in UL 60079-6.

3.5.6 ANSI/UL 60079-7 vs IEC 60079-7

ANSI/UL 60079-7 is the U.S. Nationalized version of IEC 60079-7 standard contains specific requirements for the construction and testing of electrical equipment with the type of protection Increased Safety "e", intended for use in explosive gas atmospheres. Comparative assessment of IEC 60079-7 (Ed. 5) and UL 60079-7 (Ed. 5) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL standard. Following major difference are noted between the UL and IEC 60079-7 standard.

- Additional U.S. national standards for the equipment are included in the UL standard. Additional U.S. standards referenced in the UL standard implies that there are additional requirements that need to be followed for equipment testing and acceptance.
- UL 60079-7 includes a national difference that the electrical connection should be able to provide contact pressure that is not applied through the insulating material. However, IEC 60079-7 allows the contact pressure to be applied through the insulating material if the earth

continuity test of IEC 60079-0 is accomplished. UL standards for ordinary locations do not permit the transfer of contact pressure through insulating material.

- UL 60079-7 has additional requirements added to address terminals rated greater than 1500 V. It is required by the UL standard that a terminal greater than 1500 V be subjected to the tests in UL 1059 and UL 486E.
- UL 60079-7 modified the IEC text by adding requirements that threaded connections can only be released or removed by use of a tool. It also added requirements that plugs and sockets shall be capable of being connected by wiring methods permitted in the *NEC*. Cable assemblies and associated plugs and sockets shall meet the requirements of UL 2238 and UL 2237, or other relevant standards that include requirements that address voltage and current ratings, and for suitability for field wiring applications.
- UL 600079-7 adds requirements for arcing and sparking contacts. It is required by the UL standard that for level of protection “eb” arcing or sparking contacts are not permitted. And for level of protection “ec”, manually operated arcing or sparking components located within an enclosure that are not accessible in normal operation without the use of a tool need only comply with the separation distances on the external connection points.

Based on the national differences identified, it is concluded that the requirements in IEC 60079-7 does not meet the requirements in UL 60079-7.

3.5.7 ANSI/ISA 60079-10-1 vs IEC 60079-10-1

ISA 60079-10-1 standard is a modification of IEC 60079-10-1 ed1.0 (2008-12), *Explosive Atmospheres - Part 10-1: Classification of Areas - Explosive Gas Atmospheres*, normalized as an U.S. National Standard, with additional material added as appendices specifically for the classification of locations for electrical installations classified as Class I, Zone 0, Zone 1, or Zone 2 classification of hazardous areas. Comparative assessment of IEC 60079-10-1 (Ed. 2) and ANSI/ISA-60079-10-1 (Ed. 1) was conducted to determine if the IEC standard meets, exceeds or does not meet the ANSI/ISA-standard. The following major differences are noted between the ISA and IEC 60079-10-1 standard:

- Additional U.S. national standards for the equipment are included in the ISA standard. Additional U.S. standards referenced in the ISA standard implies that there are additional requirements that need to be followed for equipment testing and acceptance.
- Definitions of Class 1, Zone 0, 1 and 2 from the *NEC* are used instead of IEC definitions as part of national differences.
- In the latest edition of the IEC standard several new terms and conditions has been introduced such as ventilation and dilution, routine maintenance, rare malfunction.
- ISA 60079-10-1 standard requires that for any change in the equipment or procedure in an area classification location, a change management procedure is to be used in accordance with 29 CFR 1910.119.

- ISA and IEC standard differs in the application of risk assessment to assess whether the consequences of ignition of an explosive atmosphere requires the use of equipment with higher Equipment Protection Level (EPL) or may justify the use of equipment with lower EPL than required. The *NEC* does not recognize the concept of employing equipment protection level in risk assessments during classification of an installation.
- IEC provides additional detailed requirements to consider for competence of personnel involved in hazardous area classification.
- The IEC Standard provides additional guidance on classification by sources of release method, use of industry codes, national standards, simplified methods and combination of methods.
- The latest edition of IEC 60079-10-1 requires that extent of the zone should consider the level of uncertainty in the assessment by the application of a safety factor.
- IEC 60079-10-1 provides additional clarification regarding the determination of the characteristic of the release based on the physical state of the release such as gas at elevated temperature or pressure, gas liquefied by application of pressure/refrigeration, liquid with release of vapor, aerosols. The additional clarification is not included in ISA standard.
- ISA 60079-10-1 requires that other parameters such as climatic conditions and rate of gas or vapor dispersion is to be considered for area classification.
- IEC Standard provides additional guidance regarding ventilation and degree of ventilation in classification of area.
- IEC 60079-10-1 provides some informative guidance regarding hybrid mixtures which is a combined mixture of a flammable gas or vapor with a combustible dust or combustible flyings.

The nationalized version of the IEC 60079-10-1 is published by ISA with National Differences and the IEC standard does not meet the ISA standard in the several sections. ISA 60079-10-1 is harmonized with IEC 60079-10-1, Edition 1; however, the latest edition of the IEC standard is IEC 60079-10-1, Edition 2.0 (2015-09) published with additional requirements. There are significant revisions in the latest edition of the IEC standard from previous editions in both technical content and design approach to classifying hazardous locations. These major changes in the latest edition of IEC 60079-10-1 have not yet been incorporated into the ISA standard.

3.5.8 ANSI/ISA 60079-11 vs IEC 60079-11

This is the common ANSI/ISA and ANSI/UL 60079-11 standard for *Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"*. ANSI/ISA 60079-11 is based on the sixth edition of IEC 60079-11 including Corrigendum 1. This standard adopts the IEC text with U.S. National Differences. Comparative assessment of IEC 60079-11 (Ed. 6) and ISA 60079-11 (Ed. 6.2) was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. The following major differences noted between the ISA and IEC 60079-11 standard are:

- Additional U.S. national standards for the equipment are included in the ISA standard. Additional references in UL 60079-11 are to align with U.S. practice and the *NEC*, and implies that there are additional requirements that need to be followed for equipment testing and acceptance.

- Clearances, creepage distances and separations between conductive parts requirements in the ISA standard is more stringent than the IEC standard.
- ISA 60079-11 requires additional condition to be met if "ia" apparatus uses series current limiters consisting of controllable and non-controllable semiconductor devices in Division 1. The conditions in the ISA standard are that both the input and output circuits are to be intrinsically safe or it is to be demonstrated that the semiconductors or controllable semiconductor devices cannot be subjected to transients from the power supply network.

The requirements in the ISA 60079-11 and IEC 60079-11 are the same except for the U.S. National Differences in the ISA standard. It is concluded that due to these national differences the requirements in IEC 60079-11 do not meet the requirements in ISA 60079-11.

3.5.9 ANSI/ISA 60079-15 vs IEC 60079-15

This is the common ISA and UL standard 60079-15 *Explosive atmospheres – Part 15: Equipment protection by type of protection "n" (nC, nA and nR)*. This ISA standard is based on the fourth edition of IEC 60079-15. This standard adopts the IEC text with U.S. National Differences. Comparative assessment of IEC 60079-15 (Ed. 4) and ISA 60079-15 (Ed. 4) was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. The following major differences are noted between the ISA 60079-15 and IEC 60079-15 standard:

- Additional U.S. national standards for the equipment are included in the ISA standard. Additional references in UL 60079-11 are to align with U.S. practice and the *NEC* and implies that there are additional requirements that need to be followed for equipment testing and acceptance.
- ISA 60079-15 has included a difference that the normal Dielectric Strength Test voltage is to be based upon the applicable industrial standard for the individual items of electrical equipment where such requirements exists. IEC 60079-15 does not have a similar requirement.
- ISA 60079-15 requires that the electrical connection should be able to provide contact pressure that is not applied through the insulating material. However, the IEC standard allows the contact pressure to be applied through the insulating material if earth continuity test of IEC 60079-0 is accomplished. The UL standards for ordinary locations do not permit the transfer of contact pressure through insulating material.
- General purpose induction motors are permitted by *NEC* Article 505. It is noted that similar statement is not included in the IEC standard.
- Per ISA 60079-15 plugs and sockets must be capable of being connected to wiring methods such as extra-hard usage cord (*NEC* Articles 400, 501), instrumentation tray cable (Type ITC) (*NEC* Article 727), power-limited tray cable (Type PLTC) (*NEC* Article 725). ISA 60079-15 also requires cable assemblies and the associated separate plugs and sockets shall be in accordance with UL

2238 *Standard for Cable Assemblies and Fittings for Industrial Control and Signal Distribution or* UL 2237*, "Multi-Point Interconnection Power Cable Assemblies for Industrial Machinery"*.
- Additional requirements included in ISA standard with regard to conduit entries, gasket seal, cable glands for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces.

The requirements in the ISA 60079-15 and IEC 60079-15 are the same except for the U.S. National Differences in the ISA standard. It is concluded that due to these national differences the requirements in IEC 60079-15 (Ed.4) do not meet the requirements in ISA 60079-15 (Ed.4).

The latest version of the IEC standard 60079-15 (Ed. 5) was published on 8 Dec 2017. IEC 60079-15:2017 (Ed. 5) specifies requirements for the construction, testing and marking for Group II electrical equipment with type of protection "n" which includes; sealed devices "nC", hermetically sealed devices "nC", non-incendive components "nC" and restricted breathing enclosures "nR" intended for use in explosive gas atmospheres. The requirement for "nA" protection have been relocated from IEC 60079-15 to IEC 60079-7 (edition 5.0). Former marking of "nA" has been replaced by marking "ec".

3.5.10 ANSI/UL 60079-18 vs IEC 60079-18

ANSI/UL 60079-18, the U.S. Nationalized version of IEC 60079-18 standard contains specific requirements for the construction and testing of electrical equipment with the type of protection Encapsulation "m", intended for use in explosive gas atmospheres. Comparative assessment of IEC 60079-18 (Ed. 4) and UL 60079-18 (Ed. 4) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. It was noted that additional U.S. national standards for the equipment are included in the UL standard. Even though these additional references are included in the UL 60079-18 Standard, there is no impact on the safety of the equipment. As such the requirement in IEC 60079-18 is considered to meet UL 60079-18 for equipment in explosive gas atmosphere.

3.5.11 ANSI/ISA 60079-25 vs IEC 60079-25

ANSI/ISA 60079-25 is the U.S. Nationalized version of IEC 60079-25 standard contains specific requirements for construction and assessment of intrinsically safe electrical systems, type of protection "i". Comparative assessment of IEC 60079-25 (Ed. 2) and ISA 60079-25 was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. The following major differences are noted between the ISA and IEC 60079-25 standard:

- Additional reference to the *NEC* is included in UL Standard.
- ISA-60079-25 references *NEC* Article 504.10 requirements regarding installation of intrinsically safe wiring. This is a U.S. national difference from the IEC standard which requires following the *NEC* requirements for intrinsically safe wiring.

- Surge protective devices for protection against lightning and other electrical surges are required to be tested to applicable industry standards as per ISA standard. It is not a requirement in IEC standard that the device be verified for requirements in ordinary location standards.

The requirements in the ISA 60079-25 and IEC 60079-25 are the same except for the U.S. National Differences in the ISA standard. It is concluded that due to these national differences the requirements in IEC 60079-25 do not meet the requirements in ISA 60079-25.

3.5.12 ANSI/UL 60079-26 vs IEC 60079-26

ANSI/UL 60079-26 is the U.S. Nationalized version of IEC 60079-26 standard contains specific requirements for Equipment with protection level EPL Ga. Comparative assessment of IEC 60079-26 (Ed. 3) and UL 60079-26 (Ed. 3) was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. The following major difference are noted between the UL and IEC 60079-26 standard:

- Additional U.S. national standards for the equipment are included in the ISA standard. Additional references in UL 60079-11 are to align with U.S. practice and the *NEC* and implies that there are additional requirements that need to be followed for equipment testing and acceptance.
- The scope of the IEC standard includes alternative requirements for construction, test and marking for electrical equipment that provide EPL Ga when single standardized type of protection (e.g. “ia”) cannot be applied. This scope is not included for the UL standard as it is not allowed in U.S.
- It is noted that IEC 60079-26 provides more detailed requirements regarding the materials of partition walls which is a mechanical element that separates the different parts of equipment with different Equipment Protection Levels, however UL 60079-26 does not appear to have any specific requirement.

The requirements in the UL 60079-26 and IEC 60079-26 are the same except for the U.S. National Differences in the ISA standard. It is concluded that due to these national differences the requirements in IEC 60079-26 do not meet the requirements in ISA 60079-26.

3.5.13 ANSI/ISA 60079-27 vs IEC 60079-27

ISA 60079-27 is based on the first edition of IEC 60079-27 and adopts the IEC text with U.S. National Differences. This standard contains the details of apparatus, systems and installation practice for use with the Fieldbus Intrinsically Safe Concept (FISCO) for installation and use in Class I, Zones 0 and 1 and the Fieldbus Non-Incendive Concept (FNICO) for installation and use in Class I, Zone 2. Comparative assessment of the first editions of IEC 60079-27 and ISA 60079-27 was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. Following major differences are noted between the ISA and IEC 60079-27 standard:

- Additional references to U.S. standards are included in ISA standard to align with U.S. practice and the NEC and implies that there are additional requirements that need to be followed for equipment testing and acceptance.
- As per ISA 60079-27, the control drawing, which is used to represent the drawing or document provided by the manufacturer that details the allowed interconnections between the intrinsically safe and associated apparatus or between the non incendive field wiring and associated nonincendive field wiring apparatus, must comply with the applicable requirements of ISA-RP12.02.02. This requirement is not included in IEC 60079-27. Instead of control drawing, IEC 60079-27 refers to apparatus documentation, however, is not required to comply with any national standards.

The requirements in the ISA 60079-27 and IEC 60079-27 are the same except for the U.S. National Differences in the ISA standard. It is concluded that due to these national differences the requirements in IEC 60079-27 do not meet the requirements in ISA 60079-27.

3.5.14 ANSI/ISA 60079-29-1 vs IEC 60079-29-1

ISA 60079-29-1 is based on the first edition of IEC Publication 60079-29-1. The document is a modification of the IEC standard and includes U.S. National Differences encompassing both additions and deletions of information. This standard provides guidance for the selection, installation, use and maintenance of gas detecting apparatus as set out in ANSI/ISA-60079-29-2*: Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen*. Comparative assessment of the first editions of IEC 60079-29-1 and ISA 60079-29-1 (12.13.01) was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. The following major differences are noted between the ISA and IEC 60079-29-1 standard:

- Additional references to U.S. standards are included in ISA standard to align with U.S. practice and the *NEC* and implies that there are additional requirements that need to be followed for equipment testing and acceptance.
- ISA 60079-29-1 has included clarification regarding the indicating devices used to show that gas detection devices are energized. Further, ISA standard has additional requirements with regard fault signals.
- ISA 60079-29-1 requirements for IR sensor test using optical filters for response to different gases has been deleted as part of national differences since special filter production by the manufacturer and filter validation by the test laboratory is impractical.
- Humidity requirements in ISA 60079-29-1 have been modified for administering the test in accordance with past U.S. practice for ease of administering the test to the minimum level requirements of the standard. The humidity test requirement in IEC 60079-29-1 is more stringent.
- With regard to the test procedures for pressure testing, selection of samples for testing, calibration curve/accuracy test, high gas concentration operation above the measuring range,

electromagnetic immunity test methods, ingress protection tests ISA standard has additional requirements.

The requirements in the ISA 60079-29-1 and IEC 60079-29-1 are the same except for the U.S. National Differences in the ISA standard. It is concluded that due to these national differences the requirements in IEC standard 60079-29-1 does not meet ISA standard 60079-29-1.

3.5.15 ANSI/ISA 60079-29-2 vs IEC 60079-29-2

ISA 60079-29-2 gives guidance on, and recommended practice for, the selection, installation, safe use and maintenance of electrically operated group II apparatus intended for use in industrial and commercial safety applications for the detection and measurement of flammable gases complying with the requirements of ISA-60079-29-1 and ANSI/ISA-12.13.04 *Performance Requirements for Open Path Combustible Gas Detectors*. Comparative assessment of IEC 60079-29-2 (Ed. 2) and ISA 60079-29-2 (12.13.02)-2012 was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. The following major differences are noted between the ISA and IEC 60079-29-2 standard:

- Additional U.S. national standards for the equipment are included in the ISA 60079-29-2 with additional references to align with U.S. practice and the *NEC*.
- In the latest edition of IEC 60079-29-2 additional requirements and guidance regarding open path gas detection system is provided. Open path equipment monitors a linear path through the atmosphere.
- ISA 60079-29-2 has included the national difference that the oxygen detector used should conform to requirements in ANSI/ISA 92.04.01*, Performance Requirements for Instruments Used To Detect Oxygen-Deficient/Oxygen-Enriched Atmospheres.*
- The latest edition of IEC 60079-29-2 has Clause 4.5, which provides additional guidance regarding the use of gas detection as means of reducing risk of explosion. ISA 60079-29-2 does not have these additional guidance as the standard is the nationalized version of the previous edition of the IEC standard. It is noted that similar provisions regarding the use of gas detection as in IEC standard is included in API RP 505 Section 6.8 and *NEC* Article 505.8 (I).
- IEC 60079-29-2 allows the use of alternative detection technologies such as ultrasonic detectors, infrared cameras for detecting presence of gas. However, the requirement that allows the use of alternative gas detection technologies is not included in the ISA 60079-29-2.
- IEC 60079-29-2 provides additional details with regard to the fixed gas detection equipment such as point detection equipment, remote sensors with centralized control equipment, sample systems with centralized sensor package, and open path equipment.
- IEC 60079-29-2 provides additional clarification regarding the effect of sudden change in temperature and pressure on the equipment when moved from area to area. These additional requirements are not included in ISA 60079-29-2.
- In IEC 60079-29-2, guidance regarding remote sensors and point sensors are provided. ISA 60079-29-2 includes a national difference in the Clause 8.1 that “Open Path or LOS gas detection

systems are not recommended for applications where gas detection is used as a protection technique, as permitted in *NEC* Articles 500.7(K) and 505.8(I)".

- IEC 60079-29-2 provides guidance that suitable precautions are to be taken to protect sensors from galvanic corrosion when in contact with other materials. This requirement regarding galvanic corrosion protection not included in ISA 60079-29-2.

The nationalized version of the IEC 60079-29-2 is published by ISA with National Differences. The IEC standard does not meet the ISA standard in some of the clauses. However, the latest edition of IEC 60079-29-2 is the second edition. The comparative assessment was performed between ISA 60079-29-2 (first edition) and IEC 60079-29-2 (Edition 2.0). There are several changes in the latest edition of the IEC standard which exceed the requirements in the ISA standard and have not yet been incorporated into ISA 60079-29-2.

3.6 IEC 60079 vs. FM Series (Task 4)

FM Approvals LLC (FM) is a developer of approval standards for testing and certifying products including electrical equipment for use in explosive atmospheres using the FM 3600 series of standards. This section provides the summary of the finding and conclusions from the Task 4 comparative assessment of the following FM standards with IEC 60079 series of standards. Detailed findings are contained in the Task 4 report in Appendix E.

- FM 3600 vs IEC 60079-0
- FM 3610 vs IEC 60079-11
- FM 3611 vs IEC 60079-15
- FM 3615 vs IEC 60079-1
- FM 3620 vs IEC 60079-2

The FM and the IEC differ on their approach to approval and certification, the FM's Basis for Approval includes two aspects; (1) verifying products meeting the performance requirements as specified in the standard(s) and (2) evaluating product manufacturers through surveillance audit programs. Although the IEC does establish standards for quality systems, testing laboratories, certifying body qualification, it does not provide any attestation of conformity. This standard series defines manufacturers' responsibilities for the products, such as type tests, routine tests, marking and instructions, etc. Manufacturer evaluation is not included in the scope.

3.6.1 FM 3600 vs IEC 60079-0

FM 3600 identifies the basis for approval of electrical equipment installed in hazardous (classified) locations. This standard was compared to IEC 60079-0, which provides general requirements for construction, testing and marking of electrical equipment for use in explosive atmospheres.

The scope of the comparative assessment between the FM3600 with the IEC Standard 60079-0 includes the topics such as Scope and application, General information, Marking requirements, Performance requirements, and Operations requirements.

Scope and Application

The scope of FM 3600 indicates that for electrical equipment for Class I, II or III, Division 1 or 2 hazardous locations, FM 3610, FM 3611, FM 3613, FM 3615, FM 3616, FM 3620 and FM 6310/6320 are applicable; and for electrical equipment for Class I, Zones 0, 1 or 2, the requirement in ANS/ISA 60079 series of standards are referenced. The scope of IEC 60079-0 standard is defined in Clause 1, which includes general requirements for construction, testing and marking of electrical equipment and Ex components for use in explosive atmosphere. The general requirements are to be supplemented or modified the listed standards concerning specific types of protection.

General Information

Both FM 3600 and IEC 60079-0 standards require that electrical equipment and components in hazardous (classified) locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However, IEC 60079-0 does not require that the compliance with the industrial standard be verified, whereas FM standards for ordinary locations have requirements that equipment be verified by the testing lab.

Marking Requirements

In general, the marking requirements in both standards provide similar information as listed here. FM 3600 also refers to ISA 60079 series of standards. The marking requirement in ISA 60079 standards are applicable for electrical equipment for Class 1, Zone 0, 1, or 2 hazardous locations. The comparison of marking requirements between IEC and ISA 60079 series of standards are summarized in Section 3.7 of this report. Although it may be considered that IEC 60079-0 does not meet FM 3600 for marking due to the differences between the standards, it should have no material effect on the safety level of equipment operation.

Performance Requirements

The performance requirements considered in FM 3600 include mechanical strength, non-metallic enclosure materials chemical compatibility, non-metallic enclosure materials aging and metallic enclosure reactance. In addition to these items covered by FM 3600, IEC 60079-0 has also specified detailed requirements on opening times, circulating currents in enclosures, gasket retention, electromagnetic & ultrasonic energy radiating equipment.

With regard to the testing for mechanical strength, it is to be noted that the Resistance to Impact test in IEC 60079-0 exceeds the requirements in FM3600. Also, IEC 60079-0 exceeds FM 3600 requirements for non-metallic enclosures testing for aging, earth continuity, surface resistance test and measurement of capacitance. However, these differences have no major impact. For electrical equipment for Class I, Zones 0, 1 or 2, it is required by FM 3600 that the requirement in ANS/ISA 60079 standards referenced in FM 3600 Clause 1.2.2 be complied with.

For metallic enclosures, FM 3600 has a maximum limit of copper content of alloy (30%) less than that is required by IEC (60%) for use in Class I, Group A (equivalent to Group IIC containing acetylene). For the enclosure material requirement for equipment in Group A classified locations, IEC 60079-0 does not meet the requirements in FM 3600.

Operations Requirement

The operations requirements in FM 3600 include manufacturers' quality control program and surveillance audit program. IEC 60079-0 defines manufacturers' responsibilities in Clause 28 and type tests and routine tests requirements in Clauses 26 and 27 respectively. The manufacturer is required to carry out the verification tests specified in the standards, prepare or have prepared certificates and make marking per the requirements as specified in Clause 29. The IEC 60079 series of standards alone do not cover manufacturing quality control, and independent third-party verification.

Based on the differences identified in the comparative assessment, it is concluded that although IEC 60079-0 exceeds some requirements in FM 3600, the IEC standard does not meet the requirements of FM 3600 in some of the sections as identified above.

3.6.2 FM 3610 vs IEC 60079-11

FM 3610 defines the approval criteria for intrinsically safe apparatus intended for use in, and associated apparatus for connection to classified locations. This standard was compared to IEC 60079-11, which includes construction and testing of intrinsically safe apparatus for use in an explosive atmosphere and for associated apparatus, which is intended for connection to intrinsically safe circuits that enter such atmosphere. IEC 60079-11 is also applicable to electrical equipment or parts located outside the explosive atmosphere or protected by another type of protection where the intrinsic safety of the electrical circuits in the explosive atmosphere may depend upon the design and construction of electrical equipment or parts of electrical equipment. The requirements for intrinsically safe systems are provided in IEC 60079-25.

For intrinsically safe equipment and circuits for used in Class I, Division 1, Group A, B, C & D hazardous locations, FM 3610 refers to U.S. nationalized version of IEC 60079-11 (ANSI/ISA 60079-11, 2014) for Category "ia", Group IIC, IIB and/or IIA, except equipment marking requirements are modified in Clause 5 of FM 3610. FM 3610 also defines the specific requirements for intrinsically safe equipment and circuits for use in Class II and III.

In addition to the general marking requirements specified in FM 3600, specific marking for intrinsically safe apparatus are required:

- FM 3610 marking for intrinsically safe apparatus provides limited information, while IEC 60079-11 marking with ia, ib and ic provide protection level and suitability to Zone classification
- Some parameters are not mentioned in FM 3610, which are required by IEC 60079-11, such as Uo, Um, IP, etc.
- FM 3610 requirements for associated apparatus are more detailed than IEC 60079-11
- FM 3610 provides more warnings examples for repair, maintenance and operational concerns

Similar to the requirements in FM 3600, the operations requirements in the FM 3610 include manufacturers' quality assurance program and surveillance audit program. In addition to the manufacturer's responsibilities requirements in IEC 60079-0, documentation for specific information related to intrinsically safe equipment are required in IEC 60079-11, including electrical parameters, special instructions for installation, live maintenance, environmental conditions, etc.

Based on the differences identified, it is concluded that the requirements in IEC 60079-11 do not meet the FM 3610 requirements in the sections identified above.

3.6.3 FM 3611 vs IEC 60079-15

FM 3611 defines approval standards for nonincendive electrical equipment for use in Class I and II, Division 2 and Class III, Divisions 1 and 2 hazardous (classified) locations. Nonincendive equipment includes equipment having electrical / electronic circuitry that is not capable of, under normal operating conditions, causing ignition of a specified gas, vapor mixture due to arcing or thermal means.

IEC 60079-15 is applicable to non-sparking electrical equipment and also to electrical equipment with parts or circuits producing arcs or sparks or having hot surfaces which, if not protected in one of the ways specified in this standard, could be capable of igniting a surrounding explosive gas atmosphere. IEC 60079-15 provides the requirements for the construction, testing and marking for Group II electrical equipment with type of protection "n" for use in explosive atmospheres. Type of "n" include "nA" for non-sparking, "nC" enclosed-break device/hermetically-sealed device/non-incendive component/sealed device and "nR" restricted breathing enclosure.

Verification of the compliance with the requirements for electrical equipment in ordinary locations is not required in IEC 60079 series; however, is required by the FM standard. Therefore the IEC standard does not meet FM 3611 requirements regarding the verification of safety of electrical equipment in ordinary locations.

FM 3611 adopts the requirements of ISA 12.12.01 Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations as the basis and adds additional marking and operational requirements. The most updated version of ISA 12.12.01 was published in 17 November 2015, as ANSI/ISA-12.12.01-2015. Comparison between ISA 12.12.01 and IEC 60079-15 was performed.

Equipment and its usages considered by ISA 12.12.01 and FM 3611 includes normally nonarching components, nonincendive components, sealed devices, enclosed-break device and their usage in a nonincendive circuit. All these components and applications are also addressed in IEC 60079-15. The following major differences are identified based on the comparative assessment:

- ISA 12.12.01 requires that fuses used in circuits that are subject to overloading in normal use are to be housed in an enclosure suitable for Division 1 location. ISA requirements are more stringent than IEC 60079-15.
- IEC 60079-15 has requirements regarding maximum capacity, connections, charging and discharging modes, creepage and clearance, containers, ventilation and seals. ISA 12.12.01 does not have similar requirements.
- ISA 12.12.01 has included requirements for components that are considered as nonarching in normal operation; such as connectors, plug-in components, plug-in fuses, circuit breakers, lamps and cables assemblies to equipment. IEC 60079-15 has equivalent requirements for most components, but specifies more details for pluggable connection, lamps, etc.
- ISA 12.12.01 requires that testing be conducted with spark test apparatus complying with ISA 60079-11, which is the same as required by IEC 60079-11, and based on a 1.0 safety factor. IEC60079-11 defines the safety factors for various applications and conditions, with a safety factor of 1.5 is used for several cases, exceeding that of the ISA standard.
- Test methods for enclosed break devices defined in ISA 12.12.01 and IEC 60079-11 are the same except for test gas mixture and their concentrations defined in ISA and IEC are different. Therefore, the test conditions defined in ISA 12.12.01 are more stringent than in the IEC standard.
- The test procedure for Air Leakage Tests is the same in ISA 12.12.01 and IEC 60079-11. IEC 60079-11 required water temperature is higher than the ISA standard (IEC 65°C vs. ISA 50°C). For sealed devices, IEC 60079 requirements exceed ISA 12.12.01.

Based on the differences identified, it is concluded that although IEC 60079-15 exceeds some of the applicable requirements in ISA 12.12.01 as referenced by FM 3611 and does not meet the FM 3611 requirements in the sections identified above.

3.6.4 FM 3615 vs IEC 60079-1

The term "Explosionproof equipment" is used in FM 3615, which is the same definition used by *NEC* Article 100. FM 3615 contains three aspects – "equipment enclosed in a case that is capable of 1) withstanding an internal explosion of a specified gas or vapor-in air atmosphere; 2) preventing the ignition of a specified gas or vapor-in-air surrounding the enclosure due to spark, flashes or internal explosion; 3) operating at temperatures which will not ignite the surrounding atmosphere."

IEC 60079-1 uses the term "flameproof" enclosure containing two aspects: enclosure can "1) withstand the pressure developed during an internal explosion of an explosive mixture; 2) prevent the transmission of the explosion to the explosive gas surrounding the enclosure." Although operating temperature is not mentioned in the definition, it is required to be indicated on the marking for certified equipment. Therefore, the scope of FM 3615 is covered by IEC 60079-1.

The scope of the comparative assessment between the FM 3615 with IEC Standard 60079-1 includes the topics such as marking requirements, construction requirements, performance requirements, and operations requirements.

Marking requirements

In addition to the marking requirements in FM 3600, FM 3615 requires three precautionary warning information to be placed on the equipment. FM 3615 and FM 3600 also refers to ISA 60079-1. The marking requirement in ISA 60079-1 is applicable for electrical equipment for Class 1, Zone 0, 1, or 2 hazardous locations.

Construction requirements

FM 3615 specifies construction requirements in the various aspects for explosion-proof equipment, such as enclosure mechanical strength, enclosure joints, flame path dimension, joint material (non-metallic), gaskets, cements, flexible cords and bushing, material applied to joint surface for corrosion protection, joint securing fasteners, enclosure requirements for outdoor classified location, and energized parts. The following differences were noted regarding construction requirement between FM and IEC standard:

- Flame-path Dimensions - FM 3615 required gaps are smaller than the IEC standard, thus FM 3615 requirements are more stringent than IEC 60079-1
- Joint Material – Non-Metallic Enclosures - IEC 60079-1 requires resistance to cracking and creepage distances on internal surfaces of the enclosure walls, which is not covered by FM 3615
- Gaskets - IEC 60079-1 requires the minimum width of cylindrical parts be maintained before and after compression; while the FM standard permits non-metallic gaskets to cushion a lens and requires them to meet non-metallic enclosure requirements.
- Cements (Sealing Adhesive and Poured Seals) - FM 3615 defines the softening point of sealing material, which is not mentioned by IEC 60079-1. IEC 60079-1 requires over-pressure test with water, which is not required by FM 3615.
- Enclosure requirements for outdoor classified locations – FM 3615 requires enclosures to meet ANSI/NEMA 250 and flame path be protected against corrosion. IEC 60079-1 doesn't specify the same. It is understood that ingress protection standard IEC 60529 will be applied.
- Energized external parts – FM 3615 requires that any energized part of explosion-proof equipment not protected by the explosion proof enclosure shall be protected using intrinsically safe type protection per FM 3610.
- IEC 60079-1 provides requirements for more types of equipment such as switchgear.

Performance Tests & Evaluation

The following differences were noted regarding the test requirements between FM 3615 and IEC 60079-1:

- Conduit Opening Torque Test - IEC provides values for stopping plugs (higher than thread adapter), which are not included in the FM 3615.
- Hydrostatic Tests - FM 3615 requires test pressure to the highest ignition pressure obtained from explosion pressure test multiplied by safety factors for various moldings and materials. IEC 60079-1 provides various options for overpressure tests: static and dynamic. Static overpressure test in IEC 60079-1 is considered as less stringent than FM 3600. FM 3615 does not have dynamic test procedure defined.
- Impact Tests - IEC 60079-1 provides more details for various groups of enclosures for impact tests as well as more stringent test conditions than FM 3615

Based on the differences identified, it is concluded that although IEC 60079-1 exceeds some of the applicable requirements in FM 3615, and does not meet the FM 3615 requirements in the sections identified above.

3.6.5 FM 3620 vs IEC 60079-2

The scope covered in FM 3620 includes purged and pressurized electrical equipment (not including purged and pressurized control rooms) and purged and pressurized electrical equipment having an internal source of gas or vapor. FM 3620 defines three types of pressurizing X, Y, Z and allows to reduce the classification within the protected enclosure, such as Division 1 to unclassified (X), to Division 2 (Y), from Division 2 to unclassified (Z).

The Scope of IEC 60079-2 includes the same topics and specifies the exclusions of enclosures having containment system releasing oxygen content greater than 21%, pressurized enclosures where explosive dusts, hybrid mixtures, etc. are present. IEC 60079-2 uses level of protection “pxb”, “pyb”, “pzc” selected based upon the required EPL, whether there is the potential for an internal release and whether the equipment within the pressurized enclosure is ignition-capable, as listed in IEC 60079-2 Table 1. Protection level in the IEC standard focuses on the hazards the equipment may face and the techniques to address the concern. No general statements for reducing hazardous classification are given in *NEC*. However, the final results are the same, proper protection measures or techniques are to be used to ensure the equipment is capable of operating safely in the environmental conditions anticipated. IEC 60079-2 and FM 3620 use different terms for describing the same subject.

FM 3620 uses ANSI/NFPA 496-2013 *Standard for Purged and Pressurized Enclosures for Electrical Equipment* as the basis for approval. Some modified requirements are specified in FM 3620. This standard is used in conjunction with FM 3600.

The scope of the comparative assessment between the FM3620 with the IEC Standard 60079-2 includes the topics such as marking requirements, performance and construction requirements, general requirements for pressurized enclosure, and operations requirements.

Marking requirement

The FM standards require Class and Division marking which is not required by the IEC standard. FM 3620 and FM 3600 also refer to ISA 60079-2. The marking requirements in ISA 60079-2 are applicable for electrical equipment for Class 1, Zone 0, 1, or 2 hazardous locations. Although it may be considered that IEC 60079-2 does not meet FM 3620 and ISA 60079-2 for marking due to the differences between the standards, it should have no material effect on the safety level of equipment operation.

Performance and Construction Requirements

FM 3620 uses ANSI/NFPA 496-2013 as the basis for approval for purged and pressurized electrical equipment. The following major differences were noted between ANSI/NFPA 496-2013 and IEC 60079-2:

- FM 3620 requires that enclosures can sustain an overpressure at greater of 300% of pressure relieving setting or of the maximum enclosure operating pressure. Compliance verification tests are required to be conducted for 1 minute. IEC 60079-2 requires the manufacturer to define the maximum overpressure rating for the enclosure, and overpressure tests are to be conducted at 1.5 times the maximum overpressure rating or 200 Pa, whichever is the greater for 2 minutes.
- In FM 3620 standard, the requirements for mechanical strength resistance to impact is considered not applicable to purged and pressurized equipment as the required interlocks and alarms would provide fail-safe conditions. In IEC 60079-2, it is indicated that the resistance of enclosure to impact is required for pressurized enclosures.

Operation Requirements

The operation requirements in FM 3620 Clause 5.0 refer to FM 3600 Clause 5.0. In addition to the general requirements specified in IEC 60079-0, the IEC standard requires that the instructions to be provided to the users regarding the protective gas and any alternative permitted. Recommendations with respect to pressurization are provided in Annex D of IEC 60079-2.

General Requirements for Pressurized Enclosures

The following major differences were noted between ANSI/NFPA 496-2013 and IEC 60079-2 regarding requirements for pressurized enclosures:

- NFPA 496 Explosion-proof conduit seal requirements are more stringent than IEC’s IP rating requirement

- NFPA 496 requires that the enclosure shall be maintained at a pressure of 25 pa above the surrounding atmosphere during operation, while IEC 60079-2 requires an overpressure 50 Pa for “pxb” and “pyb”, 25 Pa for “pzc”. Therefore IEC 60079-2 has more stringent requirements than NFPA 496 in this aspect
- NFPA 496 also requires that failure of protective gas supply shall be alarmed for Type Y and Type Z protection. IEC 60079-2 requires safety device to detect loss of minimum overpressure for all levels of protection with more detailed requirements for sensor and alarm locations, piping connections, etc.
- NFPA 496 requires that for Type Z protection, all components energized in absence of protective gas be identified. IEC 60079-2 requires equipment with level of protection “pzc” that may remain energized when it is not in operation be protected by EPL Ga, Gb, or Gc. Similar requirements are also specified for Group I and Group III gas in the IEC standard. The protections techniques in IEC 60079-2 are more stringent than NFPA 496.

Based on the differences identified, it is concluded that although IEC 60079-2 exceeds some of the applicable requirements in NFPA 496 as referenced by FM 3620, and does not meet the FM 3620 requirements in the certain aspects.

3.7 Listing, Marking and Documentation of Equipment Installed in Hazardous Locations (AEx vs EEx) (Task 4)

This section contains a summary of the finding and conclusions from the Task 4 comparative assessment of *NEC* Article 505, ANSI/ISA and UL 60079 series of standards and IEC 61892-1, IEC 61892-7 and IEC 60079 series of standards. Detailed findings are contained in the Task 4 report in Appendix E.

NEC Article 500 covers the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Division 1 and 2 locations where fire or explosion may exist due to flammable gases, flammable liquid-produced vapors and combustible liquid-produced vapors. *NEC* Article 505 covers the requirements for zone classification system as an alternative to the division classification system covered in Article 500. Article 505 covers the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Zone 0, Zone 1, and Zone 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases, vapors, or liquids.

NEC Article 505.9(I) indicates that equipment identified for Class I, Division 1 or Class I, Division 2 that are marked in accordance with 500.8 (C), are also permitted to be marked with the following:

- Class I Zone 1 or Class 1 Zone 2 (as applicable)
- Gas Classification group as per Table 505.9 (C)(1)(2)
- Temperature Classification as per 505.9(D)(1)

Also, it is to be noted that the equipment marked for Class I, Division1 hazardous locations may be used in Class I, Zone 1 or Zone 2 locations for the same gas and with suitable temperature rating. Further, equipment marked for Class I, Division 2 hazardous locations may be used in Class I, Zone 2 locations for the same gas and with suitable temperature rating. API RP 14 FZ (Edition 1) Section 6.4.1.4 (b) provides guidance on use of Division rated equipment in Zone classified locations.

Based on the comparative assessments, regarding the marking requirements in *NEC* 505, ANSI/ISA and UL 60079 series of standards and IEC 61892-1, IEC 61892-7 and IEC 60079 series of standards, the summary of assessment is noted below:

- *NEC* 505, ISA and UL 60079 require AEx marking vs IEC 60079 requires symbol EEx.
- *NEC* 505, ISA and UL 60079 require that Class and Zone of equipment be identified in the marking.
- IEC 60079 series requires that the certificate number shall include the "X" suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the requirements. However, the marking with U or X are not used for U.S. standards. For U.S. standards, it is required that the equipment be marked in accordance with ISA 60079-0 to indicate that there are special conditions of use. It is to be noted that although the requirement in the standard differs regarding marking for special conditions of use, the intent of the marking in both standards conveys the same information to the user.
- Under IEC 60079-0, an equipment can get EPL Ga protection level if the same equipment has two independent types of protection, with EPL Gb. In such cases, the equipment is marked with the symbols for the types (or levels) of protection joined with a “+”. However, ISA 60079-0 does not allow the marking for Ga equipment using two independent types of protection as this concept is not recognized in the NEC.
- For small Ex equipment and components, IEC 60079-0, considering the limitation in the space to indicate all the details, does not require the labeling to indicate the temperature class and gas group. However, ISA 60079-0 requires that Class, Zone, temperature class and gas group be on the smallest unit package to comply with NEC marking requirements.
- As per IEC 60079-7, the Level of Protection of “eb” or “ec” is to be indicated. Clarification is added in the UL 60079-7 standard that 2017 *NEC*, does not recognize “ec” as a Type of Protection. The marking “nAc” or “nA” is substituted until this can be rectified.
- IEC 60079-26 requires where more than one type of protection is used as per Clause 4.1.2, the symbols for the type of protection should be joined with a “+”. It is to be noted that the scope of the UL 60079-26 is revised to exclude the application of two independent types of protection providing EPL Gb in locations intended for EPL Ga. The application of two independent type of protection providing EPL Gb in an area required by EPL Ga is not applicable for U.S. standards.
- IEC 60079-29-1 requires the marking to be in accordance with IEC 60079-0 and if the equipment is not fully compliant with IEC 60079-0, then where equivalent safety is claimed, it is to be

marked “s”. The marking type “s” is not in accordance with the NEC, therefore is not included in ISA 60079-29-1.

3.8 Test Standard in NRTLS vs. IEC (Task 4)

This section contains a summary of the finding and conclusions from the Task 4 comparative assessment of the test standards in the Nationally Recognized Testing Laboratories (NRTLs) and the IEC. Detailed findings are contained in the Task 4 report in Appendix E.

Comparative analysis for the test standards in the NRTLs and the IEC standards for the electrical equipment for use in classified locations was performed. U.S. test standards in the NRTLs are developed by the OSHA recognized organizations such as the ANSI, UL, ISA and FM. The electrical equipment for use in Hazardous (classified) locations requires NRTL approval as per OSHA 29 CFR 1910.307.

IEC 60079 series of standards is developed by IEC which provides general requirements and explosion protection techniques for electrical equipment in explosive atmospheres.

The comparative assessment of UL, ISA, FM standards for electrical equipment for use in hazardous area with IEC 60079 series of standards were performed. One major difference identified from the assessment is regarding the requirement for verification of equipment for ordinary location standard.

- In the IEC 60079 series of standards ordinary location requirements are referenced so that the equipment is constructed in accordance with the applicable safety requirements in these industry standards. However, a clarification is given that it is not a requirement in IEC 60079 series that the compliance with these industrial standard be verified.
- In the U.S. standards, manufacturers must comply with the applicable requirements for similar equipment for use in ordinary (unclassified) locations in addition to the hazardous area requirements. U.S. standard ISA 60079-0 states that the equipment listed by NRTLs is considered to meet the applicable requirements found in the ordinary location standards.

IEC has developed various separate standards for electrical equipment for use in ordinary locations for regulatory bodies or independent testing laboratories to use. Specific testing requirements for various electrical components depends on the type of certification that the manufacturer desires and are contained in the various standards. Manufacturer can certify equipment to one or more of the standards.

3.9 Hazardous Location Standards in IRF member countries vs. United States (Task 4)

This section contains a summary of the finding and conclusions from the Task 4 comparative assessment of the hazardous location standards in the International Regulators’ Forum (IRF) member countries to those standards used in the United States. Detailed findings are contained in the Task 4 report in Appendix E.

The IRF is made up of 9 country members which include Australia, Brazil, Canada, Denmark, Mexico, The Netherlands, New Zealand, Norway, United Kingdom and United States. This forum provides international leadership on safety and safety-related regulatory matters for offshore installations. It provides a platform for sharing of regulatory practice and experience among the member countries. Research was done to identify the various electrical standards used by the offshore regulators in these countries. Some of the information identified is included below:

- Australia and New Zealand - IEC 60079 series standards are adopted with national variations, which are known as AS/NZS 60079 series standards
- Brazil - Brazilian Ex NBR IEC standards are fully harmonized with IEC 60079 Series.
- Canada - Canada Oil and Gas Installations Regulations, SOR/96-118 refers to API RP 500 for the classification of hazardous areas with respect to hazards caused by combustible gases on offshore platforms
- Denmark and The Netherlands - Allows the use of IEC and ATEX standards for fixed offshore installations
- Mexico - Mexico adopted the NEC 2011 in November 2012 with the effective date of May 30, 2013. Hence, for hazardous locations (special environments), NEC articles 500, 501, 504 and 505 should be applicable.
- Norway - Allows the use of various industry standards such as NORSOK, API or other normative documents with supplementary addendums provided in the guidelines. NORSOK Standard E-001 for electrical system is mainly based on the IEC 61892.
- United Kingdom - For electrical equipment in hazardous areas, internationally recognized standards such as IEC, IECEx, NEC, API 14/14FZ/500/505 and the ANSI/UL are accepted.

3.10 Exhibit of BSEE Personnel Using Standards for Ensuring Compliance (Task 5)

This section contains a summary of the finding and conclusions from the Task 5 review of current inspection practices used by BSEE inspectors to determine whether operators are in compliance with the electrical standards. Findings and conclusions are grouped into two sections. Detailed findings are contained in the Task54 report in Appendix F.

3.10.1 Analysis of PINCs

Analysis of the current PINCs identified some recommended modifications based on the information in API RP 14F, 14FZ, 500 and 505. The recommended changes either modify the PINC text description, the referenced authority, or both, in order to better capture Title 30 CFR 250 regulatory requirements, and better incorporate API RP 14F, 14FZ, 500 and 505Modify 4 PINCs. Modifications are recommended for the following PINCs.

- F-101
- F-108
- P-154
- P-173

Analysis of the standard currently also incorporated into regulation by reference also identified areas where new PINCs could be developed. The analysis found that 30 CFR 250 842(b)(1), 250.842(a)(3), 250.1628(b)(3) and 250.1628(d)(4)(ii) were not included in any of the existing PINCs. Further analysis of the current PINC list identify items that do not explicitly exist in the regulations but that would further promote safety during operations on the OCS, protection of the environment and a reduction in injuries, loss of life and property. Title 30 CFR 250.114(a) and 30 CFR 250.114(c) require that all areas are classified according to API RP 500 or 505 and that all electrical installations are made in accordance with API RP 14F or 14FZ. Based on the analysis for the BSEE regulations and standards incorporated into these regulations by reference, 26 new PINCs were developed for consideration by BSEE.

3.10.2 Development of an Audit Protocol

This task also involved the development of an audit protocol for inspectors to use to determine if operations are in compliance with standards. The IEC/ISA/UL harmonized standards, as well as the NEC, are not incorporated into BSEE's regulations. As such, it was determined that compliance should be best determine by use of an audit checklist.

A single combined checklist was generated instead of separate checklists for each standard in order to expedite the audit process and reduce redundancy as several inspection items are addressed in multiple standards. The intended use of the Audit Checklist is comparable to how BSEE currently utilizes the PINC list.

The use of an audit checklist could certainly help BSEE determine if operators are in compliance with the standards as they conduct offshore operations. However, since the standards included in the checklist i are not incorporated by reference into BSEE's regulation, BSEE would need to determine its regulatory authority to enforce compliance with these standards. The regulations in Title 30 CFR 250.101(a) provide a possible citation to use. However, this regulation does not contain language related to "established industry standards."

3.11 United States vs. International Accreditation Practices (Task 6)

This section contains a summary of the finding and conclusions from the Task 6 comparative assessment of the similarities and differences between how the United States accredits NRTLs and how international authorities accredit independent laboratories. Detailed findings are contained in the Task 6 report in Appendix G. The following is a summary of the key points identified in the comparative assessment.

1. Public preliminary findings published for NRTL applications but are not required for the EU, UK or IECEx.
2. A public review is held as part of a NRTL application but is not required for the EU, UK or IECEx.
3. OSHA may allow NRTLs to self-certify against their letter of recognition which is not an option for the EU, UK or IECEx.
4. The NRTL suspension, withdrawal and appeals processes are carried out in public compared to the EU, UK and IECEx which carry them out internally with only the outcome made public.
5. NRTL requirements for test facility requirements include areas such as general security and fire protection which are not covered by the EU, UK and IECEx procedures.
6. Requirements for general safety of employees are not covered by EU, UK or IECEx accreditation procedures or ISO/IEC standards.
7. NRTLs do not allow manufacturers to self-certify their own products but ATEX (EU & UK) allows for a limited amount of self-certification by manufacturers (ATEX equipment in group II, category III).
8. NRTLs and IECEx require both product testing and manufacturer quality management system assessment but ATEX (EU & UK) only requires one of the two.
9. NRTLs have strict ownership and financing requirements that may not be fully met by the organizational independence requirements for EU NBs and IECEx ExCBs and ExTLs.

The following conclusions are applicable to independent testing laboratories SGS BASEEFA, PTB and LCIE who are all accredited through EU legislation for ATEX as well as through the IECEx system for equipment. Based upon the key points identified in the analysis section, the following conclusions can be drawn:

7. NRTL applications and appeals processes involve the public at an early stage in contrast to both the EU and IECEx whose processes are all internal until the final decision. For established NB, ExCBs and ExTLs this difference will not affect the quality of conformity assessments or accredited products.
8. Renewal of NRTL recognition by self-certification against their letter of recognition is a weakness of the OSHA NRTL program in comparison to the EU and IECEx. This issue has been clarified in the draft NRTL directive and thus will close the perceived gap.
9. NRTL requirements for test facilities are not fully met for the EU and IECEx, specifically general security, fire protection and personnel safety. These aspects are typically covered by national (or regional (e.g. EU)) regulations but this difference has no significant effect on quality of conformity assessments or accredited products.
10. Independence of assessors is required in all cases but the EU and IECEx may not meet all of the NRTL requirements. The level of independence required is currently considered sufficient to

ensure integrity of testing and assessment is maintained but the NRTL, EU and IECEx requirements will become fully aligned when the draft NRTL directive is enacted.

11. ATEX does not provide a sufficient framework to be considered equivalent to the NRTL program for the following major reasons:
    a. Manufacturers are allowed to self-certify some low risk products
    b. ATEX requires products to be either tested or made under an assessed quality management system but not both
12. The IECEx Certified Equipment Scheme is broadly comparable[1] to the NRTL program. ExCBs and ExTLs can therefore be considered to be equivalent to the corresponding parts of a NRTL (ExCB for certification and ExTL for testing). However, there remain some differences which are likely to prohibit use of IECEx certification directly in the US without changes to the law (particularly labelling and markings).

As a number of NRTLs hold multiple accreditations, including IECEx, an interim solution for manufacturers is to use those NRTLs to provide a fast track service to NRTL certification based upon existing IECEx documentation. This is supported by the draft NRTL directive allowing for use of test reports from IECEx and other accredited organizations.

4. Recommendations

Throughout this project, recommendations were developed to help make BSEE's electrical-related regulations easier to follow, easier to enforce and more inclusive of international approaches, where appropriate. The intent of these recommendations is to promote safer operations on the OCS, better protection of the environment and a reduction in injuries, loss of life and property. This section provides recommendations in five areas.

4.1 Recommended changes to the PINCs

This project involved conducting a comparative assessment between various U.S. and international electrical standards. This assessment concluded that the current list of PINCs contains gaps in methods that could be help inspectors ensure compliance with each of the standards analyzed in Tasks 1 through 4 of this project.

[1] Accreditation to ISO/IEC 17025 for testing and ISO/IEC 17065 for certification are also largely comparable to the corresponding parts of a NRTL, particularly if endorsed by a regional or international cooperation body (such as IAF and ILAC). However within the context of this analysis it is unlikely to see either of these separately from a certification scheme such as ATEX or IECEx.

BSEE should review the recommended changes to the PINCs discussed in Appendix F. These include modifications to 4 existing PINCs as well as the addition of 26 new PINCs to better evaluate compliance with the standards currently incorporated into BSEE's regulations.

4.2 Implementation of an Audit Protocol

Neither the IEC, NEC nor ISA/UL harmonized standards are currently incorporated by reference into BSEE's regulations. In order to assess compliance with these standards, BSEE could implement an audit protocol by using the Audit Checklist discussed above in Appendix F. This checklist will provide inspectors with the necessary areas of focus in order to ensure BSEE facilities conduct offshore operations in a manner that is compliant with the various international electrical standards that extend beyond current regulation. BSEE should also review its authority to enforce these standards and provide the appropriate enforcement guidance to inspectors and engineers.

4.3 Recommendations for Personnel Training

Paramount to the successful implementation of the recommended changes to the PINCs and audit protocol, as well as an improved understanding of the domestic and international electrical standards, is training. Electrical inspections focus on marking, documentation, installation, maintenance, operational procedures and safe work practices. Engineering plan reviews involve a review of plans such as the Deepwater Operating Plan (DWOP), Conceptual Plans, Develop and Production Plan (DPP), Exploration Plan (EP), Development Operations Coordination Document (DOCD) and Application for Permit to Drill (APD). Inspections of electrical components and the engineering review of electrical systems during plan review and approval require extensive knowledge of the applicable regulations and standards in order to adequately ensure safety for personnel and equipment.

BSEE should provide training to inspectors and engineers on the all of the U.S. and international standards included in this project so that they are familiar with the various provisions in these standards. This training should be designed and developed so as to replicate actual on-the-job performance. For example, training scenarios could be developed that describe the current state of a particular electrical system, component or piece of equipment on an offshore facility. Participants in the training would use the PINCs and/or the audit checklist to discuss the given scenario and determine if the electrical component is in compliance with the relevant regulation and standard. Based on their conclusion, the participants would determine which enforcement option would be appropriate. ABS Group developed a similar training program in 2014 for BSEE inspectors and engineers to become familiar with the contents of API RP14F (See contract number E14PB00037), which could serve as a model for development of additional training.

4.4 Provide Reference Material to Inspectors and Engineers

BSEE should obtain copies of the all of the U.S. and international standards referenced in this project for use by engineers and inspectors during training and for use on the job. Additionally, BSEE should provide inspectors and engineers with a copy of all of the reports developed during this project so they can become familiar with the differences among the U.S. and international standards.

4.5 Recommendations to Current Regulations

BSEE incorporates standards into federal regulation by reference in Title 30, Code of Federal Regulations Part 250.198. Currently BSEE only incorporates a limited number of the standards analyzed during this project; namely API RP 14F, API RP 14FZ, API RP 500 and API RP 505. Since the federal regulations represent minimum requirements, BSEE may want to consider incorporating clauses in the various standards not currently incorporated into regulations that exceed the comparable clauses of the standards that are currently incorporated into the regulations. The Task 5 report, contained in Appendix F, includes a recommended approach for how BSEE could incorporate some of the standards included in this project into regulation. The Task 5 report also provides recommended modifications to the text in Title 30, Code of Federal Regulations, Part 250.198.

Appendix A. Abstracts of Reviewed Standards

This appendix contains abstracts of the U.S. and international standards reviewed as part of the BSEE Electrical Standards Comparison project. The abstracts were extracted from the introduction or scope from each standard referenced.

ANSI/ISA-12.12.01-2015, Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations **(FM3611 cites ANSI/ISA-12.12.01-2015 for requirements)**

The standard provides minimum requirements for the design, construction, and marking of electrical equipment or parts of such equipment for use in Class I and Class II, Division 2 and Class III, Divisions 1 and 2 hazardous locations. The equipment is not capable of causing ignition of the surrounding atmosphere under the conditions prescribed in this standard and in normal operation. However, the equipment may contain electronic components used in an incendive circuit and may also have field wiring that is an incendive circuit. The document also establishes uniformity in test methods for determining the suitability of the equipment and associated circuits and components as they relate to potential ignition of a specific flammable gas or vapour-in-air mixture, combustible dust, easily ignitable fibers, or flyings.

(The International Society of Automation, 2018)

ANSI/ISA-60079-0 (12.00.01) Ed. 6, 2013, Explosive Atmospheres - Part 0: Equipment - General Requirements

ANSI/ISA 60079-0 specifies the general requirements for construction, testing, and marking of electrical equipment and EX components used in an explosive atmosphere. Explosive atmospheres are identified as hazardous locations including Class 1, Zone 0, Zone 1, or Zone 2, and Zone 20, Zone 21, and Zone 22. The standard specifies the standard atmospheric conditions that the electrical equipment may be operated, but also specifies additional requirements when testing equipment outside of the standard conditions. This standard does not specify safety requirements that are not directly related to explosion risk.

(ANSI/ISA-60079-0 (12.00.01) Ed. 6, 2013)

ANSI/UL 60079-5, Ed. 4, April 29, 2016, Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"

UL 60079-5 contains specific requirements for the construction, testing and marking of electrical equipment, parts of electrical equipment and EX components filled with powder constituting "q" type protection intended for use in explosive gas atmospheres. This standard supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition. This standard applies to electrical equipment, parts of electrical equipment and EX components with:

- A rated supply current less than or equal to 16 A

- A rated supply voltage less than or equal to 1000 V
- A rated power consumption less than or equal to 1000 W

(ANSI/UL-60079-5, Ed. 5, 2016)

ANSI/UL 60079-6 Ed. 4, April 29, 2016, Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"

ANSI/UL 60079-6 specifies the requirements for the design, construction, testing, and marking of EX Equipment and EX Components intended for use in explosive gas atmospheres employing protection type "o" liquid immersion. These include:

- Level of Protection "ob" (EPL "MB" or "Gb"), standard applies to equipment when rated voltage does not exceed 11kV r.m.s. a.c. or d.c.
- Level of Protection "oc" (EPL "Gc"), standard applies to equipment when rated voltage does not exceed 11kV r.m.s. a.c. or d.c.

This standard supplements UL 60079-0 and supersedes it where there is a conflict, provides significant changes to the previous edition.

(ANSI/ISA-60079-6, Ed. 4, 2016)

ANSI/ISA-60079-10-1, Ed. 5, February 24, 2017 (12.24.01) Ed. 1, 2014, Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres

ANSI/ISA 60079-10-1 is concerned with the classification of areas where flammable gas or vapor hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas. It is intended to be applied where there may be an ignition hazard due to the presence of flammable gas or vapor, mixed with air, but it does not apply to: mines susceptible to firedamp; the processing and manufacture of explosives; catastrophic failures or rare malfunctions; rooms used for medical purposes; commercial and industrial applications where only low pressure fuel gas is used for appliances; domestic premises; where a hazard may arise due to the presence of combustible dusts or combustible flyings but the principles may be used in assessment of a hybrid mixture (refer also ANSI/ISA 60079-10-2). This standard supersedes ISA 60079-10.

(ANSI/ISA-60079-10-1, Ed. 1, 2014)

ANSI/ISA-60079-11 (12.02.01) Ed. 6.2, 2014, Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"

ANSI/ISA 60079-11 is concerned with the construction and testing of intrinsically safe apparatus, and for apparatus that connect to the intrinsically safe circuits, intended for use in explosive atmospheres. Intrinsically safe refers to equipment in which electrical circuits themselves cannot cause an explosion under these specific conditions. The requirements for such equipment can be found in ANSI/ISA 60079-25. This standard supplements ANSI/ISA 60079-0 and supersedes it where there is a conflict and provides significant changes to the previous edition.

(ANSI/ISA-60079-11 (12.02.01) Ed. 6.2, 2014)

ANSI/ISA-60079-15 (12.12.02) Ed. 4, 2012, Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"

ANSI/ISA 60079-15 is concerned with the construction, testing and marking of Group II electrical equipment with type "n" protection intended for use in explosive gas atmospheres. This standard applies when voltage of this equipment does not exceed 15 k r.m.s a.c or d.c. This standard is applied to non-sparking equipment, parts of equipment or circuits that produce arcs or sparks that may be an ignition hazard if not properly protected. This standard supplements ANSI/ISA 60079-0 and supersedes it where there is a conflict and provides significant changes to the previous edition.

(ANSI/ISA- 60079-15 (12.12.02) Ed. 4, 2012)

ANSI/UL 60079-18 Ed. 4 December 14, 2015, Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"

ANSI/UL 60079-18 specifies requirements for the construction, testing and marking of electrical equipment, arts and Ex components with protection designated as encapsulation “m," intended for use in explosive atmospheres. It applies when the rated voltage of components protected by encapsulation "m" does not exceed 11kV but does not apply to dusts of explosions that do not require atmospheric oxygen for combustion; or to pyrophoric substances. This standard supplements ANSI/ISA 60079-0 and supersedes it where there is a conflict and provides significant changes to the previous edition.

(ANSI/UL-60079-18, Ed. 4, 2015)

ANSI/ISA-60079-25 (12.02.05)-2011, Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems

ANSI/ISA 60079-25 specifies requirements for construction and assessment of intrinsically safe electrical systems designated as type "I" protection intended for use in in Class 1, Zone 0, 1, or 2, or Zone 20, 21, 22 hazardous locations. This standard supplements ANSI/ISA 60079-0, ANSI/ISA 61241-0, ANSI/ISA 60079-11 and ANSI/ISA 61241-11 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(ANSI/ISA-60079-25 (12.02.05)-2011, 2011)

ANSI/UL 60079-26 Ed. 3, April 21, 2017, Explosive Atmospheres - Part 26: Electrical Apparatus for Use in Class I, Zone 0 Hazardous (Classified) Locations

ANSI/UL 60079-26 specifies alternative requirements for construction, test and marking for electrical equipment mounted across a boundary where different Equipment Protection Levels may be required. This level of protection is designated as "Ga." This standard supplements ANSI/ISA 60079-0 and supersedes it where there is a conflict and provides significant changes to the previous edition.

(ANSI/UL 60079-26 Ed. 3, 2017)

ANSI/ISA-60079-27 (12.02.04) Ed. 1, 2006, Explosive Atmospheres – Part 27: Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)

ANSI/ISA 60079-27 contains details of apparatus, systems and installation practice for use with the FISCO installations in Class 1, Zones 0 and 1, and FNICO installations in Class 1, Zone 2. The standard is based on Manchester encoded, bus powered systems designed in accordance with IEC 61158-2. Requirements of FISCO and FNICO are determined in ANSI/ISA 60079-11 and ANSI/ISA 60079-15, except where modified by this standard. Parts of the Fieldbus may be protected by other explosion protection under ANSI/ISA 60079-0, in which case only parts attached to intrinsically safe or non-incendive trunks or spurs are covered by this standard.

(ANSI/ISA-60079-27 (12.02.04)Ed. 1, 2006)

ANSI/ISA-60079-29-1 (12.13.01) Ed. 1, 2013, Explosive Atmospheres - Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases

ANSI/ISA 60079-29 specifies general requirements for construction, testing and performance, and describes the test methods that apply apparatus for the detection and measurement of flammable gas or vapor concentrations with air, intended for use in explosive atmospheres and in mines susceptible to firedamp. This standard is applicable to:

- Flammable gas detection apparatus intended to provide an indication, alarm, or other output function to give warning of potential explosion hazard
- Apparatus intended for use in commercial, industrial, and non-residential safety applications This standard is not applicable to:
- External sampling systems
- Apparatus of laboratory or scientific type
- Apparatus used only for process control purposes

This standard supplements ANSI/ISA 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(ANSI/ISA-60079-29-1 (12.13.01) Ed. 1, 2013)

ANSI/ISA-60079-29-2 (12.13.02)-2012, Explosive Atmospheres - Part 29-2: Gas Detectors - Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen

ISA 60079-29-2 gives guidance on the selection, installation, use and maintenance of electrically operated group II apparatus intended for use in industrial and commercial safety applications for the detection and measurement flammable gases in compliance with ISA 60079-29-1 and ANSI/ISA 12.13.04. This standard is applicable to oxygen measurement for inertisation where explosion protection is provided by the exclusion of oxygen instead of measuring combustible gases or vapors present. The standard is a compilation of practical knowledge to assist the use, and applies to apparatus, instruments, and systems that indicate the presence of flammable or potentially explosive mixture of gas or vapor with air using electronic signals from a gas sensor. This standard is also applicable to all new and (where practicable) existing permeant installations. The standard only applies to apparatus as defined below:

- Fixed apparatus
- Transportable apparatus
- Portable apparatus

(ANSI/ISA-60079-29-2 (12.13.02)-2012, 2012)

API RP 14F - Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations (Fifth edition, July 2008, Reaffirmed, April 2013)

This document recommends minimum requirements and guidelines for the design, installation, and maintenance of electrical systems on fixed and floating petroleum facilities located offshore. For facilities classified as Zone 0, Zone 1 or Zone 2, reference API 14FZ, Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1 or Zone 2. These facilities include drilling, producing and pipeline transportation facilities associated with oil and gas exploration and production.

This recommended practice (RP) is not applicable to Mobile Offshore Drilling Units (MODUs) without production facilities. This document is intended to bring together in one place a brief description of basic desirable electrical practices for offshore electrical systems. The recommended practices contained herein recognize that special electrical considerations exist for offshore petroleum facilities.

API RP 14FZ - Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1 and Zone 2 Locations 1 and Division 2 Locations (First edition, September 2001, Reaffirmed March 2007)

Recommends minimum requirements and guidelines for the design and installation of electrical systems on fixed and floating petroleum facilities located offshore when hazardous locations are classified as Zone 0, Zone 1, or Zone 2. These facilities include drilling, producing and pipeline transportation facilities associated with oil and gas exploration and production. RP 14FZ describes basic desirable electrical practices for offshore electrical systems. This document recognizes that special electrical considerations exist for offshore petroleum facilities. These special considerations include the inherent electrical shock possibility presented by the marine environment and steel decks; space limitations that require equipment be installed in or near classified locations; the corrosive marine environment; motion and buoyancy concerns associated with floating facilities. RP 14FZ applies to both permanent and temporary electrical installations, and the guidelines provide a high level of electrical safety when used in conjunction with well-defined area classifications. This document emphasizes safe practices for classified locations on offshore petroleum facilities but does not include guidelines for classification of areas.

API RP 500 - Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2, (Second edition, November 1997, Reaffirmed: November 2002)

This recommended practice provides guidelines for determining the degree and extent of Class I, Division 1 and Class I, Division 2 locations at petroleum facilities, for the selection and installation of electrical equipment. Basic definitions provided in the "National Electric Code" have been followed in developing this document which applies to the classification of locations for both temporarily and permanently installed electrical equipment. RP 500 is intended to be applied where there may be a risk of ignition due to the presence of flammable gas or vapor, mixed with air under normal atmospheric conditions.

API RP 505 - Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2 2 (First edition, November 1997, Reaffirmed August 2013)

This recommended practice provides guidelines for determining the degree and extent of Class I, Zone 0, Zone 1, and Zone 2 locations at petroleum facilities, for the selection and installation of electrical equipment. Basic definitions provided in the "National Electrical Code" have been followed in developing this document which applies to the classification of locations for both temporarily and permanently installed electrical equipment. RP 505 is intended to be applied where there may be a risk of ignition due to the presence of flammable gas or vapor, mixed with air under normal atmospheric conditions.

Decision No 768/2008/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 on a common framework for the marketing of products

Decision No 768/2008/EC recommends a common framework or principles and reference provisions for drawing up Community legislation harmonizing the conditions for the marketing of products. This decision establishes procedures by which to assess conformity and quality. This decision amends Directive 94/9/EC and repeals Decision 93/465/EEC.

(Decision No 768/2008/EC, 2008)

DIRECTIVE 2014/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast)

Directive 2014/34/EU is a declaration of conformity of the laws of Member States relating to equipment and systems intended for use in potentially explosive atmospheres. The directive applies to:
- equipment and protective systems intended for use in potentially hazardous atmospheres
- safety devices, controlling devices and regulating devices intended for use outside potentially explosive atmospheres but required for or contributing to the safe functioning of equipment and protective systems with respect to the risks of explosion
- components intended to be incorporated into equipment and protective systems referred to in point (a)

This directive is applicable as of April 20, 2016 and replaces Directive 94/9/EC.

(DIRECTIVE 2014/34/EU, 2014)

FM 3600: Approval Standard for Electrical Equipment for Use in Hazardous (Classified) Locations - General Requirements (2001-12)

This standard serves as the basis for Approval of electrical equipment for use in hazardous (classified) locations. This standard shall apply to:

a) Electrical equipment or parts of electrical equipment rated for use in Hazardous (Classified) Locations as defined by the National Electrical Code® (NEC®), ANSI/NFPA 70;

b) Associated equipment located outside of the Class I, II or III location whose design and construction may influence those parts of the equipment within the classified location.

FM 3610: Approval Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II & III, Division 1, Hazardous (Classified) Locations (2015-12)

This standard serves as the basis for Approval of intrinsically safe apparatus and associated apparatus. Approval criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program. This standard provides requirements for the construction and testing of electrical apparatus, or parts of such apparatus, whose circuits are incapable of causing ignition in:

Classes I, ll & Ill, Division 1 hazardous (classified) locations as defined in Article 500 of the National Electrical Code. ANSI/NFPA-70 (NEC). This standard is intended to be used in conjunction with FM Approval Standard 3600 which includes the general requirements that apply to all types of classified location protection methods. Intrinsically Safe Equipment and/or circuits for use in Class I. Division 1, Groups A. B. C and/or D Hazardous (Classified) Locations shall comply with all applicable requirements in ANSI/ISA-60079- 11 2014 for Category "ia ", Group IIC, liB and/or IIA.

FM 3611: Approval Standard for Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations (2016-12)

This standard serves as the basis for Approval of Nonincendive Electrical Equipment for use in Class I and II, Division 2, and Class III, Divisions 1 and 2. hazardous (classified) locations as defined in Articles 500, 501, 502 and 503 of the National Electrical Code*, ANSI/NFPA- 70 (NEC). Approval criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program.

FM 3615 Approval Standard for Explosion proof Electrical Equipment General Requirements (2006-08)

This standard serves as the basis for Approval of Explosion proof Electrical Equipment. This standard contains the basic requirements for the construction and testing of explosion proof electrical equipment. The standards is intended to be used in conjunction with Approval Standard 3600 which includes the general requirements that apply to all types of hazardous (classified) location protection methods.

FM 3620: Purged and Pressurized Electrical Equipment for Hazardous (Classified) Location (2014-12)

This standard serves as the basis for Approval of electrical equipment for use in hazardous (classified) locations employing the type of protection defined as "Purged and Pressurized". This standard is intended to be used in conjunction with the Class 3600 FM Approval Standard which include the general requirements that apply to all types of protection for electrical equipment for use in hazardous (classified) locations. This standard contains the basic requirement for the construction and testing of purged and pressurized electrical equipment available in the following configurations: Purged and pressurized electrical equipment which are not occupied portions of building (control rooms), Purged and pressurized electrical equipment having an internal source of gas vapor. Note: the requirements of the standard do not included purged or pressurized control rooms.

IEC 60079-0 Ed. 6, 2011-06, Explosive Atmospheres - Part 0: Equipment - General Requirements

This part of the IEC 60079 specifies the general requirements for construction, testing, and marking of electrical equipment and EX components used in an explosive atmosphere. Explosive atmospheres are identified as hazardous locations including Class 1, Zone 0, Zone 1, or Zone 2, and Zone 20, Zone 21, and Zone 22. This part specifies the standard atmospheric conditions that the electrical equipment may be operated, but also specifies additional requirements when testing equipment outside of the standard conditions. It does not specify safety requirements that are not directly related to explosion risk. This part is supplemented by IEC 60079-13: Explosive atmospheres – Part 13: Equipment protection by pressurized room “p” and includes a discussion on markings for Ga equipment using two independent types of protection.

(IEC 60079-0 Ed. 6 , 2011)

IEC 60079-1 Ed. 7, 2014-06, Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"

This part of IEC 60079 contains specific requirements for construction and testing of electronic equipment with electronic equipment intended for use in explosive gas atmospheres. This part supplements IEC 60079-0 and supersedes it where there is a conflict and provides significant changes to the previous edition. This part documents the requirements for the levels of protection "da," "db," and "dc" flameproof enclosures. It provides design recommendations for flameproof joints, sealed joints, operating rods, shafts and bearings, light transmitting parts, breathing and draining devices, fasteners and openings. It also recommends routine tests to ensure integrity of flameproof containers.

(IEC 60079-1 Ed. 7 , 2014)

IEC 60079-2 Ed. 6, 2014-07, Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures "p"

This part of IEC 60079 contains specific requirements for the construction and testing of electrical equipment with pressurized enclosures. It supplements IEC 60079-0 and supersedes it where there is a conflict and provides significant changes to the previous edition. It includes testing of, and requirements for temperature limits, safety provisions, supplying protective gas, pressurized equipment with internal release, release conditions, and enclosure design.

(IEC 60079-2 Ed. 6, 2014)

IEC 60079-5 Ed. 4, 2015-02, Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"

This part of IEC 60079 contains specific requirements for the construction, testing and marking of electrical equipment, parts of electrical equipment and EX components filled with powder constituting "q" type protection intended for use in explosive gas atmospheres. It supplements IEC 60079-0 and supersedes it where there is a conflict and provides significant changes to the previous edition. This part applies to electrical equipment, parts of electrical equipment and EX components with:

- A rated supply current less than or equal to 16 A
- A rated supply voltage less than or equal to 1000 V
- A rated power consumption less than or equal to 1000 W

(IEC 60079-5 Ed. 4, 2015)

IEC 60079-6 Ed. 4, 2015-02, Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"

This part of IEC 60079 specifies the requirements for the design, construction, testing, and marking of EX Equipment and EX Components intended for use in explosive gas atmospheres employing protection type "o" liquid immersion. These include

- Level of Protection "ob" (EPL "MB" or "Gb"), standard applies when rated voltage does not exceed 11kV r.m.s. a.c. or d.c.
- Level of Protection "oc" (EPL "Gc"), standard applies when rated voltage does not exceed 11kV r.m.s. a.c. or d.c.

This part supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(IEC 60079-6 Ed. 4, 2015)

IEC 60079-7 Ed. 5, 2015-06, Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"

This part of IEC 60079 contains specific requirements for the design, construction, testing and marking of electrical equipment and EX components employing protection type "e" that are intended for use in explosive atmospheres. These include:

- Level of Protection "eb" (EPL "Mb" or "Gb"), standard applies to equipment when rated voltage does not exceed 11 kV r.m.s., a.c. or d.c.
- Level of Protection "ec" (EPL "Gc"), standard applies to equipment when rated voltage does not exceed 15 kV r.m.s., a.c. or d.c.

This part also supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(IEC 60079-7 Ed. 5, 2015)

IEC 60079-10-1 Ed. 2, 2015-09, Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres

IEC 60079-10-1:2015 is concerned with the classification of areas where flammable gas or vapor hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas. It is intended to be applied where there may be an ignition hazard due to the presence of flammable gas or vapor, mixed with air, but it does not apply to: mines susceptible to firedamp; the processing and manufacture of explosives; catastrophic failures or rare malfunctions;

rooms used for medical purposes; commercial and industrial applications where only low pressure fuel gas is used for appliances; domestic premises; where a hazard may arise due to the presence of combustible dusts or combustible flyings but the principles may be used in assessment of a hybrid mixture (refer also IEC 60079-10-2). This standard supersedes ISA 60079-10.

(IEC 60079-10-1 Ed. 2, 2015)

IEC 60079-11 Ed. 6, 2011-06, Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"

IEC 60079-11 is concerned with the construction and testing of intrinsically safe apparatus, and for apparatus that connect to the intrinsically safe circuits, intended for use in explosive atmospheres. Intrinsically safe refers to equipment in which electrical circuits themselves cannot cause an explosion under these specific conditions. The requirements for such equipment can be found in IEC 60079-25. This standard supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(IEC 60079-11 Ed. 6 , 2011)

IEC 60079-15 Ed. 4, 2010-01, Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"

IEC 60079-15 is concerned with the construction, testing and marking of Group II electrical equipment with type "n" protection intended for use in explosive gas atmospheres. This standard applies when voltage of this equipment does not exceed 15 k r.m.s a.c or d.c. This standard is applied to non-sparking equipment, parts of equipment or circuits that produce arcs or sparks that may be an ignition hazard if not properly protected. This standard supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(IEC 60079-15 Ed. 4, 2010)

IEC 60079-18 Ed. 4, 2014-12, Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"

IEC 60079-18 specifies requirements for the construction, testing and marking of electrical equipment, arts and Ex components with protection designated as encapsulation “m," intended for use in explosive atmospheres. It applies when the rated voltage of components protected by encapsulation "m" does not exceed 11kV but does not apply to dusts of explosions that do not require atmospheric oxygen for combustion; or to pyrophoric substances. This standard supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(IEC 60079-18 Ed. 4, 2010)

IEC 60079-25 Ed. 2, 2010-02, Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems

IEC 60079-25 specifies requirements for construction and assessment of intrinsically safe electrical systems designated as type "I" protection intended for use in locations that require the use of Group I, II, and III apparatus. This part supplements IEC 60079-0 and IEC 60079-11 and supersedes it where there is a conflict and provides significant changes to the previous edition.

(IEC 60079-25 Ed. 2, 2010)

IEC 60079-26 Ed. 3, 2014-10, Explosive Atmospheres - Part 26: Electrical Apparatus for Use in Class I, Zone 0 Hazardous (Classified) Locations

This part of IEC 60079 specifies alternative requirements for construction, testing and marking for electrical equipment as EPL "Ga" when a single standard type of protection cannot be applied. This standard also applies to equipment mounted across a boundary where multiple levels of protection are required. Equipment with this designation ensures a high level of protection when operating within manufacturer specified parameters, limiting the occurrence of malfunction to those that are rare, or two happening independent of one another. his standard supplements IEC 60079-0 and supersedes it where there is a conflict and provides significant changes to the previous edition.

(IEC 60079-26 Ed. 3, 2014)

IEC 60079-27 Ed. 1, 2005-04, Explosive Atmospheres – Part 27: Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)

IEC 60079-27 contains details of apparatus, systems and installation practice for use with the FISCO and FNICO. The standard is based on Manchester encoded, bus powered systems designed in accordance with IEC 61158-2. Requirements of FISCO and FNICO are determined in IEC 60079-11, IEC 60079-14 and IEC 60079-15, except where modified by this standard, parts of the Fieldbus may be protected by other explosion protection under IEC 60079-0 depending on the Zone of intended use, in which case only parts attached to intrinsically safe or non-incendive trunks or spurs are covered by this standard.

(IEC 60079-27 Ed. 1, 2005)

IEC 60079-29-1 Ed. 1 2007-08, Explosive Atmospheres - Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases

ICE 60079-29 specifies general requirements for construction, testing and performance, and describes the test methods that apply apparatus for the detection and measurement of flammable gas or vapor concentrations with air, intended for use in explosive atmospheres and in mines susceptible to firedamp. This standard is applicable to:

- Apparatus in which Manufacturer makes any claims regarding special features of construction or superior performance exceeding minimum requirements
- Flammable gas detection apparatus intended to provide an indication, alarm, or other output function to give warning of potential explosion hazard
- Apparatus intended for use in commercial, industrial, and non-residential safety applications
  This standard is not applicable to:
- External sampling systems
- Apparatus of laboratory or scientific type
- Apparatus used only for process control purposes

This standard supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(IEC 60079-29-1 Ed. 1, 2007)

IEC 60079-29-2 Ed. 2, 2015-03, Explosive Atmospheres - Part 29-2: Gas Detectors - Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen

IEC 60079-29-2 gives guidance on the selection, installation, use and maintenance of electrically operated group II apparatus intended for use in industrial and commercial safety applications for the detection and measurement flammable gases in compliance with IEC 60079-29-1. This standard is applicable to oxygen measurement for inertisation where explosion protection is provided by the exclusion of oxygen instead of measuring combustible gases or vapors present. The standard is a compilation of practical knowledge to assist the use, and applies to apparatus, instruments, and systems that indicate the presence of flammable or potentially explosive mixture of gas or vapor with air using electronic signals from a gas sensor. This standard is also applicable to all new and (where practicable) existing permanent installations. The standard only applies to apparatus as defined below:

- Fixed apparatus
- Transportable apparatus
- Portable apparatus

(IEC 60079-29-2 Ed. 2, 2015)

IEC 61892-1, Ed. 3.0, 2015-07, Mobile and fixed offshore units – Electrical installations - Part 1: General requirements and conditions

IEC 61892-1:2015 contains provisions for electrical installations in mobile and fixed offshore units including pipeline, pumping or 'pigging' stations, compressor stations and exposed location single buoy moorings, used in the offshore petroleum industry for drilling, processing and storage purposes. This International Standard applies to all installations, whether permanent, temporary, transportable or hand-held, to AC installations up to and including 35 000 V and DC installations up to and including 1 500 V (AC and DC voltages are nominal values). This standard does not apply either to fixed equipment for medical purposes or to the electrical installations of tankers. This edition includes the following significant technical changes with respect to the previous edition:

a) The general requirement to harmonic distortion has been changed from IEC 61000-2-4 Class 2 to Class 1.
b) The voltage tolerance for a DC system has been changed from +-10 % to +10 %, -15 %.
c) Annex C (informative) regarding specification of surface treatment and protective painting system has been added.

(IEC 61892-1, Ed. 3, 2015)

IEC 61892-2, Ed. 2.0, 2012-03, Mobile and fixed offshore units – Electrical installations - Part 2: System design

IEC 61892-2:2012(E) contains provisions for system design of electrical installations in mobile and fixed units used in the offshore petroleum industry for drilling, production, processing and for storage purposes, including pipeline, pumping or 'pigging' stations, compressor stations and exposed location single buoy moorings. It applies to all installations, whether permanent, temporary, transportable or hand-held, to a.c. installations up to and including 35 000 V and d.c. installations up to and including 1 500 V. (a.c. and d.c. voltages are nominal values). This standard does not apply either to fixed equipment used for medical purposes or to the electrical installations of tankers. This edition includes the following significant technical changes with respect to the previous edition:

- The d.c. voltage given in clause 1 has been updated to 1 500 V, to ensure consistency through all parts of the IEC 61892 series
- Clause 4 has been rewritten, such that all requirements to emergency power are now given in 4.3
- The tables for nominal a.c. voltages have been updated in accordance with the last revision of IEC 60038
- The requirement to cross sectional area for earthing conductors has been made dependent on the system earthing arrangement
- Requirement for emergency stop for motor-driven fuel-oil transfer and fuel-oil pressure pumps has been added.

(IEC 61892-2 Ed. 2, 2012)

IEC 61892-3, Ed. 3.0, 2012-03, Mobile and fixed offshore units – Electrical installations - Part 3: Equipment

IEC 61892-3:2012(E) contains provisions for electrical equipment in mobile and fixed offshore units including pipeline, pumping or 'pigging' stations, compressor stations and exposed location single buoy moorings, used in the offshore petroleum industry for drilling, processing and for storage purposes. This standard applies to equipment in all installations, whether permanent, temporary, transportable or hand-held, to a.c. installations up to and including 35 000 V and d.c. installations up to and including 1 500 V (a.c. and d.c. voltages are nominal values). This standard sets requirements for equipment, which are additional to the requirements given in the product standard for the relevant equipment. This standard does not apply to the electrical installations in rooms used for medical purposes or in tankers. This edition includes the following significant technical changes with respect to the previous edition:

a. Table 4 in the previous edition of IEC 61892-3 regarding type testing has been deleted. Information regarding environmental conditions, including requirements to vibration, is now given in Clause 4;
b. for liquid immersed transformers requirement for overheating alarm and shut down has been added;
c. requirements for low voltage switchgear and control gear have been rewritten, based on IEC 61439-1 and IEC 61439-2. Only additional requirements to those given in IEC 61439 are given in the standard;
d. requirements to low voltage circuit breakers, switches, contactors and fuses have been added;
e. requirement for subdivision of high voltage switchboard has been added;
f. requirements for luminaires have been deleted and replaced with reference to IEC 60598 series and IEC 60092-306;

g. requirements for heating and cooking appliances have been deleted and replaced with reference to IEC 60335 series;
h. requirement for portable equipment has been added."

(IEC 61892-3, Ed. 3, 2012)

IEC 61892-4, Ed. 1.0, 2007-06, Mobile and fixed offshore units – Electrical installations - Part 4: Cables

This part of IEC 61892 specifies requirements for the choice and installation of electrical cables intended for fixed electrical systems in mobile and fixed offshore units, including pumping or ""pigging"" stations, compressor stations and exposed location single buoy moorings, used in the offshore petroleum industry for drilling, production, processing and for storage purposes."

(IEC 61892-4 Ed. 1, 2007)

IEC 61892-5, Ed. 3.0, 2014-11, Mobile and fixed offshore units – Electrical installations - Part 5: Mobile Units

IEC 61892-5:2014 specifies the characteristics for electrical installations in mobile units, for use during transfer from one location to another and for use during the exploration and exploitation of petroleum resources. It applies to all installations, whether permanent, temporary, transportable or hand-held, to AC installations up to and including 35 000 V and DC installations up to and including 1 500 V (AC and DC voltages are nominal values). This third edition includes the following significant technical change with respect to the previous edition: the requirement to protection against flooding has been rewritten.

(IEC 61892-5, Ed. 3, 2014)

IEC 61892-6, Ed. 3.0, 2013-12, Mobile and fixed offshore units – Electrical installations - Part 6: Installation

IEC 61892 6 2013 contains provisions for electrical installation in mobile and fixed offshore units including pipeline pumping or pigging stations compressor stations and exposed location single buoy moorings used in the offshore petroleum industry for drilling processing and for storage purposes It applies to all installations whether permanent temporary transportable or hand held to AC installations up to and including 35 000 V and DC installations up to and including 1 500 V AC and DC voltages are nominal values This standard does not apply to electrical installations in rooms used for medical purposes or in tankers This edition includes the following significant technical changes with respect to the previous edition br a Table 1 size of earth continuity conductors has been replaced with the table in IEC 61892 4 br b. The requirements for installation of batteries has been rewritten in order to distinguish better between batteries of the vented type and VRLA sealed type br c. An informative annex regarding cable termination has been added br d. The applicability for DC installations has been increased from 750 V to 1 500 V in accordance with Part 1 of the series

(IEC 61892-6, Ed. 3, 2013)

IEC 61892-7, Ed. 3.0, 2014-12, Mobile and fixed offshore units – Electrical installations - Part 7: Hazardous Areas

IEC 61892-7:2014 contains provisions for hazardous areas classification and choice of electrical installation in hazardous areas in mobile and fixed offshore units, including pipelines, pumping or 'pigging' stations, compressor stations and exposed location single buoy moorings, used in the offshore petroleum industry for drilling, processing and for storage purposes. It applies to all installations, whether permanent, temporary, transportable or hand-held, to AC installations up to and including 35 000 V and DC installations up to and including 1 500 V. (AC and DC voltages are nominal values). This standard does not apply to electrical installations in rooms used for medical purposes, or in tankers. This edition includes the following significant technical changes with respect to the previous edition.

a. The EPL (Explosion Protection Level) concept has been introduced.
b. The requirements to installations in hazardous area has been rewritten, based on the requirements of IEC 60079-14:2013.

(IEC 61892-7, Ed. 3, 2014)

ISO/IEC 17011:2004(E) Conformity assessment – General requirements for accreditation bodies accrediting conformity assessment bodies

ISO/IEC 17011:2004 specifies general requirements for accreditation bodies assessing and accrediting conformity assessment bodies (CABs). It is also appropriate as a requirements document for the peer evaluation process for mutual recognition arrangements between accreditation bodies. ISO/IEC 17011:2004 provides the following conformity assessment services:

- Testing
- Inspection
- Management system certification
- Personnel certification
- Product certification
- Calibration

This standard has been revised by ISO/IEC 17011:2017.

(ISO/IEC 17011:2004(E), 2004)

ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories

ISO/IEC 17025:2005 specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling. It covers testing and calibration performed using standard methods, non-standard methods, and laboratory-developed methods. ISO/IEC 17025:2005 is for use by laboratories in developing their management system for quality, administrative and technical operations. Laboratory customers, regulatory authorities and accreditation bodies may also use it in confirming or recognizing the competence of laboratories. ISO/IEC 17025:2005 is not intended to be used as the basis for certification of laboratories. This standard was revised by ISO/IEC 17025:2017.

(ISO/IEC 17025:2005, 2005)

ISO/IEC 17065:2012 Conformity assessment – Requirements for bodies certifying products, processes and services

This International Standard contains requirements for the competence, consistent operation and impartiality of product, process and service certification bodies. Certification bodies operating to this International Standard need not offer all types of products, processes and services certification. Certification of products, processes and services is a third-party conformity assessment activity (see ISO/IEC 17000:2004, definition 5.5).

(ISO/IEC 17065:2012, 2012)

NFPA 70®: National Electrical Code® (NEC)

The document serves as the 2017 Edition of the *National Electrical Code* (*NEC*) developed by the National Fire Protection Association. The purpose of the NEC is to provide practical safeguards of persons and property from hazards that can develop when using electricity. The NEC covers the installation and removal of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment and raceways; and optical fiber cables and raceways in public, private, and industrial buildings. The *NEC* is not intended to provide design specifications or used as an instruction manual for untrained individuals.

(National Fire Protection Association, 2017)

***NFPA 496 Purged and Pressurized Enclosures for Electrical Equipment* (FM 3620 cites NFPA 496 for requirements)**

The standard provides information on the methods for purging and pressurizing electrical equipment enclosures to prevent ignition of a flammable atmosphere, whether introduced into the enclosure by a surrounding external atmosphere or by an internal source.

(National Fire Protection Association (NFPA), 2018)

OSHA Instruction (Directive) CPL 01-00-003 (1999) NRTL Program Policies, Procedures, and Guidelines

OSHA Directive CPL 01-00-003 provides further details on the OSHA NRTL program policies and guidelines that clarify regulations found in 29 CFR 1910.7 and its Appendix A. This instruction updates the process for processing applications for recognition and monitoring process for recognized OSHA NRTL's. This instruction is applicable to all OSHA offices engaged in or supporting the operations of the OHSA NRTL Program.

(OSHA Instruction (Directive) CPL 01-00-003, 1999)

OSHA Instruction (Directive) CPL 1-00.XXX (Effective Date: TBD) NRTL Program Policies, Procedures, and Guidelines (Draft 2014)

Directive CPL1-00.XXX specifies policies, procedures and interpretations that supplement and clarify NRTL Program regulation of 29 CFR 1910.7 and its Appendix A. This directive deems compliance with ISO/IEC 17025:2012 and ISO/IEC 17065:2012as compliance with requirements under the NRTL Program regulation.

(OSHA Instruction (Directive) CPL 1-00.XXX, TBD)

OSHA NRTL Program - Application Guidelines, October 2000

The OSHA NRTL Program - Application Guidelines detail the process that organizations must go through to become recognized as a nationally Recognized Testing Laboratory (NRTL). These guidelines include the categories eligibility requirements, associated fees and instructions associated with the NRTL program, as well as evaluation criteria for the application.

(OSHA, 2000)

OSHA Regulations, Standards 29 CFR, 1910.7 Definition and requirements for a nationally recognized testing laboratory. (Including Appendix A)

This section of the CFR provides definitions and requirements of nationally recognized testing laboratories (NRTL) where a NRTL is an organization which is recognized by OSHA in accordance with Appendix A of this CFR section and which tests for safety, and lists or labels or accepts, equipment or materials. Appendix A of this CFR provides requirements and criteria which OSHA will use to evaluate and recognize a NRTL. The Appendix provides procedures for renewal, expansion and revocation of OSHA recognition and puts the burden on the applicant to establish by a preponderance of the evidence that it is entitled to recognition as an NRTL. The process of evaluating a NRTL involves the evaluation of the product evaluation and control programs being operated by the NRTL, as well as the NRTL's testing facilities being used in its program.

(Occupational Safety and Health Administration, 2018)

UL 674 Ed. 5 May 31, 2011, Standard for Safety for Electric Motors and Generators for Use in Hazardous (Classified) Locations (Revised on May 19, 2017)

The document is a harmonized ANCE, CSA, and UL standard for electrical motors and generators. The standard is approved by ANSI as an American National Standard and is considered suitable for use for conformity assessments. The standard applies to electric motors and generators or submersible and nonsubmersible sewage pumps and systems for use in Class I, Division 1, Groups B, C, and D, and Class II, Division 1, Groups E, F, and G hazardous locations. The standards also covers the same type of electrical equipment needed for installation and use in lass I, Zone 1, Groups IIA and IIB, IIB+H_2 and Zone 20 and 21 hazardous locations. The standard also covers rotating machinery such as electric brakes but does not address protection other than explosion-proof or dust-ignition-proof.

(Underwriters Laboratories Inc., 2011)

UL 823 Ed. 9 October 20, 2006, Standard for Safety for Electric Heaters for Use in Hazardous (Classified) Locations (Reaffirmed on April 22, 2016)

The requirements included in the standard covers explosion-proof, dust-ignition-proof, and dust tight portable and fixed electric heaters for installation and use in hazardous (classified) locations. The locations covered for the electrical heaters are: Class I, Divisions 1 and 2, Groups A, B, C, and D; Class II, Division 1, Groups E, F, and G; Class II, Division 2, Groups F and G; and Class III, Divisions 1 and 2. These locations are in accordance with the National Electrical Code, NFPA 70. The standard also covers explosion-proof electrical equipment for installation and use in Class I, Zone 1, Group IIA, IIB, and IIC hazardous (classified) locations as well as dust-ignition-proof equipment for use in Zone 20, 21, and 22 locations. The requirements in the standard do not cover medical equipment.

UL 844 Ed. 13 June 29, 2012, Standard for Luminaires for Use in Hazardous (Classified) Locations (including revisions through March 11, 2016)

The document is the thirteenth edition of the safety standard that is provided by the Underwriters Laboratories and was designated as an American National Standard in March 2016. The standard covers requirements for fixed and portable luminaires for installation and use in Class I, Division 1 and 2, Groups A, B, C, and D; Class II, Division 1, Groups E, F, and G; Class II, Division 2, Groups F and G; and Class II, Divisions 1 and 2 hazardous locations. These standards are in accordance with the National Electrical Code, NFPA 70. The standard also provides specifics for luminaires depending on the specifics of the location of use.

(Underwriters Laboratories Inc., 2012)

UL 913 Ed. 8 December 06, 2013, Standard for Safety for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations (including revisions through October 16, 2015)

This document serves as the eighth edition of the safety standard by the Underwriters Laboratories and is approved as an American National Standard. The standard covers requirements to apparatus or parts of an apparatus for installation and us in Class I, II, or III, Division 1 hazardous locations. This is in accordance with requirements from the National Electrical Code, NFPA 70. Additionally, the requirements within this standard also apply to apparatus or parts of apparatus for use and installation in Zone 20, Groups IIIA, IIIB, and IIIC hazardous locations as well as any associated apparatus located outside of the hazardous location where the design and construction may influence the safety of an electrical circuit within the hazardous locations. The requirements found in the standard are based on ignition in locations classified as hazardous with the presence of flammable or combustible materials under normal atmospheric conditions.

(Underwriters Laboratories Inc., 2013)

UL 1203 Ed. 5 November 22, 2013, Standard for Safety for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations (including revisions through October 16, 2015)

This document serves as the fifth edition of the safety standard by the Underwriters Laboratories and is approved as an American National Standard. The standard covers requirements for explosion-proof and dust-ignition-proof electrical equipment for installation and use in Class I, Division 1, Groups A, B, C, and D, and class II, Division 1, Groups E, F, and G, hazardous locations in accordance with the National Electrical Code, NFPA 70. The requirements in this standard also cover explosion-proof electrical equipment for installation and use in Class I, Zone 1, Groups IIA, IIB, and IIC hazardous locations and dust-ignition-proof equipment use in Zone 20, 21, and 22 locations. The requirements within this standard do not cover equipment for use in hazardous locations that is already specifically covered in a separate safety standard. Additionally, the requirements do not cover electrostatic devices, circuits or systems, refrigeration system controllers, or the internal construction of electrical instruments such as meters.

(Underwriters Laboratories Inc., 2013)

UL 2225 Ed. 4 September 30, 2013, Standard for Safety for Cables and Cable-Fittings for Use In Hazardous (Classified) Locations (including revisions through March 24, 2017)

This document serves as the fourth edition of the safety standard by the Underwriters Laboratories and is approved as an American National Standard. The standard covers requirements for Type MC-HL metal-clad cable for use in Class I, Division 1, Groups A, B, C, and D; Class II, Division 1, Groups E, F, and G; Class I, Zone 1, Groups IIA, liB, and IIC; and Zone 20, 21, and 22 hazardous locations, in accordance with the National Electrical Code, NFPA 70. Additionally, the standard provides requirements that covers Type ITC-HL instrumentation tray cable for use in Class I, Division 1, Groups A, B, C, and D, and Class I, Zone 1, Groups IIA, liB, and IIC; and Zone 20, 21, and 22 hazardous locations, in accordance with the National Electrical Code, NFPA 70. Finally, the standard provides requirements that covers Type TC-ER-HL tray cable for use in Class I, Zone 1, Groups IIA, liB, and tiC hazardous locations in accordance with the National Electrical Code, NFPA 70.

(Underwriters Laboratories Inc., 2013)

UL-60079-1, Ed. 7, September 18, 2015, Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"

UL 60079-1 contains specific requirements for construction and testing of electronic equipment with electronic equipment intended for use in explosive gas atmospheres. This standard supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition. This standard details the requirements for the levels of protection "da," "db," and "dc" flameproof enclosures. This standard provides design recommendations for flameproof joints, sealed joints, operating rods, shafts and bearings, light transmitting parts, breathing and draining devices, fasteners and openings. The standard also recommends routine tests to ensure integrity of flameproof containers.

(UL-60079-1, Ed. 7, 2015)

UL-60079-2, Ed. 6, June 2, 2017, Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures "p"

UL 60079-2 contains specific requirements for the construction and testing of electrical equipment with pressurized enclosures. This standard supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition. It includes testing of, and requirements for temperature limits, safety provisions, supplying protective gas, pressurized equipment with internal release, release conditions, and enclosure design.

(UL-60079-2, Ed. 6, 2017)

UL-60079-7, Ed. 5, February 24, 2017, Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"

UL 60079-7 contains specific requirements for the design, construction, testing and marking of electrical equipment and EX components employing protection type "e" that are intended for use in explosive atmospheres. These include:

- Level of Protection "eb" (EPL "Mb" or "Gb"), standard applies to equipment when rated voltage does not exceed 11 kV r.m.s., a.c. or d.c.
- Level of Protection "ec" (EPL "Gc"), standard applies to equipment when rated voltage does not exceed 15 kV r.m.s., a.c. or d.c.

This standard supplements IEC 60079-0 and supersedes it where there is a conflict, and provides significant changes to the previous edition.

(UL-60079-7, Ed. 5, 2017)

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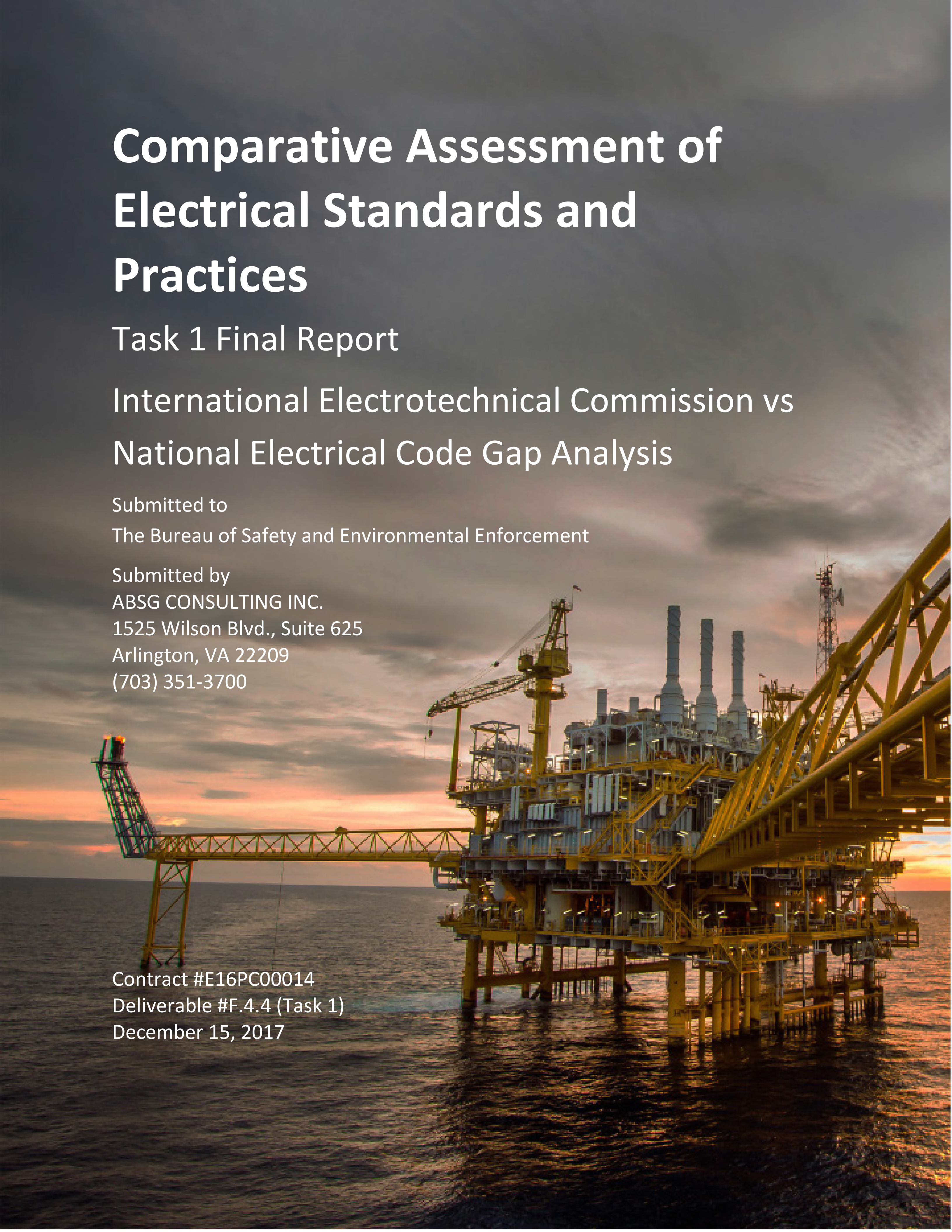
Appendix B. Task 1 Report: IEC vs NEC Gap Analysis



Comparative Assessment of Electrical Standards and Practices

Task 1 Final Report

International Electrotechnical Commission vs National Electrical Code Gap Analysis

Submitted to
The Bureau of Safety and Environmental Enforcement

Submitted by
ABSG CONSULTING INC.
1525 Wilson Blvd., Suite 625
Arlington, VA 22209
(703) 351-3700

Contract #E16PC00014
Deliverable #F.4.4 (Task 1)
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1. Introduction

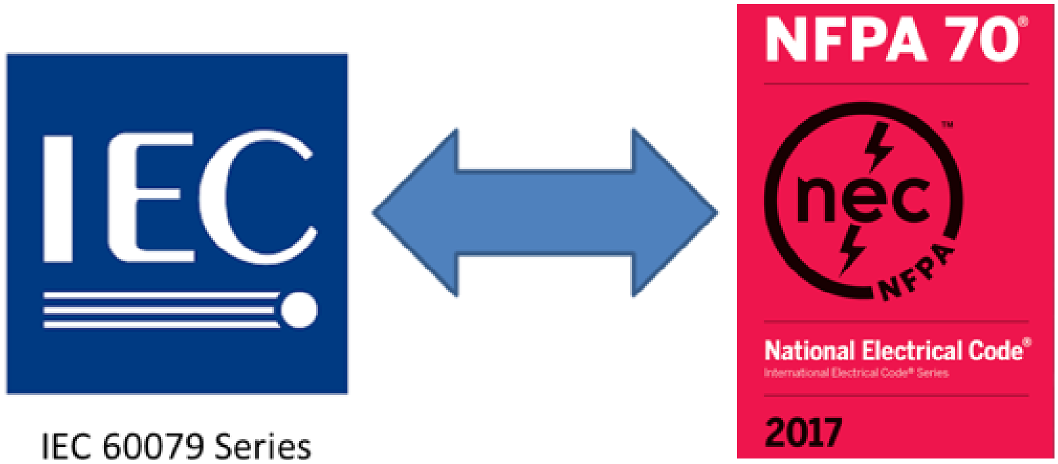
On September 16, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) Office of Offshore Regulatory Programs (OORP) contracted ABSG Consulting, Inc. (ABSG) to conduct the Comparative Assessment of Electrical Standards and Practices study (GS-00F-026A, #E16PC00014). BSEE currently incorporates various industry standards by reference into Title 30 Code of Federal Regulations (CFR) 250.198. BSEE considers it a priority to have an accurate understanding of the concepts detailed in these industry standards documents when conducting inspections of offshore oil and gas facilities to ensure compliance with regulations.

With more facilities and components being manufactured overseas to international standards, determining acceptable equivalencies between the domestic standards incorporated by reference (IBR) and the comparable international standards has become challenging. BSEE recognizes these challenges with many of the electrical standards IBR in 30 CFR 250.198. The purpose of this study was to conduct a gap analysis to compare domestic electrical standards (i.e., NEC, API, ANSI and UL standards) to international electrical standards (i.e., International Electrotechnical Commission standards). As part of this study the following comparative assessments were conducted:

- Task 1 – IEC vs. NEC standards
- Task 2 – IEC vs. API standards
- Task 3 – IEC vs. ANSI/UL standards
- Task 4 – Other gap analysis assessments
- Task 6 – United States vs International Accreditation Practices

Through this comparative gap analysis, BSEE may determine that some of the existing international electrical standards may be easier to follow by the offshore oil and gas industry, more robust, and easier to enforce. BSEE may use the results of this analysis to inform the policies and regulations associated with the electrical-related standards IBR. The ultimate goal of improved regulations is safer operations on the OCS, resulting in better protection of the environment and a reduction in the loss of life and property

This report presents the results of Task 1, the comparative assessment to determine if the requirements of International Electrotechnical Commission (IEC) 60079 series of explosive atmosphere standards meets, exceeds or does not meet the requirements of *NFPA 70, National Electrical Code* (NEC) published by the National Fire Protection Association (NFPA).



IEC 60079 Series

2. Methodology

ABSG conducted a comparative assessment to determine if the IEC 60079 Series standards meets, exceeds or does not meet the NEC. ABSG met with the BSEE program office to review the scope of the IEC vs. NEC gap analysis. During this meeting, ABSG validated BSEE's request to compare the latest editions IEC 60079 Series of standards to the NEC using the latest version, *NFPA 70 (2017)*. Based on the review, the scope of the comparative assessment focused on Class I hazardous locations (flammable gases, flammable/combustible vapors) for offshore facilities which includes the following articles of the NEC:

- Article 500 Hazardous (Classified) Locations, Classes I, II, and III, Divisions 1 and 2
- Article 501 Class I Locations
- Article 504 Intrinsically Safe Systems
- Article 505 Zone 0, 1, and 2 Locations

The assessment included a comparison of various subjects in the NEC and IEC. Using an analysis template, the project team reviewed articles 500, 501, 504, 505 of the NEC compared the information in these articles to the IEC 60079 Series standards to determine how this international standard either met, exceeded or did not meet the domestic standard. The assessment focused in the following subject area;

- Hazardous Location Classification Methods
- Wiring methods,
- Lighting methods,
- Motor requirements,
- Harmonics mitigation and recording requirements,
- Power quality,
- Electrical protections,
- Electrical equipment construction and installation.

This report is structured to summarize the results of this comparative assessment in each of the subject areas listed above. Each section includes a brief overview of the subject area, a table highlighting the assessment results and a discussion where there are differences between the international and domestic standards.

To conduct the analysis, ABSG developed a Standards Analysis Tool to facilitate the comparative assessment. The Standards Analysis Tool was used to map the domestic baseline standard (NEC) to the comparable section of the international standard (IEC 60079 series of standards). The Standards Analysis Tool incorporated an Impact Type criteria, which allowed for a side-by-side comparison of each section of the domestic baseline standard (NEC) to the comparable section of the international standard (IEC 60079 series of standards). Lastly, the Standards Analysis Tool included an analysis section for the SME to provide comments on the impact category that was selected. The comments includes a justification of each designation (meets, exceeds, or does not meet) descriptions of similar provisions, additional requirements or shortfalls. Summary versions of the completed analysis templates are provided in Appendices A through F as references in this report.

Table 1 provides a description of the Impact Type criteria used for the comparative assessment. The subject matter expert (SME) reviewed each section and assigned an impact category.

Table 1: Impact Type Criteria

Impact Category	Description
Type 1 - Exceeds	The International Electrotechnical Commission standards exceed the standards currently used by BSEE
Type 2 - Meets	The International Electrotechnical Commission standards meet the standards currently used by BSEE
Type 3 - Does Not Meet	The International Electrotechnical Commission standards does not meet the standards currently used by BSEE

3. Hazardous Location Classification Methods

The NEC contains methods for classifying hazardous locations that are widely used for electrical installation on offshore facilities in OCS (Outer Continental Shelf). API RP 14F (2008), the recommended practice for design, installation and maintenance of electrical systems for fixed and floating offshore petroleum facilities for unclassified and Class I, Division 1 and Division 2 locations, requires that the electrical systems in offshore petroleum facilities be designed and installed in accordance with the NEC except where specific departures are noted. NEC Articles 500, 501 and 505 describe the requirements regarding hazardous area classification, types of protection techniques and suitability of electrical equipment for installation in hazardous areas as described below.

IEC 60079 Explosive atmospheres - Part 0: Equipment – General requirements (IEC 60079-0) contains the requirements for construction, testing and marking of electrical equipment and Ex components intended for use in explosive atmospheres. *IEC 60079 Explosive atmospheres - Part 10-1: Classification of areas – Explosive gas atmospheres* (IEC 60079-10-1) provides information regarding the classification of areas into different Zones such as Zone 0, Zone 1 and Zone 2. Other parts of the IEC 60079 series of standards cover specific requirements for the construction and testing of electrical equipment with different types of protection techniques such as flameproof enclosure, pressurized enclosure, and intrinsically safe. Also, *IEC 60079 Explosive atmospheres - Part 14: Electrical installations design, selection and erection* (IEC 60079-14) contains the specific requirements for the design, selection and initial inspection of electrical installations in hazardous areas.

Table 2 provides a summary of the analysis of hazardous location classification methods. Subsequent discussions below provide an analysis of the similarities and differences between the baseline domestic standard (NEC Articles 500 and 505) and the associated sections of IEC 60079 series of standards.

Table 2: Hazardous Location Classification Methods Assessment Results

Section Title / Subject Issue	Baseline Standard NEC Art. 500 and 505	International Standard IEC 60079 Series	Assessment Results
Classification of Locations and Material Groups	505.5 and 505.6	Part 10-1 3 (Terms and Reference); 4.1 (Safety Principles); 4.2 (Area Classifications Objectives)	Type 2 - Meets
Protection Techniques	505.8	Part 0, Section 1 (Scope)	Type 3 - Does Not Meet
Suitability of Electrical Equipment	505.9	Part 0, Section 29	Type 3 - Does Not Meet
Intrinsically Safe System	504	Part 11 (Equipment protection by intrinsic safety 'i')	Type 3 - Does Not Meet
Gas Dispersion Models between a national standard and equivalent IEC standard	NFPA 59A	Part 10-1 Section 5 (Area Classification Methodology)	Type 1 - Exceeds

3.1 Classification of Hazardous Areas (NEC Art. 500 and Art. 505 vs. IEC 60079 series parts)

NEC Article 500 provides requirements and describes how Class I, II and III locations should be classified. Class I locations are the locations where flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors can exist under normal operating conditions. Class II locations have the presence of combustible dust and Class III locations have the presence of ignitable fibers or combustible flyings. This analysis focuses on Class I locations which pertains to offshore installations. NEC Article 500 describes the Division method whereas NEC Article 505 covers the requirements based on the Zone method. No IEC standard exists for the Division method while IEC 60079-10-1 covers the Zone Classification method.

NEC Article 500.5 Classifications of Locations, provides definitions and classifications for Class I locations. Class I locations are divided into Division 1 and Division 2 locations. Class I, Division 1 locations are defined as a location in which ignitable concentration of gases and vapors can exist under normal operating conditions. This classification includes locations containing:

- Open tanks or vats of volatile flammable liquids
- Gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape
- All other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

Class I, Division 2 locations are defined as a locations in which volatile flammable gases are not likely to exist under normal operating condition and would only become hazardous in case of an accident or some unusual operating condition. An example of the Class I, Division 2 locations are piping without valves, checks, meters and similar devices which would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases.

Under the Division method, Class I groups are divided into Groups A, B, C and D. For these groups, classification involves determinations of maximum explosion pressure and maximum safe clearance between parts of a clamped joint in an enclosure. It is necessary, that equipment be identified not only for class but also for the specific group of the gas or vapor that will be present.

NEC Article 505.5 Classifications of Locations, defines the Zone classification method as an alternative to the division classification method as described above. Zones are divided into:

- Class I, Zone 0 is a location in which ignitable concentrations of flammable gases or vapors are present continuously or present for a long period of time.
- Class I, Zone 1 is a location in which ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions or may exist frequently because of repair or maintenance operations or because of leakage.
- Class I, Zone 2 is a location in which flammable gases or vapors are not likely to occur in normal operation, and if they do occur will only exist only for a short period.

For material groups, flammable gases are considered as Group II and subdivided into Group IIA, Group IIB and Group IIC (See Table 3). This gas and vapor subdivision is based on the maximum experimental safe gap (MESG), minimum igniting current (MIC) or both.

IEC 60079- 10-1 describes the Zone method for hazardous area classification. Zones are also divided in Zone 0, Zone 1 and Zone 2.

- Zone 0 is described as an area in which explosive gas atmosphere is present continuously for long periods or frequently.
- Zone 1 is an area in which explosive gas atmosphere is likely to occur periodically or occasionally in normal operation.

- Zone 2 is an area in which explosive gas atmosphere is not likely to occur in normal operation but if it occurs then it will exist for a short period only.

Electrical equipment placed in explosive gas atmospheres is assigned as Group II. Group II Electrical equipment is subdivided according to the nature of the explosive gas atmosphere for which it is intended. Group II is divided into:

- Group IIA
- Group IIB - Equipment marked IIB is suitable for applications requiring Group IIA
- Group IIC - Equipment marked IIC is suitable for applications requiring Group IIA or Group IIB equipment.

In general, the definitions and basis for the Zone method classification in NEC Article 505 and IEC 60079 series of standards are very similar. The Division method is not covered by the IEC 60079 series of standards however it is comparable to NEC's Zone method as shown in Table 3.

Table 3: Comparison of NEC and IEC 60079 Classification of Locations and Material Groups

Area Classification NEC Article 500	Area Classification NEC Article 505 & IEC 60079
Divisions	**Zones**
Class I, Division I	Zone 0 Zone 1
Class I, Division II	Zone 2
Division Flammable Gas Groups	**Zone Flammable Gas Groups**
Group A – Acetylene	IIC
Group B – Hydrogen	IIC
Group C – Ethylene	IIB
Group D – Methane, Propane	IIA

As shown in the table Division 2 is equivalent to Zone 2, while Division 1 is either Zone 0 or Zone 1. Zone 0 is reserved for areas with continuous presence of flammable gas/vapor which falls into Division 1 category since there is no separate category as Division 0. The same type of comparison can be made for gas groups. The gas groups A and B from the Division method are equivalent to gas group IIC in Zone method. Also, Gas group C is equal to group IIB and gas group D is equal to IIA.

Based on the analysis above, the IEC meets the NEC in this subject area.

3.2 Protection Techniques

NEC Article 500.7 Protection Techniques, identifies the acceptable protection techniques for electrical and electronic equipment in hazardous locations. Protection techniques for Class I, Division 1 or Division 2 locations include:

- Explosion proof equipment,

- Purged and pressurized,
- Intrinsic safety,
- Nonincendive circuit,
- Nonincendive equipment,
- Oil immersion,
- Hermetically sealed and
- Combustible gas detection systems.

Similarly, NEC Article 505 identifies acceptable protection techniques such as:

- Flameproof
- Pressurization
- Intrinsic safety
- Type of protection
- Oil immersion
- Increased safety
- Encapsulation
- Powder filing and
- Combustible gas detection system.

The above protection techniques covered by NEC Article 505 are based on IEC 60079-0.

IEC 60079 does not identify some of the protection techniques contained in the NEC, such as explosion proof equipment. Part 1 of the IEC 60079 discusses explosive atmosphere and contains provisions for equipment protection by flameproof enclosures. This part of the IEC provides requirements on flameproof enclosures, which is comparable to explosion proof enclosure described in the NEC. However, there are differences between explosion proof enclosures used in NEC Article 500 and flameproof enclosures used in IEC 60079-1. For example, the explosion proof enclosures have higher withstand rating than the flameproof enclosures. The explosion proof enclosures in NEC Article 500 are individually factory tested to four times the maximum pressure that is released in an explosion, whereas the flameproof enclosures are referenced in IEC 60079-1 are tested to 1.5 times the maximum pressure that is released in an explosion.

The IEC 60079 also does not cover the combustible gas detection system, which is identified as an acceptable method by both NEC Article 500 and NEC Article 505. Combustible gas detection systems are installed on the offshore platforms to detect combustible gas leaks in equipment and piping and to warn personnel of such leaks and to initiate remedial action. Combustible gas detection systems are also installed in the hazardous area which reduces the level of area classification.

Based on the analysis above, IEC 60079 does not meet the level of safety as in the NEC since IEC 60079 does not identify explosion proof equipment and combustible gas detection system as protection techniques.

3.3 Suitability of Electrical Equipment

NEC Article 500.8 Equipment, provides the requirements in regard to the suitability of the electrical equipment for installation in hazardous areas. The suitability of an identified equipment should be based on one of the following:

- Equipment listing or labeling
- Evidence of equipment evaluation from a qualified testing laboratory or testing agency
- Evidence acceptable to AHJ such as a manufacturer's self-evaluation or an owner's engineering judgment.

Equipment shall be marked to show the information such as Class, Division, Material Classification Group, Equipment Temperature and Ambient Temperature Range unless otherwise specified under special allowance. According to NEC Article 505.9 Equipment, Zone equipment meeting one or more protection techniques mentioned in Section 3.1.2 above should be marked with the following order

1. Class
2. Zone
3. Symbol 'AEx'
4. Protection technique(s)
5. Applicable material group
6. Temperature classification.

IEC 60079-0 provides information regarding marking. Marking should include the information such as:

- The name of the manufacturer or the registered trademark
- The manufacturer's type identification
- Serial number
- Name of the certificate issuer
- Symbol 'X' if it is necessary to indicate any specific use
- Symbol 'Ex" corresponding to one or more type of protection
- Symbol of each type of protection
- Symbol of the group such as group IIA, IIB or IIC
- Symbol indicating temperature class
- Symbol Ta or Tamb together with the range of ambient temperature.

As described above, the IEC standard does not require the equipment to be marked with Class I. However, it can be identified based on group type indicated on the equipment label. In addition, IEC 60079 does not require the equipment to be marked with type of Zone such as Zone 0, Zone 1 or Zone 2. However, it can be identified based on the type of protection used for the equipment. For example, protection type code 'ia' is suitable for installation in Zone 0, whereas protection type code 'ib' is suitable for installation in Zone 1.

As described above, the marking and listing requirements in the NEC differ from the requirements presented by IEC standard. As such, the IEC standard does not meet the marking and listing requirements described by NEC.

3.4 Intrinsically Safe System

NEC Article 504 Intrinsically Safe Systems, states that all intrinsically safe apparatus and associated apparatus shall be listed by a qualified electrical testing laboratory. However, a simple apparatus described on the control drawing shall not be required to be listed. An intrinsic safety barrier, which limits the energy to intrinsically safe apparatus located in hazardous area, is an example of a safety apparatus. General purpose enclosures are permitted for intrinsically safe apparatus and associated apparatus unless otherwise specified in the manufacturer's documentation. For intrinsically safe systems, the test conditions are described in *ANSI/UL 913 Standard for safety, intrinsically safe apparatus and Associated Apparatus for Use in Class I, II and III, Division 1, Hazardous Locations* (UL913). UL 913 contains construction and performance requirements for intrinsically safe systems.

IEC 60079, *Explosive atmospheres, – Part 11: Equipment protection by intrinsic safety "i"* (IEC 60079-11) describes spark ignition and thermal ignition compliance requirements, along with the apparatus construction requirements. However, that the IEC does not require that all intrinsically safe apparatus be tested by an independent testing lab.

Based on this analysis, the IEC standard does not meet the requirements described in NEC Article 504.

3.5 Gas Dispersion Models

A gap analysis between *NFPA 59A, Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)* and IEC 60079-10-1 was completed on the gas dispersion models. NFPA 59A is the standard for the production, storage and handling of LNG. NFPA 59A provides limited guidance on the use of vapor dispersion models for the analysis of safety features. IEC 60079-10-1 provides information on different criteria that can be considered for a gas/vapor dispersion model.

NFPA 59A does not contain any guidance or requirements regarding the criteria for the gas dispersion models. However, NFPA 59A refers to the model described in *Gas Research Institute Report 0242 "LNG Vapor Dispersion Prediction with the DEGADIS Dense Gas Dispersion Model*". This model incorporates the physical factors influencing LNG vapor dispersion, including but not limited to gravity spreading, heat transfer, humidity, wind speed and direction, atmospheric stability, buoyancy and surface roughness.

IEC 60079-10-1 describes different approaches (methods) that can be taken to classify an area where there may be an explosive gas atmosphere. One of the methods is the classification by sources of release method. The source of release approach consists of:

1. Identifying the source of the release

2. Determine the release rate and grade of release for each source based on the likely frequency and duration of release.

Each item of process equipment such as tank, pump, and pipeline should be considered as a potential source of release of a flammable substance. Characteristics of any release depends on the physical state of the flammable substance, its temperature and pressure. Another method that can be considered is the Simplified Method. The simplified method may be used where it is not practicable to make required assessments from individual sources of release. Simplified methods shall identify sources for each of the zone types, Zone 0, 1 and 2 that are suitably conservative to allow for the potential sources of release without individual detail. Larger zone areas are characteristic of simplified methods. Another approach is the use of combination methods where the use of different methods may be appropriate for classification of a platform at various stages of its development or for various parts of the plant.

As described above, the NEC doesn't contain any guidance or requirements regarding the criteria for the gas dispersion models. However, a national standard such as NFPA 59A, refers to a model described in *GRI Report 0242*. IEC 60079-10-1 describes different methods that can be used to classify a hazardous area. Three methods are called simplified methods, classification by sources of release and combination methods. Any of these methods can be considered based on the physical factors and practical application of it. Based on this information, the IEC 60079-10-1 exceeds the information and requirements described in NFPA 59A.

4. Wiring Methods

NEC Article 501.10 Wiring Methods, covers the different types of wiring methods that are permitted in Class I, Division 1 and Division 2 locations. NEC Article 505.15 Wiring Methods, covers the wiring methods that are allowed in Class I, Zone 0, Class I, Zone 1 and Class I, Zone 2 locations.

Table 4 provides a summary of the analysis of wiring methods. Subsequent discussions below provide an analysis of the similarities and differences between NEC Articles 501, 505 and the IEC 60079 Series.

Table 4: Wiring Methods Assessment Results

Section Title / Subject Issue	Baseline Standard NEC Art. 500 and 505	International Standard IEC 60079 Series	Assessment Results
Wiring Methods/ Specific Wiring Methods	505.10 & 505.15	IEC 60079-14 Section 9 (Cables and Wiring System)	Type 3 - Does Not Meet
Sealing and Drainage	501.15 & 505.16	IEC 60079-14 Section 9 (Cables and Wiring System)	Type 2 - Meets
Grounding and Bonding	501.30 and 505.25	IEC 60079-14 Section 9 (Cables and Wiring System)	Type 3 - Does Not Meet

In Class I, Division 1 locations, threaded rigid metal conduits or threaded steel intermediate metal conduit, type mineral insulated (MI) cable terminated with suitable listed fittings are allowed to be installed. Also, in areas with restricted access of qualified persons, Type MC-HL (metal-clad cable for hazardous locations) Cable and type ITC-HL (Instrumentation tray cable for hazardous locations) listed for use in Class I, Zone 1 or Division 1 locations, with gas/vapor tight continuous corrugated metallic sheath are allowed for use.

For Class I, Division 2 locations, wiring methods that are suitable for Class I, Division 1 locations are acceptable. Additionally for Class I, Division 2 locations, other types of permitted wiring methods authorized include:

- Enclosed gasketed busways,
- Enclosed gasketed wireways,
- Type MC,
- Type MV (medium voltage cable),
- Type TC (Power and Control tray cable) and cablebus.

Wiring methods described under the Division method in the NEC are comparable to wiring methods for Zone in the IEC.

4.1 Specific Wiring Methods

NEC Article 505.15 identifies the specific wiring methods permitted for installation in Class I, Zone 0, Zone 1 and Zone 2 locations. For Zone 0 locations, equipment protected by intrinsic safety methods and equipment protected by encapsulation methods are to be connected to intrinsically safe circuits with the wiring methods described per NEC Article 504. According to NEC Article 504, intrinsically safe circuits shall be installed separately from non-intrinsically safe circuits when placed in any raceways and cable trays. Wiring methods permitted for Class I, Division 1 locations are acceptable for Class I, Zone 1 as mentioned above. Similarly, wiring methods permitted for Class I, Division 2 locations are acceptable for Class I, Zone 2.

IEC 60079-14 describes the requirements for cables and wiring system. Cables are to be sheathed with thermoplastic, thermosetting or elastomeric material. Cables such as mineral insulated metal sheathed (Type MI Cable) are allowed for installation in hazardous areas in Zone 1 and Zone 2. Also, mineral insulated cables shall be sealed where there is likelihood that propagation of flames may occur through the interstices between individual cores of a cable. Also, the IEC requires that there shall be distance between the conductors of any core of an intrinsically safe circuit and any core of non-intrinsically safe circuits in accordance with IEC 60079-11.

The requirements in the NEC are specific with regard to type of the wiring permitted in different types of hazardous locations. Wiring methods covered by the IEC standard are general and don’t provide as much detail as in the NEC. As such, the wiring methods covered by the IEC standard do not meet the requirements presented by NEC.

4.2 Seals and Drainage

For Class I, Division 1 or Zone 1 locations, the NEC requires that each conduit entry into an explosion proof enclosure or a flame proof enclosure should be provided with a conduit seal where the enclosure contains apparatus such as switches, circuit breakers, fuses, relays or resistors. For Zone 0 locations, seals in conduit are to be provided within 10 feet of where a conduit leaves a Zone 0 location.

IEC 60079 also requires that the conduit shall be provided with a conduit sealing device where it enters or leaves a hazardous area to prevent the transmission of gases or liquids from the hazardous area to non-hazardous area. Cable glands are to be sealed with setting compound (barrier cable glands) in accordance with IEC 60079-1 and are to be certified.

Based on the above analysis, the requirements described in IEC standard meet the requirements in the NEC standard.

4.3 Grounding and Bonding

NEC Article 501.130 Grounding and Bonding, Class I, Divisions 1 and 2 contains the requirements for grounding and bonding in Class I, Division 1 and 2 locations. NEC Article 505.25 Grounding and Bonding, contains the requirements for grounding and bonding in Class I, Zone 0, Zone 1 and Zone 2 locations. Wiring and equipment in Class I, Division 1 and Division 2 or Class I, Zone 0, Zone 1 and Zone 2 are to be grounded per requirements specified in NEC Article 250 Grounding and Bonding, Class I, Divisions 1 and 2. Flexible metal conduit and liquid tight flexible metal conduit are to include an equipment bonding jumper of the wire type in accordance with NEC Article 250.102 Grounded Conductor, Bonding Conductors, and Jumpers.

IEC 60079-14 provides some information about grounding. For example, the conduit system is allowed to be used as a protective earthing conductor (Equipment grounding conductor) provided that the threaded junction is suitable to carry the fault current.

The NEC requires a separate equipment grounding conductor or equipment bonding jumper whereas the IEC allows the conduit system to be used as the equipment grounding conductor. Based on the analysis the grounding requirements in the IEC standard does not meet the requirements covered by the NEC.

5. Lighting Methods

Table 5 provides a summary of the analysis of lighting methods. For lighting methods, the requirements in IEC 60079 meets the NEC Articles 500 and 505, as discussed below.

Table 5: Lighting Methods Assessment Results

Section Title / Subject Issue	Baseline Standard NEC Art. 500 and 505	International Standard IEC 60079 Series	Assessment Results
Lighting Methods	Article 501.130	IEC 60079-0 Section 21; IEC 60079-14 Section 12	Type 2 - Meets

NEC Article 501 describes the requirements for lighting methods. For Class I, Division 1 locations, each luminaire should be identified as a complete assembly and shall be clearly marked for the maximum wattage lamps for which it is identified. Box, box assemblies or fittings used for the support of the luminaire shall also be suitable for installations in Class I locations. The article also describes some specific requirements in regards to lighting fixtures installations such as for Class I, Division 1 and Division 2 locations. For example, pedant luminaires should be suspended and supplied by threaded RMC stems/threaded steel intermediate conduit stems and threaded joints should be secured with set-screws or other effective means to prevent loosening.

IEC 60079-0 and IEC 60079-14 describe some design and installation requirements for lighting and luminaires. For example, it describes that mounting of luminaires shall not depend on just one screw. A single eyebolt may be used only if this is an integral part of the luminaire, such as by being cast or welded to the enclosure. There are requirements about the types of lamps and types of luminaires that can be installed in hazardous locations. Luminaires with fluorescent lamps and electronic ballast in types of protection ‘e’ or ‘nA’ are not to be installed in areas where the ambient temperature exceeds 60° C. Also, lamps with metallic sodium are not permitted.

Overall, the requirements for lighting methods contained in the IEC standards are comparable with the requirements described in the NEC. IEC standards cover the design and installation requirements for lighting methods, whereas NEC emphasizes more on installation requirements of lighting methods. Based on the analysis above, the lighting method requirements described in IEC standards meet the requirements indicated in NEC articles.

6. Motor Requirements

Table 6 provides a summary of the analysis of motor requirements. Subsequent discussions below provide an analysis of the similarities and differences between the NEC Articles 500 and 505 and the IEC 60079 Series.

Table 6: Motor Requirements Assessment Results

Section Title / Subject Issue	Baseline Standard NEC Art. 500 and 505	International Standard IEC 60079 Series	Assessment Results
Motors and Generators	Article 501.125	IEC 60079-14 Section 5; IEC 60079-0 Section 17 & 26; IEC 60079-1 Section 15	Type 2 - Meets
Transformers and Capacitors	Article 501.100	IEC 60079-7 Section 6	Type 3 - Does Not Meet
Increased Safety 'e' Motors and Generators	Article 505.22	IEC 60079-7 Section 9; IEC 60079-14 Section 11	Type 3 - Does Not Meet

6.1 Motors and Generators

NEC Article 501.125 Motors and Generators, describes the requirements for motors, generators and other rotating electrical machinery installed in Class I, Division 1 or 2 locations. For Class I, Division 1 locations, motors are to be identified for Class I, Division 1 location. Totally enclosed type of motors supplied with positive-pressure ventilation from a source of clean air with discharge to a safe area are allowed to be installed in the hazardous areas. Also, the motors should be provided with the arrangement to prevent energizing until ventilation has been established and the enclosure has been purged with at least 10 volumes of air.

NEC Article 501.125 allows open or non-explosionproof enclosed motors given that these motors are squirrel-cage induction motors without brushes, switching mechanisms or any other arc-producing devices in Class I, Division 2 locations. Also, motors with sliding contacts, any type of switching mechanism (including motor overcurrent, overloading and over-temperature devices) are to be suitable for Class I Division 1 locations whether they are installed in Division 1 or Division 2 locations.

The IEC describes different types of protection technique methods that can be used for rotating equipment, such as motors and generators, for installation in hazardous areas. Such protection techniques are flameproof enclosures, increased safety, pressurized enclosures and non-Sparking. Rotating equipment such as motors with flameproof enclosures are suitable for installation in Zone 1 areas. Equipment that is suitable for installation in Zone 1 area, may also be suitable for installation in Class I, Division 1 location except in certain locations such as cargo oil tanks.

According to IEC 60079-2, motors with pressurized enclosures for Zone 1 and Zone 2 locations are to be provided with suitable ingress protection. An automatic control system including safety devices shall be provided to energize the electrical equipment within a pressurized enclosure only after purging has been completed. For example, a pressurized enclosed motor with “enhanced” level of protection is suitable for installation in Zone 2 location.

In general, the requirements contained in the IEC for motors installed in hazardous areas are comparable to the requirements provided in the NEC. The IEC standards describe that rotating equipment, protected with different protection techniques, such as flameproof enclosure, pressurized enclosure, increased safety or non-Sparking, are allowed to be installed in Zone 1 and Zone 2 areas. For example, a motor with a flameproof enclosure is suitable for installation in Zone 1 location.

Based on the analysis, the IEC standards meet the requirements in the NEC for motors and generators in hazardous areas.

6.2 Transformers and Capacitors

NEC Article 501.100 Transformers and Capacitors, provides some requirements in regard to the installation of transformers in hazardous areas. For Class I, Division 1 locations, liquid filled transformers are to be installed in vaults whether the liquid will burn or not. In lieu of vaults, liquid filled transformers are to be certified for Class I locations. For Class I, Division 2 locations, dry type transformers, less-flammable liquid-insulated transformer, Nonflammable Fluid-Insulated transformers, Askarel-Insulated transformers and Oil insulated transformers are allowed to be installed in accordance with Article 450.21 through 450.27.

IEC 60079 Explosive atmospheres – Part 7: Equipment protection by increased safety «e» (IEC 60079-7) provides test requirements for the temperature rise of power transformers. It also provides test requirements for the temperature rise of the instrument transformers.

The IEC standard does not provide any comparable information with regard to transformers as covered by the NEC. Therefore, the IEC standard does not meet the requirements covered by the NEC with regard to transformers.

6.3 Increased Safety 'e' Motors and Generators

NEC Article 505.22 Increased Safety "e" Motors and Generators, describes the requirements for the increased safety 'e' motors for Class I, Zone 1 locations. Increased safety 'e 'motors of all voltage levels are to be listed for Zone 1 locations and motors are to be marked with the starting current ratio, IA/IN and time, tE. Motor controllers are to be marked with the model/identification number, output rating, full load amps, starting current ratio (IA/IN) and time (tE) of the motors. The IEC standard also requires that motors with type of protection 'e' should be additionally marked with the starting current ratio IA/IN and time tE. Also, the IEC standard requires that inverse-time delay overload protective devices shall be such that not only is the motor current monitored, but a stalled motor will also be disconnected within the time tE stated on the marking plate.

The requirements in the NEC and the IEC standard are comparable. However, the NEC requires the motor controller to have the specific marking when provided for motors with type of protection 'e'. Based on the analysis described above, the requirements for increased safety 'e' motors described in the IEC standard do not meet the requirements provided in the NEC article as described above.

7. Harmonics Mitigation and Recording Requirements Methods

The NEC does not have any direct requirements in regard to harmonic mitigation and recording requirements methods. The NEC does provide some guidance to address the issues due to harmonics, especially the 3rd harmonics. Article 310.10(H) describes one of requirements for existing installations, grounded neutral conductors smaller than 1/0 AWG are permitted to alleviate overheating of neutral conductors due to high content of triplen harmonic currents.

Additional information on harmonics can be found in Chapter 10 of *NFPA 70B, Recommended Practice for Electrical Equipment Maintenance*.

IEC 61000 Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto, (IEC 61000-4-7) provides general guidelines on harmonics, inter-harmonics measurements and instrumentation. In order to determine whether IEC 61000-4-7 meets, exceeds or does not meet NFPA 70B, it is recommended that further analysis comparing the IEC standard and NFPA 70B needs to be carried out.

8. Power Quality

The NEC does not have any direct requirements in regards to power quality. However, the NEC does provide guidance in fine print notes to address some of the power quality issues. One of the requirements is that conductors for branch circuits, in order to provide reasonable efficiency of operation, should be sized to prevent the voltage drop of more than 3% and the voltage drop on both feeder and branch circuits should not exceed 5% according to NEC Article 210.19(A) FPN No.4. Article 280 Surge Arresters, Over 1000 Volts, contains some requirements about the surge arresters (installation requirements and connection requirements).

IEC 60079 does not contain power quality requirements. IEC 61000, Part 1 through Part 7 on Electromagnetic compatibility provides information on power quality and power-quality-related issues. In order to conclude whether IEC 61000 series meets, exceeds or does not meet NFPA 70B, it is recommended that further analysis comparing IEC 61000 and NFPA 70B needs to be carried out.

9. Surge Protection

Table 7 provides a summary of the analysis of the surge protection requirements. Subsequent discussions below provide an analysis of the differences between the NEC Articles 500 and 505 and the IEC 60079 Series.

Table 7: Surge Protection Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard NEC Art. 500 and 505	International Standard IEC 60079 Series	Assessment Results
Surge Protection	501.35	Annex F IEC 60079-25	Type 3 - Does Not Meet

NEC Article 501.35 Surge Protection, contains some requirements about the surge protection devices installation in hazardous area. For Class I, Division 1 locations, surge arresters, surge-protective devices and capacitors shall be installed in enclosure identified for Class I, Division 1 location. Also, surge protective capacitors shall be of a type designed for specific duty. For Class I, Division 2 locations, surge arresters and surge-protective devices shall be non-arcing, such as metal-oxide varistor (MOV) sealed type. Enclosures shall be permitted to be of the general-purpose type.

In general, IEC 60079 series does not contain many requirements about the surge arresters except in Annex F of IEC 60079 part 25. Annex F provides information on use of surge arrester protect against lightning induced surges.

Based on the analysis described above, the surge protection devices in the IEC 60079 do not meet the requirements described in NEC.

10. Electrical Protections

Table 8 provides a summary of the analysis of electrical protection requirements. Subsequent discussions below provide an analysis of the similarities between the NEC and the IEC.

Table 8: Electrical Protection Requirements Assessment Results

Section Title / Subject Issue	Baseline Standard NEC Art. 500 and 505	International Standard IEC 60079 Series	Assessment Results
Electrical Protection	501.115	Multiple IEC 60079 Series Parts	Type 2 - Meets
Instruments and Relays	501.105	IEC 60079 Part 7 and Part 14	Type 2 - Meets

10.1 Electrical Protection

NEC Article 501.115 Switches, Circuit Breakers, Motor Controllers, and Fuses, provides the requirements for electrical protective devices such as switches, circuit breakers, motor controllers installed in hazardous locations. For Class I, Division 1 locations, switches, circuit breakers, motor controllers and fuses are to be provided with the suitable enclosures. The explosionproof enclosures and purged/pressurized enclosures are considered as suitable enclosures. For Class I, Division 2 locations, a general-purpose enclosure can be acceptable if it meets certain conditions such as the interruption of current occurs within a chamber hermetically sealed or the interruption occurs within an enclosure identified for the location. Also, for Class I, Division 2 locations, the general-purpose enclosure can be acceptable if the device is a solid state, switching control without contacts where the surface temperature does not exceed 80% of the auto ignition temperature of the gas or vapor involved.

IEC 60079-1 and IEC 60079-7 provide the requirements for equipment protection by flameproof enclosures and increased safety 'e' respectively. The IEC standards allow circuit breakers and switches in flameproof enclosures along with the increased safety 'e' method to be installed in Zone 1 areas. Per

IEC 60079-7, Clause 5.9, non-renewable types of fuses with increased safety protection are allowed to be installed in Zone 2 locations. IEC 60079-11, clause 7.3 requires that fuses with intrinsic safety protection are to be encapsulated, which allow the fuses to be installed in Zone 1 locations.

Based on the analysis, the IEC 60079 provisions for the installation of the electrical protective devices meets the NEC Article 501.115.

10.2 Instruments and Relays

Similarly, NEC Article 501.105 Meters, Instruments, and Relays, provides the requirements for instruments and relays to be installed in hazardous areas. For Class I, Division 1 locations, instruments and relays including current transformers, resistors and rectifiers are to be provided with enclosures identified for Class I, Division 1 locations. For Class I, Division 2 locations, contacts such as switches, circuit breakers, make and break contacts of pushbuttons, relays, alarm bells and horns are to be installed in an enclosure suitable for Class I, Division 1 locations. General purpose enclosures are allowed in cases without make-or-break contacts such as transformer windings, impedance coils, solenoids and other windings that do not incorporate sliding or make-or-break contacts.

In similar manner, the IEC standards also contain requirements in regard to devices and components that can produce arc or spark during normal operation. The IEC standard describes the parts which in normal operation can produce arcs, sparks or hot surfaces which otherwise would be capable of igniting a surrounding atmosphere shall be protected against causing ignition by one or more of the following methods:

- Enclosed-break device
- Nonincendive component
- Hermetically sealed device
- Sealed device
- Restricted-breathing enclosure

For Zone 2 locations, Non-rewirable and non-indicating cartridge types fuses can be deemed as non-sparking devices therefore fuses of this type can be installed in general type of enclosures.

In general, the NEC allows the installation of electrical protective devices in the hazardous area given that they are provided with suitable enclosures such as the explosion proof enclosure. For Class, I Division 2 locations, the NEC allows circuit breakers, switches, and motor controllers to be installed in a general type enclosure given that the electrical part designed to interrupt the current is provided with the acceptable type of protection. Similarly, the IEC standards require for Zone 1 and Zone 2 installations current interrupting contacts that can produce arcs or sparks which would be capable of igniting a surrounding atmosphere are to be installed in suitable enclosures such as a flameproof enclosure.

Based on the analysis, the IEC 60079 provisions for instruments and relays meets the NEC Article 501.115.

11. Electrical Equipment Construction and Installation

Table 9 provides a summary of the analysis of electrical equipment construction and installation standards. Subsequent discussions below provide an analysis of the differences and similarities between the NEC and the IEC.

Table 9: Electrical Protection Standards Assessment Results

Section Title / Subject Issue	Baseline Standard NEC Art. 500 and 505	International Standard IEC 60079 Series	Assessment Results
Guarding against Electrical shock and arc flash risks	Article 110	IEC 61482-1-1, IEC 61482-1-2	Type 1 - Exceeds
Protecting Equipment from ingress of solid foreign objects	Article 110.28	IEC 60529 (Section 4)	Type 3 - Does Not Meet

11.1 Guarding against Electrical Shock and Arc Flash Risks

NEC Article 110 Requirements for Electrical Installations, specifies that electrical equipment that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a warning sign stating potential electric arc-flash hazards. This equipment includes switchboards, switchgear, panel boards, etc. The NEC refers to *NFPA 70E-2015, Standard for Electrical Safety in Workplace* for further guidance regarding this topic.

IEC 61482 (series) Live working - Protective clothing against the thermal hazards of an electric arc, covers the requirements with regard to guarding against arc flash risks. In addition to the marking required by the equipment design standards, arc flash data and the required personal protective equipment (PPE) are to be indicated at each location where work on high voltage equipment could be conducted. This IEC standard also covers the methods for testing of clothing fabrics and garments that are designed to protect against arc flashes. Requirements regarding the switchgear and control gear assemblies are covered in *IEC 62271 High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV.*

As described above, the NEC doesn't contain extensive requirements in regard to Arc-flash. However, the IEC standards contain the requirements regarding the testing of PPE. In this area, sections of IEC 61482-1-1 and 61482-1-2 exceed the requirements in Article 110 of the NEC.

11.2 Protecting Equipment from ingress of solid foreign objects

NEC Article 110.28 Enclosure Types, contains requirements regarding the types of enclosures that can be installed in different environmental conditions. Table 110.28 Enclosure Selection in the NEC provides a selection of enclosures based on the degree of protection against the environmental conditions and location of enclosure (indoor or outdoor use). The enclosures are meant to provide a degree of protection against different environmental conditions such as falling dirt, falling liquids & light splashing, temporary submersion and permanent submersion including incidental contact with the enclosed equipment. The NEC advises in the guidance notes that Ingress protection (IP) ratings may be found in *ANSI/NEMA 60529 (Degrees of Protection Provided by Enclosures*. Also, the NEC suggests that IP ratings are not a substitute for Enclosure type ratings.

IEC 60529 Degrees of Protection Provided by Enclosures (IP Code), defines the degree of protection provided by an enclosure. The enclosure rating is indicated by the IP Code. The enclosures are to protect against the incoming solid foreign objects as well as against the harmful effects of ingress water. The enclosure ratings in IEC is provided with the combination of two digits, i.e. IP22. First digit indicates the level of protection against the solid objects and the second digit indicates the level of protection against water.

The degree of protection provided by an enclosure that is identified by IP rating is comparable to the enclosure type number identified in NEC Table 110.28. For example, an enclosure with IP 22 rating is comparable to enclosure type 2 indicated in NEC. It should be noted that for most part the degree of protection provided by an enclosure with IP code is comparable to the type rating of the enclosure identified in NEC. However, there are enclosures with enclosure type rating 4X and 7, for which there are no equivalent enclosures identified by IP rating.

Based on this analysis, the IEC standard 60529 does not meet the requirement in NEC Article 110.28.

11.3 Design Criteria for submarine cable used for subsea production equipment

The NEC does not contain any requirements for the submarine cables. NEC Article 340 Underground Feeder and Branch-Circuit Cable: Type UF, provides the information on the use, installation and construction specifications for underground cables and branch-circuit cables and does not provide any information on submarine cables. Similarly, there is no specific IEC standard that provides requirements for submarine cables. The *API Specification 17E, Specification for Subsea Umbilicals* and *IEEE 1120 IEEE Guide for the Planning, Design, Installation, and Repair of Submarine Power Cable Systems* provide design criteria for submarine cables.

12. Summary Conclusion and Recommendations

12.1 Comparative Assessment Conclusions

Based on the comparative assessments in the above sections, various sections of the IEC meet, exceed do not meet the NEC.

IEC 60079 ***meets*** the requirements outlined in NEC Articles 500, 501 and 505 in the following hazardous areas subject areas:

- Classification of hazardous areas

- Seals and drainage
- Lighting methods
- Motor and generators
- Electrical protection
- Instrument and relays

On the other hand, the IEC standard ***exceeds*** the NEC standard in the subject areas of:

- Gas dispersion models
- Guarding against electrical shock and arc flash risks

The IEC standard ***does not meet*** the requirements outlined in the NEC standard, in the subject areas of:

- Protection techniques
- Suitability of electrical equipment
- Intrinsically safe system
- Specific wiring methods
- Grounding and bonding
- Transformers and capacitors
- Increased safety 'e' motors
- Surge protection
- Protecting equipment from ingress of solid foreign objects

Neither the NEC nor the IEC 60079 contained requirements on:

- Harmonics mitigation and recording requirement methods
- Power quality
- Design criteria for submarine cables used for subsea production equipment.

12.2 Recommendations

The following recommendations are based on the comparative assessment of the between NEC Articles 500 and 505 to IEC 60079. BSEE incorporates industry standards by reference into Title 30, CFR Part 250.198. Inasmuch as these regulations represent the minimum requirements, adherence to other standards that exceed the comparable standards IBR into regulation, including international standards, should represent at least an equivalent level of safety.

The following recommendations are offered for BSEE's considerations;

1. BSEE should consider incorporating sections of IEC 60079 that exceed the comparable sections of the NEC Articles 500 and 505 as identified in this report.
2. Once incorporated into regulation by reference, BSEE should develop and/or revise the Electrical Potential Incidents of Non-Compliance that reference the NEC 500, 505 and IEC 60079. New and/or revised PINC will be considered during Task 5 of this project.

3. For electrical standards not incorporated into regulation by reference, BSEE should consider developing an audit protocol that would enable BSEE inspectors and engineers to determine compliance with these standards. Development of an audit protocol will be considered during Task 5 of this project.
4. BSEE should provide training to inspectors and engineers on the IEC 60079 so that they are familiar with the various provisions.
5. BSEE should provide inspectors and engineers with a copy of this report so they can become familiar with the result of the analysis.
6. BSEE should conduct further analysis of IEC 61000- 4-7 to determine if the harmonics, inter-harmonics measurements and instrumentation requirements in this standard meets, exceeds or does not meet the requirements in NFPA 70B.
7. BSEE should conduct further analysis of IEC 61000 series to determine if the power quality requirements in this standard meets, exceeds or does not meet the requirements in NFPA 70B.
8. BSEE should obtain copies of the NPFA 70 and the I IEC60079 series for use by engineers and inspectors.

Appendix A. Comparative Assessment Results of NEC vs IEC 60079 for Hazardous Location Classification Methods

Table 10 provides a summary of the comparative assessment between the NEC and IEC 60079. This appendix contains the analysis for the following subjects:

- Classification of Locations and Material Groups
- Protection Techniques
- Equipment and Zone Equipment
- Classification of Locations and Material Groups
- Protection Techniques
- Equipment
- Intrinsically Safe System
- Gas Dispersion Models between a national standard and equivalent IEC standard

Table 10: Comparative Assessment Results - NEC vs IEC 60079 Hazardous Location Classification Methods

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Classification of Locations and Material Groups	500.5 and 500.6			Division method described in Article 500 of NEC is not covered by IEC. IEC describes Zone method for area classification as shown below in item no.4. Division method of Classification is comparable to Zone Method.
2	Protection Techniques	500.7			Refer to analysis described in item no.5 below.
3	Equipment and Zone Equipment	500.8 and 501.5			Refer to analysis described in item no.6 below.
4	Classification of Locations and Material Groups	505.5 and 505.6	Part 10-1 3 (Terms and Reference); 4.1 (Safety Principles); 4.2 (Area Classifications Objectives)	Type 2 - Meets	Definitions and basis for the Zone method classification in NEC and IEC are same as described.

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
5	Protection Techniques	505.8	Part 0, Section 1 (Scope)	Type 3 - Does Not Meet	- NEC in Article 500 identifies explosion proof as one of the protection techniques whereas IEC does not require explosion proof equipment. However, NEC in Article 505 also allows flameproof 'd' as one of protection techniques. - Explosion proof enclosures have higher withstand rating than the Flameproof enclosures. Explosion proof enclosures are individually factory tested to four times the maximum pressure that is released in an explosion, whereas Flameproof enclosures are tested to 1.5 times the maximum pressure that are released in an explosion. - Protection techniques allowed by NEC Article 505 and IEC are the same except the combustible gas detection system. - It is to be noted that NEC in Article 500 recognizes Nonincendive Equipment as one of the protection techniques for installation in Division 2 locations. However, there is no provision made for it in NEC Article 505. IEC Standard 60079 Part 15 (Equipment protection by type of protection 'n') provides requirements for the non-incendive components producing arcs, sparks or hot surfaces. Refer to analysis on FM 3611 standard for the further information on use of Nonincendive equipment. * Note: Refer to Task 3 in regard to analysis on UL 1203 (Standard for Explosion proof electrical equipment) vs. IEC 60079-1 for further details.
6	Equipment	505.9	Part 0, Section 29	Type 3 - Does Not Meet	- IEC does not require the equipment to be marked with Class I. However, it can be identified based on group type indicated on the equipment label. - IEC also doesn't require the equipment to be marked with type of Zone such as Zone 0, Zone 1 or Zone 2 .

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
					However, it can be identified based on the type of protection used for the equipment. - For example, protection type code 'ia' is suitable for installation in Zone 0, whereas protection type code 'ib' is suitable for installation in Zone 1. - NEC in article 505 provides a Table 505.9(C)(2)(4) with the information on type of protection designation and corresponding type of zone. - IEC 60079 Part 14, Table 1 and Table 2 provide the same type of information on relationship between type of protection and EPL and type of zone. - Detailed information regarding marking 'AEx' and 'EEx' are covered under Task 4 analysis. Please refer to Task 4 Report for further information on marking requirements provided in NEC 505.9(C), ISA 60079 series standards verses relevant IEC 60079 series standards.
7	Intrinsically Safe System	504	Part 11 (Equipment protection by intrinsic safety 'i')	Type 3 - Does Not Meet	NEC in this article refers to UL 913 in regard to construction and performance requirements for intrinsically safe apparatus and associated apparatus. Also, UL 913 refers to UL 60079-11 for the testing requirements for this equipment. UL 60079-11 is based on IEC 60079-11. - Refer to refer to Task 3 analysis for the comparison between UL 913 and relevant IEC standard. Also, refer to task 4 analysis for the comparison between UL 60079-11 and IEC 60079-11.
8	Gas Dispersion Models between a national standard and equivalent IEC standard	NFPA 59A	Part 10-1 Section 5 (Area Classification Methodology)	Type 1 - Exceeds	NEC doesn't contain any guidance or requirements regarding the criteria for the gas dispersion models. However, NFPA 59A refers to model described in GRI Report 0242 "LNG Vapor Dispersion Prediction with the DEGADIS Dense Gas Dispersion Model". This model incorporates the physical factors influencing LNG vapor

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
					dispersion, including but not limited to gravity spreading, heat transfer, humidity, wind speed and direction, atmospheric stability, buoyancy and surface roughness. IEC 60079 Part 10-1 describes different methods that can be used to classify a hazardous area. Three methods are called as simplified methods, classification by sources of release and combination methods. Any of these methods can be considered based on the physical factors and practical application of it.

Appendix B. Comparative Assessment Results of NEC vs IEC 60079 for Wiring Methods

Table 11 provides a summary of the comparative assessment between the NEC and IEC 60079. This appendix contains the analysis for the following subjects:

- Wiring Methods
- Sealing and Drainage
- Grounding and Bonding

Table 11: Comparative Assessment Results - NEC Articles vs IEC 60079 Wiring Methods

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Wiring Methods	501.10			IEC does not cover the Division classification method. IEC covers the Zone method as described under subtask 1.1. Wiring methods described under Division method are comparable to wiring methods for Zone method as described below.
2	Wiring Methods	505.15	IEC 60079-14 Section 9 (Cables and Wiring System)	Type 3 - Does Not Meet	The requirements described in NEC are specific in nature as to what type of wiring is allowed in hazardous areas. Wiring method described in IEC is general and doesn't provide much detail.
3	Sealing and Drainage	501.15			Sealing and drainage requirements described under Division methods are comparable to equipment sealing and drainage requirements described for Zone method below.
4	Sealing and Drainage	505.16		Type 2 - Meets	In general, the requirements for seals in conduits and cables in IEC meet NEC. However, NEC specifically describes the distances where the seals in conduits and cables are to be installed in different arrangements.
5	Grounding and Bonding	501.30 and 505.25	IEC 60079-14 Section 9 (Cables and Wiring System)	Type 3 - Does Not Meet	NEC requires a separate equipment grounding conductor or equipment bonding jumper whereas IEC allows conduit system to be used as the equipment grounding conductor.

Appendix C. Comparative Assessment Results of NEC vs IEC 60079 for Lighting Methods and Motor Requirements

Table 12 provides a summary of the comparative assessment between the NEC and IEC 60079. This appendix contains the analysis for the following subjects:

- Lighting Methods
- Motors and Generators
- Transformers and Capacitors
- Increased Safety 'e' Motors and Generators

Table 12: Comparative Assessment Results - NEC Articles 500 and 505 to IEC 60079 (continued)

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Lighting Methods	Article 501.130	IEC 60079-0 Section 21; IEC 60079-14 Section 12	Type 2 - Meets	Requirements listed in this article of NEC in regard to lighting methods are covering more the installation than the design criteria. IEC 79 series parts covers some of both.
2	Motors and Generators	Article 501.125	IEC 60079-14 Section 5; IEC 60079-0 Section 17 & 26; IEC 60079-1 Section 15	Type 2 - Meets	- NEC provides the requirements in regard to what type of motors, generators or other rotating electrical machinery can be installed in Class I Division 1 or Division 2 locations. - IEC describes that rotating equipment such as motors and generators protected with different protection techniques such as flameproof enclosure, pressurized enclosure, increased safety or non-sparking are allowed to be installed in hazardous areas. For example, motor with flameproof enclosure is suitable for installation in Zone 1 area. Similarly, pressurized enclosed motor with level of protection 'pzc' is suitable for installation in Zone 2 area or Division 2 location.

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
3	Transformers and Capacitors	Article 501.100	IEC 60079-7 Section 6	Type 3 - Does Not Meet	NEC provides the requirements for what type of transformers can be installed in Class I, Division 1 or Division 2 areas. The requirements indicated for Class I Division 1 transformers are for onshore installation. In Class I Division 2 locations, dry type transformers and less flammable liquid-insulated are allowed to be installed. There is not much information in regard to transformers for hazardous area installation in IEC 79 series standards.
4	Increased Safety 'e' Motors and Generators	Article 505.22	IEC 60079-7 Section 9; IEC 60079-14 Section 11	Type 3 - Does Not Meet	With regard to the motors with type of protection 'e', marking and overload protection requirements in NEC and IEC are comparable. However, NEC requires the motor controller should also have the specific marking when provided for motors with type of protection 'e'.

Appendix D. Comparative Assessment Results of NEC vs IEC 60079 for Harmonic Mitigation, Power Quality and Surge Protection

Table 13 provides a summary of the comparative assessment between the NEC and IEC 60079. This appendix contains the analysis for the following subjects:

- Harmonic Mitigation: Conductors in Parallel & Neutral Conductor Sizing
- Power Quality
- Surge Protection

Table 13: Comparative Assessment Results - NEC vs IEC 60079 Harmonic Mitigation, Power Quality and Surge Protection

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Harmonic Mitigation Conductors in Parallel Neutral Conductor Sizing	310.10(H); 220.61(C)	IEC 61000	Undetermined	NEC provides some guidance in form of the fine print notes to address the issues due to harmonics, specially the 3rd harmonics. NEC also directs to Chapter 10 of NFPA 70B for additional guidance and information on harmonics and ways to address the harmonic issues. Further analysis between NFPA 70B and pertaining parts of IEC Standard 61000 is required in order to determine the impact type for topic of harmonic mitigation.
2	Power Quality	210.19 (A) FPN No.4; Article 280	IEC 61000	Undetermined	NEC in some of the articles provides guidance in fine print notes to address some of the power quality issues. However, NEC does not have any direct requirements on power quality. It directs to Chapter 10 of NFPA 70B for additional information in regard to power quality and power quality related issues. In order to determine an impact type for this topic, a detailed analysis between NFPA 70B and pertaining parts of IEC standard 61000 is needed.
3	Surge Protection	501.35	Annex F IEC 60079-25	Type 3 - Does Not Meet	Surge arresters, surge-protective devices and capacitors are to be installed in a suitable enclosure for Class I Division 1 location. For Class I Division 2

					locations, nonarcing surge arresters and surge-protective devices are allowed to be installed in general-purpose type enclosures. Also, there is not much information mentioned in IEC 79 series standards with regard to surge arresters and surge protective devices.

Appendix E. Comparative Assessment Results of NEC vs IEC 60079 for Electrical Protections

Table 14 provides a summary of the comparative assessment between the NEC and IEC 60079. This appendix contains the analysis for the following subjects:

- Electrical Protection
- Instruments and Relays

Table 14: Comparative Assessment Results - NEC vs IEC 60079 Electrical Protections

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Electrical Protection	501.115	Multiple IEC 60079 Series Parts	Type 2 - Meets	NEC allows the installation of electrical protective devices in the hazardous area given that are provided with the suitable enclosure such as the explosion proof enclosure. In Class I Division 2, NEC allows the circuit breakers, switches, motor controllers to be installed in general type enclosure given that the electrical part that are to interrupt the current are provided with the acceptable type of protection. IEC also makes the same provision for the installation of the electrical protective devices in the hazardous area.
2	Instruments and Relays	501.105	IEC 60079 Part 7 and Part 14	Type 2 - Meets	For Class I Division 1 or Division 2 locations, contacts such as switches, circuit breaker or relays, alarm bell and horns that can arc, spark and ignite the surrounding atmosphere are required to be installed in suitable enclosures such as an explosion proof or purged/pressurized enclosures. Similarly, IEC standard for Zone 1 and Zone 2 installations require the current interrupting contacts that can produce arcs or sparks which would be capable of igniting a surrounding atmosphere are to be installed in suitable enclosure such as a flameproof enclosure.

Appendix F. Comparative Assessment Results of NEC vs IEC 60079 for Electrical Equipment Construction and Installation

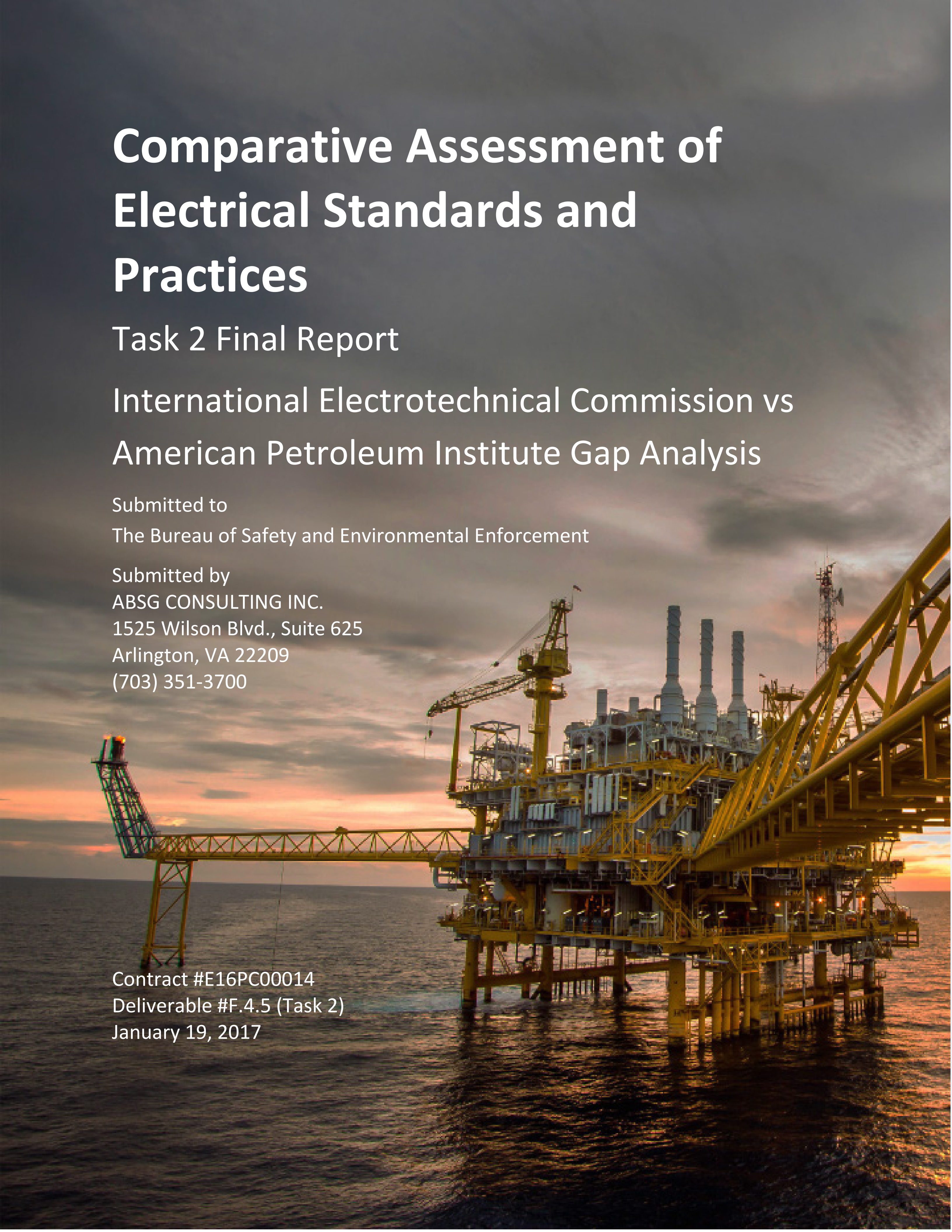
Table 15 provides a summary of the comparative assessment between the NEC and IEC 60079. This appendix contains the analysis for the following subjects:

- Guarding against Electrical shock and arc flash risks
- Protecting Equipment from ingress of solid foreign objects
- Submarine Cables used for Subsea production equipment
- Requirements (design criteria) for submarine cable used for subsea production equipment

Table 15: Comparative Assessment Results - NEC vs IEC 60079 Electrical Equipment Construction and Installation

No.	Section Title / Subject Issue	Baseline Standard NEC	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Guarding against Electrical shock and arc flash risks	Article 110	IEC 61482-1-1, IEC 61482-1-2	Type 1 - Exceeds	NEC doesn't contain extensive requirements in regard to Arc-flash.
2	Protecting Equipment from ingress of solid foreign objects	Article 110.28	IEC 60529 (Section 4)	Type 3 - Does Not Meet	For most part the degree of protection provided by an enclosure which is indicated by the IP code is comparable to the type rating of the enclosure identified in NEC. However, there are NEMA enclosures with type rating 4X and 7 for which there are no equivalent enclosures identified by IP rating.
3	Submarine Cables used for Subsea production equipment	N/A	N/A	Type 2 - Meets	This subject is not included in either the NEC or the IEC.
4	Requirements (design criteria) for submarine cable used for subsea production equipment				NEC doesn't contain any requirements for submarine cables for the subsea production equipment. Similarly, there is no specific standard in IEC that provides requirements for submarine cables.

Appendix C. Task 2 Report: IEC vs. API Gap Analysis



Comparative Assessment of Electrical Standards and Practices

Task 2 Final Report

International Electrotechnical Commission vs American Petroleum Institute Gap Analysis

Submitted to
The Bureau of Safety and Environmental Enforcement

Submitted by
ABSG CONSULTING INC.
1525 Wilson Blvd., Suite 625
Arlington, VA 22209
(703) 351-3700

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1. Introduction

On September 16, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) Office of Offshore Regulatory Programs (OORP) contracted ABSG Consulting, Inc. (ABSG) to conduct the Comparative Assessment of Electrical Standards and Practices study (GS-00F-026A, #E16PC00014). BSEE currently incorporates various industry standards by reference into Title 30 Code of Federal Regulations (CFR) 250.198. BSEE considers it a priority to have an accurate understanding of the concepts detailed in these industry standards documents when conducting inspections of offshore oil and gas facilities to ensure compliance with regulations.

With more facilities and components being manufactured overseas to international standards, determining acceptable equivalencies between the domestic standards incorporated by reference (IBR) and the comparable international standards has become challenging. BSEE recognizes these challenges with many of the electrical standards IBR in 30 CFR 250.198. The purpose of this study was to conduct a gap analysis to compare domestic electrical standards (i.e., NEC, API, ANSI and UL standards) to international electrical standards (i.e., International Electrotechnical Commission standards). As part of this study the following comparative assessments were conducted:

- Task 1 – IEC vs. NEC standards
- Task 2 – IEC vs. API standards
- Task 3 – IEC vs. ANSI/UL standards
- Task 4 – Other gap analysis assessments
- Task 6 – United States vs International Accreditation Practices

Through this comparative gap analysis, BSEE may determine that some of the existing international electrical standards may be easier to follow by the offshore oil and gas industry, more robust, and easier to enforce. BSEE may use the results of this analysis to inform the policies and regulations associated with the electrical-related standards IBR. The ultimate goal of improved regulations is safer operations on the OCS, resulting in better protection of the environment and a reduction in the loss of life and property

This report presents the results of Task 2, the comparative assessment to determine if the requirements of *International Electrotechnical Commission (IEC) 61892 Mobile and fixed offshore units – Electrical installations* series of standards meets, exceeds or does not meet the requirements of the *American*

Petroleum Institute (API) Recommended Practice (RP) 14F Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations (API RP 14F) and *API RP 14FZ Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1 and Zone 2 Locations 1 and Division 2 Locations* (API RP 14FZ).

This report also presents the results of the comparative assessment of *IEC 60079 Explosive atmospheres - Part 10-1: Classification of areas – Explosive gas atmospheres* (IEC 60079-10-1) to *API RP 500 Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2* (API RP 500) and *API RP 505 Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2* (API RP 505).

2. Methodology

ABSG conducted a comparative assessment to determine if the IEC 61892 and IEC 60079 standards meet, exceed or do not meet the API RP 14, API RP 14F, API RP 500 and API RP 505 standards. The editions of API RP 14F and API RP 14FZ, API RP 500 and API RP 505 referenced by 30 CFR 250, were used along with the latest editions of IEC 61892 and 60079 Series standards for this analysis as shown in Table 1.

Table 1: Standards used for the comparative assessment of API RP 14F, API RP 14FZ, APR RP 500 and APR RP 505

Baseline Standards	IEC Standards
API RP 14F - Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations (Fifth edition, July 2008, Reaffirmed, April 2013) API RP 14FZ - Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1 and Zone 2 Locations 1 and Division 2 Locations (First edition, September 2001, Reaffirmed March 2007)	IEC 61892, Mobile and fixed offshore units – Electrical installations: IEC 61892-1 Part 1: General requirements and conditions (Ed. 3.0: 2015-07) IEC 61892-2, Part 2: System design(Ed. 2.0 2012-03) IEC 61892-3, Part 3: Equipment (Ed. 3.0 2012-03) IEC 61892-4, Part 4: Cables (Ed. 1.0 2007-06) IEC 61892-5, Part 5: Mobile Units (Ed. 3.0 2014-11) IEC 61892-6, Part 6: Installation (Ed. 3.0 2013-12) IEC 61892-7, Part 7: Hazardous Areas (Ed. 3.0 2014-12)

Baseline Standards	IEC Standards
API RP 500 - Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2, (Second edition, November 1997, Reaffirmed: November 2002) API RP 505 - Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2 2 (First edition, November 1997, Reaffirmed August 2013)	IEC 60079-0 Explosive atmospheres - Part 0: Equipment – General requirements (Ed. 6.0: 2011-06) IEC 60079-10-1 Explosive atmospheres - Part 10-1: Classification of areas – Explosive gas atmospheres (Ed. 2.0: 2015-09)

To conduct the analysis, ABSG developed a Standards Analysis Tool to facilitate the comparative assessment. The Standards Analysis Tool was used to map the domestic baseline standard (API) to the comparable section of the international standard (IEC). The Standards Analysis Tool incorporated an Impact Type criteria, which allowed for a side-by-side comparison of each section of the domestic baseline standard (API) to the comparable section of the international standard (IEC). Lastly, the Standards Analysis Tool included an analysis section for the SME to provide comments on the impact category that was selected. The comments includes a justification of each designation (meets, exceeds, or does not meet) descriptions of similar provisions, additional requirements or shortfalls. Summary versions of the completed analysis templates are provided in Appendices A and B as references in this report.

Table 2 provides a description of the Impact Type criteria used for the comparative assessment. The subject matter expert (SME) reviewed each section and assigned an impact category.

Table 2: Impact Type Criteria

Impact Category	Description
Type 1 - Exceeds	The International Electrotechnical Commission standards exceed the standards currently used by BSEE
Type 2 - Meets	The International Electrotechnical Commission standards meet the standards currently used by BSEE
Type 3 - Does Not Meet	The International Electrotechnical Commission standards does not meet the standards currently used by BSEE

3. API RP 14F & RP 14FZ vs. IEC 61892

API RP 14F is the RP for electrical systems on offshore petroleum facilities using the division classification method for hazardous locations as described API RP 500. This RP identifies features of offshore electrical systems and recommends generally accepted practices for electrical design and installation in the offshore industry. API RP 14FZ is the RP for electrical systems on offshore petroleum facilities using the zone classification method for hazardous locations as described API RP 505.

The comparable IEC standards to API RP 14F and API RP 14 FZ are the IEC 61892 series of standards, which also provides guidance for the design and installation of electrical systems for the offshore petroleum industry. API RP 14F was written for electrical installations on offshore facilities where areas are classified by the division method and the IEC standards only recognize the zone method of area classification, it is not possible to make a direct comparison in some cases. In these cases, the requirements in the IEC standard will be compared with those in the API standard to determine if an equivalent level of safety can be achieved by following the IEC standard.

The scope of the comparative assessment between the API RP 14F and API RP 14FZ with the IEC Standard 61892 included the following topics:

- General provisions
- Electrical equipment for hazardous (classified) locations
- Electrical power generating stations
- Electrical distribution systems
- Electrical equipment
- Special systems
- Special considerations
- System checkout

3.1 General Provisions

Table 3 provides the results of the comparative assessment for the general provisions.

Table 3: General Provisions - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
Scope	Section 1.1	Part 1: Clause 1	Type 2 - Meets
Applicability of NEC	Section 1.2	Part 2 Part 6	Type 2 - Meets
References (Codes, Rules, Guides & standards from Industries, Government and Class Society)	Section 2	All Parts, Clause 2	Type 2 - Meets
Acronyms and Abbreviated Definitions	Section 3	All parts, Clause 3	Type 2 - Meets

Both API and IEC standards cover fixed and floating petroleum facilities located offshore. The IEC standard also covers mobile offshore drilling units.

The API standard refers to the National Fire Protection Association *NFPA 70, National Electrical Code* (NEC) for detailed design and installations of electrical systems and equipment and U.S. Code of Federal Regulations (CFR) for other special systems. The IEC standard does not refer to any national standard but provides the relevant requirements within the standard for general electrical installations and refers to other international standards and Codes for special systems.

API RP 14F and API RP 14FZ reference and are derived from North American standards such as National Fire Protection Association (NFPA), Institute of Electrical and Electronic Engineers (IEEE), National Electrical Manufacturer's Association (NEMA), etc. IEC 61892 references and are derived from other IEC and international standards such as SOLAS (International Convention for the Safety of Life at Sea), IMO MODU Code, IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities).

Both API and IEC standards provide adequate definitions of the terms used within the standard.

3.2 Electrical Equipment for Hazardous (Classified) Locations

Section 4 of the API RP 14F provides guidance for selection of electrical equipment in hazardous locations designated as Class I, Division 1 or Division 2. Different types of protection techniques are introduced. Among these are explosion-proof, hermetically sealed, intrinsically safe, non-incendive and purged enclosures. For purged enclosures *UL Standard for Safety for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and Ill, Division 1, Hazardous (Classified) Locations* (UL 913) and *NFPA 496 Standard for Purged and Pressurized Enclosures for Electrical Equipment* are specified. However, no specific standards are specified for explosion-proof, hermetically sealed or non-incendive equipment. The concept of High Temperature Devices is also introduced. Although the NEC is applicable for electrical installations on offshore facilities, it should be noted that API RP 14F does not permit isolating switches for a transformer to be installed within general purpose enclosure located in Division 2 area. This is a departure from the NEC.

Similarly, section 4 of the API RP 14FZ provides guidance for selection of electrical equipment in hazardous locations designated as Class I, Zone 1 or Zone 2. Additional protection techniques such as flameproof, increased safety, oil immersion, etc. are introduced along with the ISA standards specified for these protection techniques. Along with NFPA 496 and UL 913, IEC standards *60079-2 Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures "p* and *60079-11 Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"* are recognized. Specific marking requirements for equipment is provided. According to the NEC, equipment listed and marked for hazardous zones may be installed in area classified by division for the same gas group and with a suitable temperature class.

Part 7 of the IEC 61892 provides guidance for the selection of electrical equipment in hazardous areas. To determine which type of protection technique is acceptable for a particular hazardous area, IEC 60079-14 should be consulted as this standard has tables listing the acceptable protection methods for Zone 0, 1 and 2. Note that IEC 61892-7 permits only equipment certified to IEC 60079 to be installed in hazardous areas. Such equipment must have a certificate issued by a recognized certifying body.

Table 4 provides the results of the comparative assessment regarding requirements for Electrical Equipment for Hazardous Locations.

Table 4: Electrical Equipment for Hazardous (Classified) Locations – Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
General Considerations and High Temperature Devices	Sections 4.1 & 4.2	Part 7, Clause 4.2 & 7	Type 2 - Meets
Protection Techniques	Sections 4.3 thru. 4.5	Part 7, Clause 11 thru. 23	Type 3 - Does Not Meet (API RP 14F) Type 2 – Meets (API RP 14FZ)
Marking of Electrical Equipment, Gas Groups	Sections 4.6 & 4.7 (API RP 14FZ only)	Part 7, Clause 7	Type 3 - Does Not Meet

3.2.1 General Considerations and High Temperature Devices

Both the API and IEC standards recommend placing electrical equipment in lower classified areas (least hazardous such as Division 2, Zone 2 or unclassified (non-hazardous) areas.

Section 4.2 of API RP 14F and API RP 14FZ requires high temperature devices (operating temperature exceeds 80% of the auto ignition temperature of the flammable gas involved) that have not been certified by a nationally recognized testing laboratory (NRTL) for a specific temperature rating to be installed inside explosion-proof, flameproof or purged enclosures. Part 7 of IEC 61892 requires all equipment installed in hazardous locations to be certified according to IEC 60079, and the certified equipment will be marked showing the temperature code assigned to the equipment. If non-certified equipment or electrical components has to be located in hazardous area, other protection techniques such as installing the equipment in a flameproof enclosure or purged/pressurized enclosure should be applied.

Based on this analysis, the IEC 61892 requirements meet the recommended practices in API RP 14F and API RP 14FZ for this topic.

3.2.2 Protection Techniques

The protection techniques used in the IEC standard are similar to those described in the API RP 14FZ. API RP 14FZ lists both IEC 60079 series and "normalized" versions of the IEC 60079 (deviations based on national differences) series for certifying equipment for hazardous. The IEC 60079 series of standards were compared to the "normalized" versions of the 60079 standards with the results of the comparative assessment presented in the Task 4 report.

API RP 14F allows explosion-proof equipment to be used in Division 1 and Division 2 locations. Although the standard for testing and certifying explosion-proof is not clearly stated in API RP 14F, it is included in the NEC as an informational note stating that ANSI/UL 1203-2009 is the nationally recognized standard.

There is no IEC standard for explosion-proof equipment. The only IEC standard that is comparable is the IEC 60079-1 for flameproof equipment. Equipment certified to this IEC standard is approved for Zone 1 and Zone 2 locations. The testing requirements for the explosion-proof equipment are higher than the testing requirements for the flame-proof equipment.

Based on this analysis, the IEC 61892 requirements meet the recommended practices in API RP 14FZ but not API RP 14F for this subject. It should be noted that according to section 4.4 of API RP 14F, equipment approved for Zone 0, 1 or 2 locations is permitted only in Division 2 locations. It implies that equipment certified for zones cannot be placed in Division 1 locations.

3.2.3 Marking of Electrical Equipment

Both the IEC and API standards require electrical equipment suitable for hazardous locations to be properly marked. According to section 4.6 of API RP 14F, marking of Division equipment is required to show the class and division, gas group and operating temperature or temperature range. API RP 14FZ requires marking for zone equipment to show class and zone, the symbol AEx, the protection technique, gas group and temperature code. It should be noted that equipment marked with the AEx symbol is tested to American National (ANSI) Standards. API RP 14FZ uses the same gas groups as *IEC 60079-0 Explosive atmospheres – General requirements*.

Part 7 of the IEC 61892 requires electrical equipment installed in hazardous areas to be third party certified by a recognized certifying body, according to IEC 60079 series or IEC/ISO 80079 series standards. Information on recognized certifying body accreditation is contained in the ISO/IEC 17000 series on Conformity Assessment (e.g. 17025, 17065) which is covered in the Task 6 report.

IEC certified equipment will have marking showing Ex symbol, protection technique, gas group and temperature code. The area classification and zone is not required by IEC for marking of equipment. Further comparison of U.S. and international marking of electrical equipment for hazardous locations is contained in the Task 4 report. Examples of required marking of electrical equipment is provided below:

- API RP 14F (NEC 500.3 C) - Class I, Divisions 1 or 2, Groups A, B, C & D, T4 (T-Code)
- API RP 14FZ (NEC 505.9 C) - Class I, Zone 1, AEx de IIC T6
- IEC 61892 (IEC 60079) - Ex de IIC T6

Based on this analysis, the IEC 61892 requirements do not meet the recommended practices in API RP 14F and API RP 14FZ for Marking of Electrical Equipment.

3.3 Electrical Power Generating Stations

Section 5 of the API RP 14F and API RP 14FZ provides general guidance for sizing the prime mover and generator and typical protections for the prime mover as well as the generator. Basic design requirements and construction standards for electrical switchboards are also covered. For floating facilities, additional requirements are contained in U.S. Coast Guard regulations in Title 46 Code of Federal Regulations, Subpart 58.10. Classification Societies, such as the American Bureau of Shipping

(ABS), DNV-GL, and Lloyd's Register also provide class requirements for the prime movers. The USCG regulations and class rules for floating facilities require an independent emergency generator and switchboard.

IEC 61892 also has requirements for the design of electrical power system as well as electrical equipment in Part 2 and Part 3 of the series, respectively. However, it does not provide guidance for protection of the prime mover. IEC 61892 requires at least two (2) generators for the main power system and also an independent emergency power generator and switchboard. IEC 61892 also requires the busbar of the main switchboard to be subdivided so that some services may be restored even if a section of the bus is damaged due to a fault. Requirements for generators and motors are contained *IEC 60034-1 Rotating electrical machines - Part 1: Rating and performance*. The standards for low voltage and high voltage switchgears are contained in *IEC 61439-1 Low-voltage switchgear and controlgear assemblies - Part 1: General rules* and *IEC 62271-1 High-voltage switchgear and controlgear - Part 1: Common specifications for alternating current switchgear and controlgear*, respectively.

Table 5 provides the results of the comparative assessment regarding power generation system. Subsequent discussions below provide an analysis of where the IEC 61892 Series either exceeds or does not meet API RP14 and API RP 14FZ.

Table 5: Electric Power Generation System – Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
Prime Mover, Generators and Generator Packaging Consideration	Sections 5.2, 5.3, 5.4	Part 2, Clause 10.4.2, Part 3, Clause 5	Type 3 - Does Not Meet
Switchboards	Section 5.5	Part 3: Clause 7 (7.4 and 7.5)	Type 1 - Exceeds
Emergency Power	Section 5.6	Part 2: Clause 4.3	Type 2 - Meets

3.3.1 Prime Movers and Generators

The API standard requires generators to be designed to perform in accordance with *National Electrical Manufacturers Association – Motors and Generators* (NEMA MG1), while the IEC standard requires generators to comply with IEC 60034-1. The National Electrical Manufacturers Association Motors and Generators (NEMA MG1) and the IEC 60034 have the similar performance requirements.

Section 5.2 of API RP 14F and API RP 14FZ provides general guidance for sizing, locations of air intakes and exhaust, typical control functions and automatic shutdown conditions for the prime mover. Section 5.3 provides typical requirements for the control and protection of the prime movers and the generators. Section 5.4 provides some packing and installation considerations such as noise and vibration from the generating units.

Part 2 of the IEC 61892 also has similar protection requirements for the generators, speed governing and other requirements for the prime movers. However, the IEC standard does not have protection requirements for the prime movers.

Based on this analysis, IEC 61892 does not meet the recommended practices contained in API RP14F and API 14 FZ for protection requirements for prime movers.

3.3.2 Switchboards

The API requires low voltage switchboards to be dead front type meeting *UL Standard for Safety Switchboards,* UL 891; *ANSI/IEEE C37.20.1 Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear* and *ANSI/IEEE C37.20.2 Standard for Metal-Clad Switchgear*. Some recommendations regarding the use of copper bus, stranded copper type SIS wiring for instrumentation, etc. were also included.

The IEC standard requires switchgear and control-gear to comply with *IEC 61439-1 Low-voltage switchgear and controlgear assemblies - Part 1: General rules* and *IEC 62271 High-voltage switchgear and controlgear - Part 1: Common specifications for alternating current switchgear and controlgear*.

The IEC standard also requires the main bus of the switchgear connecting multiple generators to be subdivided so that some services may be restored even a section of the bus is damaged. API RP14F and API RP 14 FZ do not have the requirements for dividing the main bus as described in IEC standards.

Based on the above analysis, the IEC 61892 requirements for switchboards exceed the recommended practices contained in API RP14F and API RP 14 FZ.

3.3.3 Emergency Power System

For floating installations, API RP14F and API RP 14 FZ requires an emergency power system consisting of an emergency generator that is sized to supply 100% of the connected loads that are essential for safety, and can supply power continuously for 18 hours. The emergency power system should have a dedicated switchboard normally receiving power from the main power system. The emergency power system should be self-contained.

Part 2 Clause 4.3 of IEC 61892 has similar requirements for an emergency power system, however, it also offers an alternative arrangement without a specific emergency power source provided the main source of power is located in two or more spaces which have their own completely independent systems, including power distribution and control systems, such that a fire or other casualty in any one space will not affect the power distribution from the other spaces. A list of loads essential for safety that should be energized by the emergency power system are included in the both the API and IEC standards.

Based on the comparative assessment, the IEC 61892 requirements for Emergency Power System meets the recommended practices contained in API RP14F and API RP 14 FZ.

3.4 Electrical Distribution Systems

The design and installation of electrical distribution systems focuses on proper selection and protection of electrical cables and wiring for safe distribution of electric power. In general, the wiring methods and circuit protection described in the IEC 61892 are comparable to those indicated in API RP14F and API RP 14 FZ.

Section 6 of the API RP 14F and API RP 14FZ provides guidance for selection of voltage level, electrical conductor selection criteria including ampacity, shielding (for medium voltage power cables) and voltage drop considerations. This section also discussed wiring method for classified locations. Many figures are provided to show acceptable arrangements for cables and conduit run across classified area boundaries. Discussion of general wiring considerations, circuit protection and grounding are included in Section 6. Section 6 also includes recommended requirements for working space around electrical equipment.

Part 2 of the IEC 61892 standard provides similar requirements for selection of cables, voltage drop consideration and circuit protection. Part 4 provides requirements for the selection of electrical cables up to 30kV and requirements for minimum size of the grounding conductor. Ampacity tables for cables of various voltage rating is also provided. Part 6 provides requirements for installations including working space for low voltage electrical equipment, which is generally comparable to the API recommended practices. For working space about electrical equipment, both API RP 14F and API RP 14FZ refer to NEC Article 110 Requirements for Electrical Installations for minimum clear working space. The required depth of working space varies depending on the voltage class of the equipment. The NEC requires greater working space depth for higher voltage class equipment. The IEC standard does not have similar requirements.

Table 6 provides the results of the comparative assessment regarding Electrical Distribution Systems. Subsequent discussions below provide an analysis of where the IEC 61892 Series either meets or does not meet the API RP14F and API RP 14FZ.

Table 6: Electrical Distribution Comparative – Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
Voltage Level Selection	Section 6.1 & 6.2	Part 2 & Part 4	Type 2 - Meets
Conductor Selection	Section 6.3	Part 4 Clause 4.1, 4.3, 4.6	Type 3 - Does Not Meet
Wiring Considerations	Sections 6.4, 6.5, 6.7, 6.8	Part 4 & Part 7, Clauses 9.4, 9.5, 9.7	Type 2 - Meets
Circuit Protection, Grounding and Enclosures	Sections 6.9, 6.10, 6.11	Part 2, Clause 10, Clause 5 and Table 9	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
Working Space	Section 6.12	Part 6, clause 9	Type 3 - Does Not Meet
Requirements for Floating Facilities	Section 6.13	Part 5, clause 5	Type 2 - Meets

3.4.1 Voltage Level Selection

Section 6.1 of the API RP14F and API 14 FZ indicates the design of the power distribution relies primarily on provisions of the NEC. Section 6.2 presents some of the factors affecting voltage level selection for power distribution. Included in this section are standards for low and medium voltage levels normally used for offshore electrical distribution.

IEC 61892 requires voltage and frequency to be chosen according to IEC 60038, *IEC standard voltages*. Typical voltage levels used for offshore are listed in IEC 61892-2, Table 4 and Table 5 which are in accordance with IEC 60038.

Based on the comparative assessment, the IEC 61892 meets the recommended practices contained in API RP14F and API RP 14 FZ for Voltage Level Selection.

3.4.2 Conductor Selection

API RP14F and API RP 14 FZ allow several methods of determining cable ampacity. The ampacity of a cable can be based on the NEC, calculation, or using ampacity tables within the API standard for marine shipboard cables. For medium voltage system, the NEC requires shielding on insulated conductors operated above 2000 volts to ground. Proper grounding of cable shields is required.

Part 4 Clause 4.1 of IEC 61892 recommends cables used for offshore installations to be constructed in accordance with:

- IEC 60092-350, *Electrical installations in ships - Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications*
- IEC 60092-353, *Electrical installations in ships - Part 353: Power cables for rated voltages 1 kV and 3 kV*
- IEC 60092-354, *Electrical installations in ships – Part 354: Single and three-core power cables with extruded solid insulation for rated voltages 6 kV (Um=7,2 kV); up to 30 kV (Um=36 kV)*
- IEC 60092-376, *Electrical installations in ships – Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)*

Part 4 Clause 4.3 covers factors regarding selection of conductor cross-section area (mm2) and current carrying capacity of insulated conductors. Included in this clause are several ampacity tables for conductors of different temperature rating (70, 90 and 95 degrees ^{0}C) and table for temperature correcting factors. IEC standard also allows determining ampacity based on a calculation method.

Part 4, Clause 4.6 provides the minimum size allowable for a parallel connection of cables is 10mm2 (approx. #7 AWG). It should be noted that the minimum size of conductor allowed for paralleling is 1/0 according to NEC article 310.10. Size 1/0 AWG is much larger than the 10mm2 (about 7 AWG).

Based on the differences of minimum conductor size allowed for paralleling, the requirements in IEC 61892 for conductor selection do not meet the recommended practices contained in API RP14F and API 14 FZ.

3.4.3 Wiring Considerations

Section 6.4 thru. 6.8 of API RP14F and API 14 FZ cover wiring methods to be used for classified and unclassified locations, locations on drilling and workover rigs, miscellaneous wiring considerations, and conduit and cable seal requirements. The API standard recommends the wiring methods employed for unclassified outdoor locations be similar to those recommended for Zone 2 locations.

Part 4 Clause 4.1 of IEC 61892 recommends cables used for offshore installations to be constructed in accordance with IEC 60092-350, IEC 60092-353, IEC 60092-354 and IEC 60092-376. Part 7 of IEC 61892 standard provides installation guidance for hazardous locations.

Based on the comparative assessment, the IEC 61892 meets the recommended practices contained in API RP14F and API RP 14 FZ for wiring considerations.

3.4.4 Circuit Protection, Grounding and Enclosures

Section 6.9 thru. 6.11 of API RP14F and API 14 FZ covers basic requirements for circuit protection, system and equipment grounding, and selection of enclosure for equipment protection.

Similar requirements are found in Part 2, Clause 10, Clause 5 and Table 9 of the IEC 61892.

Based on the comparative assessment, the IEC 61892 requirements for circuit protection, system and equipment grounding, and selection of enclosure for equipment protection meets the recommended practices contained in API RP14F and API RP 14 FZ.

3.4.5 Working Space

Section 6.12 of API RP14F and API 14 FZ refers to the NEC for minimum spacing in regards to working space around voltage electrical equipment for different voltage levels. Part 6 Clause 9 of the IEC 61892 requires a minimum 1 meter (3.28 feet) in front of switchgear and additional 0.4 meter for switchgear with withdrawable breakers. The minimum space of 0.6 meter is required behind the switchgear if access to the rear is necessary. The NEC Article 110.34 has greater working space requirements for higher voltage equipment (600 volts), the IEC standard does not have increased working space requirements for higher voltage system equipment.

Based on the above assessments, the IEC does not meet the recommended practices contained in API RP 14F and API RP 14FZ for working space.

3.5 Electrical Equipment

Sections 7, 8, 9 and 10 of the API RP 14F and API RP 14FZ provides guidance for selection, control and protection for electric motors, transformers, normal and emergency lightings, and provides general guidance regarding the use of direct current (DC) power systems. Specific standards are included for electric motors and transformer. Different types of lighting fixtures are also discussed. Explanations for the need of standby lighting and recommended duration are provided along with the minimum illumination levels required for normal tasks and minimum illumination level required for safe passage. DC Power systems including batteries, battery chargers and Uninterruptible Power Supplies are presented with simple calculations for sizing battery chargers. Minimum instrumentation requirements are listed, along with recommended alarms for different types of abnormal conditions in the systems.

Part 3 of the IEC 61892 provides construction standards for many types of electrical equipment. Part 2, Clause 11 of the IEC standard explains the differences between general lighting, emergency lighting and escape lighting. Minimum illumination levels required for different types of areas are also provided. Part 6, Clause 11 provides requirements for proper installation of batteries and Part 7, Clause 25 provides ventilation requirements for battery compartment/room.

Table 7 provides results of the comparative assessment for Electrical Equipment. Based on the above assessments, it can be concluded that the IEC 61892 meets the API RP 14F and API RP 14FZ requirements for electrical equipment.

Table 7: Electrical Equipment– Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
Electric Motors	Section 7	Part 3, Clause 5	Type 2 - Meets
Transformers	Section 8	Part 3, Clause 6	Type 2 - Meets
Lighting	Section 9	Part 3: Clause 10 Part 2: Clause 11	Type 2 - Meets
Battery-Powered DC Supply Systems	Section 10	Part 3, Clause 8, 9 Part 6, Clause 11 Part 7, Clause 25	Type 2 - Meets

3.6 Special Systems

Section 11 of the API RP 14F and API RP 14FZ introduces safety systems typically required for offshore production facilities. Subsection 11.1 recommends the concept of fail-safe design to be used for safety systems. Design considerations such as power supplies, radio frequency interference, vibration, etc. are also discussed. The remaining subsections provide general guidance or reference materials for various systems.

Part 2 of IEC 61892 includes requirements for various systems. Safety critical systems are required to have a high degree of availability. IEC *61508, Functional safety of electrical/electronic/programmable electronic safety-related systems* is referenced for the design of safety critical systems. For process safety, IEC 61511, *Functional safety - Safety instrumented systems for the process industry sector* is referred. Requirements for systems and equipment such as navigation-aids, heat tracing, fire pumps, etc. are addressed in various parts of the IEC 61892.

Table 8 provides the results of the comparative assessment for Special Systems. Subsequent discussions below provide an analysis differences where API RP14 and API RP 14FZ either exceeds or does not meet the IEC 61892 Series. Most of the special systems and equipment covered by the API are also covered by the IEC 61892 except those listed as “Not addressed” in Table 8.

Table 8: Special Systems– Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
Platform Safety Control System	Section 11.1	Part 2, Clause 12.12.1	Type 2 - Meets
Gas Detection System	Section 11.2	Part 2, Clause 12.12.2 Part 7, Clause 5.5	Type 2 - Meets
Fire Detection System	Section 11.3	Part 2, Clause 12.12.2	Type 2 - Meets
Aid-to-Navigation Equipment	Section 11.4	Part 2, Clause 11.6 Part 6, Clause 12.3	Type 3 - Does Not Meet
Communication Equipment	Section 11.5	Part 3, Clause 13 Part 2, Clause 12.15	Type 2 - Meets
Heat Trace Systems	Section 11.6	Part 7. Clause 12.5 Part 6, Clause 14	Type 2 - Meets
Fire Pumps	Section 11.7	Part 2, clause 10.4.6.2 Part 7, Clause 9.1	Type 2 - Meets
Adjustable Frequency Controllers	Section 11.8	Part 3, Clause 8	Type 2 - Meets
Submarine Cables	Section 11.9	Part 4	Type 2 - Meets
Electric Oil-Immersion Heaters	Section 11.10	Not addressed	Type 3 - Does Not Meet
Electric Power-Operated Winches for Survival Craft	Section 11.11	Not addressed	Type 3 - Does Not Meet
Electric Power-Operated Watertight Doors	Section 11.12	Not addressed	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
Hull Mechanical Systems Controls	Section 11.13	Not addressed	Type 3 - Does Not Meet
Cargo Tanks for Floating Facilities	Section 11.14	Part 7, Clause 4.8	Type 2 - Meets
Cargo Handling Rooms	Section 11.15	Part 7, Clause 4.8	Type 1 - Exceeds
General Alarm System	Section 11.16	Part 2, Clause 12.15 Part 3, Clause 13.4	Type 3 - Does Not Meet
Cathodic Protection System	Section 11.17	Not addressed	Type 3 - Does Not Meet

3.6.1 Aids to Navigation

Section 11.4 of API RP14F and API 14 FZ refers to 33 CFR Subchapter C, Part 67 for Aids to Navigation. This section also provides guidance for equipment installation and wiring methods. The API standard also points out that there are variations in requirements for different USCG districts. IEC 61892 refers to *International Association of Marine Aids to Navigation and Lighthouse Authorities Marking of Man-Made Offshore Structures O-139* for marking of structures.

Requirements for the duration of battery operation in the IEC differ from API RP14F, API 14 FZ and USCG regulations. IEC 61892 requires that batteries for aids to navigation to be designed for 4 days operation. The USCG requires battery operation for 8 days.

Based on the differences in the battery operation requirement, the IEC 61892 requirements for aids to navigation batteries do not meet the recommended practices contained in API RP14F and API 14 FZ.

3.6.2 Electric Oil-Immersion Heaters

Section 11.10 of API RP14F and API 14 FZ provides design and installation requirements for oil-immersion heaters for hydrocarbon process. To operate safety, these heaters must be continuously immersed in the process fluid and temperature must be regulated. These are safety requirements intended to prevent fire or explosion. It should be noted that oil-immersion heaters are engineered items normally provided with the process equipment.

IEC 61892 does not mention oil-immersion heaters and only includes standards for equipment protection. Based on the above analysis, the IEC 61892 requirements for electric oil-immersion heaters do not meet the recommended practices contained in API RP14F and API 14 FZ.

3.6.3 Electric Power-Operated Winches for Survival Craft

Section 11.11 of API RP14F and API 14 FZ does not have specific requirements but refers to U.S. Coast Guard regulations in Title 46 CFR Subchapter J, Subpart 111.95 for requirements regarding power operated winches for survival craft. IEC 61892 does not mention Electric Power-Operated Winches for survival craft. IEC 61892 is intended to be an international standard, it does not refer to any national standards for requirements. Proper degree of protection (IP rating) is a general requirement for IEC standard. Therefore, IEC 61892 requirements for electric power operated winches for survival craft do not meet the recommended practices contained in API RP14F and API 14 FZ.

3.6.4 Electric Power-Operated Watertight Doors

Section 11.12 of API RP14F and API 14 FZ does not have specific requirements but refers to U.S. Coast Guard regulations in Title 46 CFR Subchapter J, subpart 111.97 for requirements regarding power operated watertight doors for floating structures. IEC 61892 does not mention Electric Power-Operated Watertight Doors. However, the detailed requirements for Electric Power-Operated Watertight Doors can be found in SOLAS and Class Society Rules. Further, IEC 61892 is intended to be an international standard, it will not refer to any national standards for requirements. Therefore, the IEC 61892 requirements for electric power operated watertight doors do not meet the recommended practices contained in API RP14F and API 14 FZ

3.6.5 Hull Mechanical Systems Controls

Section 11.13 of API RP14F and API 14 FZ provides requirements for mechanical equipment in hull spaces, such as, ventilation systems, pumps, and monitoring systems. IEC 61892 does not mention mechanical systems controls in the hull of floating facilities.

Therefore, the IEC 61892 requirements for hull mechanical system controls do not meet the recommended practices contained in API RP14F and API 14 FZ

3.6.6 Cargo Handling Rooms

Section 11.15 of API RP 14F and API RP 14FZ recommends a minimum 6 air changes per hour for cargo handling rooms. Part 7 Clause 4.8 of IEC 61892 references to the *IEC standard 60092-502 Electrical installations in ships – Part 502: Tankers – Special features* for the area classification of cargo tank spaces and cargo handling space. IEC 60092-502 requires minimum of 20 air changes per hour ventilation requirement. Therefore, the IEC requirements for cargo handling rooms exceeds the recommended practices contained in API RP14F and API 14 FZ.

It is important to note API RP 14FZ, Second Edition, May 2013, which is not incorporated into BSEE regulations is aligned with IEC standards regarding the minimum number of air changes. As such, BSEE may want consider incorporating the second edition of API RP 14FZ into regulation.

3.6.7 General Alarm System

Section 11.16 of API RP14F and API 14 FZ includes a requirement for a multi-tone general alarm (including abandon platform signal) system supplemented by verbal instructions over the public address system. General installation requirements for identifying the alarm pushbutton stations and sounding devices with signage are also provided. For floating platforms, additional requirements are provided for power supply, redundancy, and locations of the push-button stations. Public address and general alarm systems requirements are contained in Part 2, Section 12.15 of IEC 61892. Minimum sound level and the minimum numbers of message broadcasting stations are specified, along with requirements for redundancy of speaker loops and main / emergency power supplies. The IEC standard does not specify the general alarm system to have multiple tones for different types of alarm. It also does not address signage that is required with the alarm speaker.

Based on the above analysis, the IEC requirements for general alarm systems do not meet the recommended practices contained in API RP14F and API 14 FZ.

3.6.8 Cathodic Protection System

Section 11.17 of API RP14F and API 14 FZ include a detailed discussion of impressed current type of corrosion protection. This topic is not mentioned in IEC 61892. Therefore, IEC 61892 does not meet the recommended practices contained in API RP14F and API 14 FZ for cathodic protection systems.

3.7 Special Considerations

Section 12 of the API RP 14F and API RP 14FZ recommends additional considerations to be taken in the selection of materials for electrical installations including:

- Construction practices
- Electronic instrumentation
- Electric tools
- Electrical appliances
- Extension cords
- Electrical equipment buildings
- Signs
- Lockout tagout procedures
- Portable electronic devices

IEC 61892 does not include a dedicated section for the listed considerations although the considerations are addressed throughout Parts 1, 3, 6 and 7 of IEC 61892. Table 9 provides results of the comparative assessment for Special Considerations. Based on the analysis, IEC 61892 meets the considerations of API RP 14F and API RP 14FZ.

Table 9: Special Considerations – Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
Special Considerations	Section 12	Parts 1, 3, 6, 7	Type 2 - Meets

3.8 System Checkout

Section 13 of the API RP 14F and API RP 14FZ provide the minimum requirements for checking out electrical, control and instrumentation systems and equipment before putting them in operation. Annex-A also provides recommended inspection intervals for different electrical equipment.

Part 6 of the IEC 61892 provides inspection and testing requirements for electrical systems and equipment after installation is completed. Part 7 of the IEC 61892 also provide guidance for inspection, maintenance, repair and overhaul. Isolation of electrical connections to equipment in hazardous area is required before opening any enclosure. Inspection and maintenance shall be carried out only by experienced personnel with proper training.

Table 10 provides the results of the comparative assessment for Special Considerations. Based on the comparative assessment, IEC61892 meets the requirements in the API RP 14F and API RP 14FZ for system checkout procedures.

Table 10: System Checkout – Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 14F and API RP 14FZ	International Standard IEC 61892 Series	Assessment Results
System Checkout	Section 13	Part 6, Clause 18 Part 7, Clause 26, 27	Type 2 - Meets

4. API RP 500 and API RP 505 vs. IEC 60079

The comparative assessment between the API RP 500 and API RP 505 and the IEC Standard 60079-10-1 contains detailed analysis of topics such as Classification Criteria, Extent of a Classified Location and Recommendations for determining degree and extent of classified locations on offshore platforms and other types of vessels.

API RP 500 and API RP 505 provide the standards for hazardous area classification for installation of electrical equipment on offshore platforms. IEC standard 60079-10-1 is not specifically written for petroleum facilities; however, it pertains to the classification of areas where there are risks of ignition due to presence of flammable gas, liquid or vapor.

The scope of the comparative assessment between the API RP 500 and API RP 505 with the IEC Standard 60079-10-1 included the following topics:

- General provisions

- Basic conditions for fire/explosion and flammable/combustible liquids, gases and vapors
- Classification criteria
- Extent of a classified location
- Recommendations for determining degree and extent of classified locations – common applications
- Recommendations for determining degree and extent of classified locations - other locations
- Appendices in API RP 500, API RP 505 and Annexes in IEC 60079-10-1

4.1 General Provisions

Table 11 provides the results of the comparative assessment general provisions. The IEC meets the recommended practices contained in API RP500 and API RP 505.

Table 11: General Provisions - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079	Assessment Results
Scope	1	Part 10-1 Clause 1	Type 2 - Meets
References (Codes, Rules, Guides & standards from Industries, Government and Class Society)	2	Part 10-1 Clause 2	Type 2 - Meets
Acronyms and Abbreviated Definitions	3	Part 10-1 Clause 3	Type 2 - Meets

4.2 Basic Conditions for fire/explosion and Flammable/Combustible Liquids, Gases and Vapors

Table 12 provides a summary of the comparative assessment for Sections 4 and 5 of the API RP 500 and API RP 505 for basic conditions for fire or explosion and flammable/combustible liquids, gases and vapors. Subsequent discussions below provide an analysis of where the API RP 500 and API RP 505 does not meet the IEC 60079 Series.

Table 12: Basic Conditions for fire/explosion and Flammable/Combustible Liquids, Gases and Vapors – Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079-10-1	Assessment Results
Basic Conditions for a Fire or Explosion	Section 4	Part 10-1 Clause 4.1	Type 3 - Does Not Meet
Flammable and Combustible liquids, gases and vapors	Section 5	No provisions	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079-10-1	Assessment Results
Flammable and Combustible Liquids, Gases, and Vapors	Section 5.5	Part 0 Clause 4.2 (Equipment Grouping)	Type 2 - Meets

4.2.1 Basic Conditions for a Fire or Explosion

Section 4 of API RP 500 and API RP 505 provides information about basic condition for a fire or explosion. Three basic elements required for a fire or explosion to occur are flammable gas or vapor, oxygen (in air) and an ignition source. In API RP 500 and API RP 505, the source of ignition is understood to be an electrical and instrumentation equipment operating at energy levels sufficient to ignite the gas/air mixture in atmosphere.

IEC 60079-10-1 does not contain any comparable information on basic condition for a fire or explosion. However, sub-clause 4.1 talks about safety principles indicating the options for preventing an explosion is to eliminate the likelihood of an explosive gas atmosphere occurring around the source of the ignition or to eliminate the source of ignition.

As such, the IEC standard 60079-10-1 does not meet the API RP500 and API RP 505 on this subject.

4.2.2 Flammable and Combustible Liquids, Gases and Vapors

Section 5 of API RP 500 and API RP 505 provides information about different types of flammable and combustible liquids, gas and vapors. It provides information on Class I, Class II and Class III liquids. It should be noted that crude oil is categorized as Class I liquid. IEC 60079-0 divides the explosive atmosphere into three groups such as Group I, II and III. Group II is associated with electrical installation on facilities with flammable liquids, gases and vapors. Group II is further divided into Group IIA, IIB and IIC.

The explanation and information on flammable/combustible liquids, gases and vapor are not covered by IEC 60079-10-1. Therefore, IEC 60079-10-1 does not meet the recommended practices contained in API RP 500 and API RP 505.

4.3 Classification Criteria

Section 6 of API RP 500 and API RP 505 provides the criteria for area classification. The base definitions for the Class I, Division 1 and Class I, Division 2 are derived from Article 500 of NEC. Similarly, Class I Zone 0, Zone 1 and Zone 2 definitions are derived from Article 505 NEC. The API standards expands on these definitions by providing relevant examples related to offshore platforms. Classification criteria described in API RP 500 and API RP 505 are the same.

Table 13 provides a summary of the analysis of the classification criteria. Subsequent discussions below provide additional information on the comparison between the API RP 500 and API RP 505 the IEC 60079 Series.

Table 13: Classification Criteria– Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079-10-1	Assessment Results
Classification Criteria	6	Part 10-1 Clause 3, Clause 5; Part 0, Clause 4	Type 2 - Meets

Section 6 of API RP 500 and API RP 505 contain information about the importance of the ventilation and its role in determining the classification and the extent of the hazardous area. The API documents define adequate ventilation as keeping the gas concentration below 25% LEL. Recommended methods of calculating adequate ventilation is provided for enclosed areas, such as buildings of approximately 30 cubic meters or less. For naturally ventilated enclosed areas, 12 air changes per hour is recommended with the safety factor of two.

API RP 500 and API RP 505 allow the installation of the gas detection equipment for an inadequately ventilated area and can be a basis for hazardous area reduction (i.e. an inadequately ventilated area with gas detection equipment can be designated as Division 2 or Zone 2 instead of Division 1 or Zone 1). Gas detector equipment should be of a type approved or listed by a NRTL.

According to API RP 505, zone designation depends mainly on the grade of release and the ventilation. A continuous grade of release is identified as a Class I, Zone 0 designation, a primary grade as a Class I, Zone 1 designation and a secondary grade to a Class I, Zone 2 designation.

IEC standard 60079-10-1, Clause 3 covers the definitions for Zone 0, Zone 1 and Zone 2 which are similar to definitions provided in API RP 505 for Class I, Zone 0, Class I, Zone 1 and Class I, Zone 2. Clause 5 of IEC standard describes that suitable ventilation rates can reduce the persistence time of an explosive gas atmosphere which influences the type of zone. Detailed information on natural and artificial ventilation is provided in this clause.

According to clause 7 of IEC Standard, a Zone is identified based on the grade of release and the ventilation. The likelihood of the presence of explosive gas atmosphere depends mainly on the two factors (grade of release and ventilation). The grade of release generally determines the type of zone. In adequately ventilated area (typical open air plant) a continuous grade of release generally leads to a Zone 0 classification, a primary grade to Zone 1 and a secondary grade to Zone 2. Degree of dilution and availability of ventilation can impact the type of zone which may result in a more or less severe classification.

API RP 500 and API RP 505 includes a provision for use of combustible gas detection equipment for certain scenarios. For example, an inadequately ventilated area containing equipment that could release flammable gas or vapor can be classified as a Division 2 or Zone 2 area.

IEC 60079- 29-2 provides guidance on the selection, installation, safe use and maintenance of detectors for flammable gases and oxygen. The purpose of gas detection system can be to initiate the actions such as safe evacuation of premises, appropriate fire-fighting and other emergency procedures, removal of hazards, shutdown of process and increasing ventilation. It is important to note from safety perspective, this can be viewed that IEC is more stringent as it does not allow the use of combustible gas detection equipment for purpose of reducing the Zone classification.

The API standards define an adequate ventilation as keeping the gas concentration below 25% which is not quantified by the IEC standard. However, the IEC standard provides detailed qualitative guidance on the assessment of ventilation and its influence on hazardous area.

Based on the comparative assessment IEC standard 60079-10-1 meets the provision and recommendations provided in API RP 500 and API RP 505 for classification criteria.

4.4 Extent of a Classified Location

Section 7 of API RP 500 and API RP 505 emphasizes that locations are classified solely for the selection, design, and installation of electrical equipment. The extent of classified locations is determined only by the location of sources of release of flammable liquids, gases and vapors and not by the location of source of ignition whether electrical or non-electrical.

Table 14 provides a summary of the analysis of the extent of a classified location. Based on the comparative assessment, IEC 60079 Series meets the Section 7 of the API RP 500 and API RP 505.

Table 14: Extent of a Classified Location – Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079	Assessment Results
Extent of a Classified Location	Section 7	IEC 60079-10-1 Clause 8 and IEC 60079-0 Clause 4	Type 2 - Meets

Section 7 of API recommended practices also contains information on extent of a classified location whether it is an outdoor location or an enclosed location. Outdoor locations and locations having ventilation equivalent to normal outdoor conditions can be classified as Division 2 or unclassified. For enclosed locations, if adequate ventilation is provided, mechanically or naturally, many enclosed locations can be classified as Division 2 or Zone 2 instead of Division 1 or Zone 1.

Referring to Clause 8 of IEC standard 60079-10-1, the extent of the zone depends either on the estimated or calculated distance over which the explosive atmosphere can exist before it disperses to a concentration in air below lower flammable limit. The availability of the ventilation can greatly impact the presence or formation of an explosive gas atmosphere which can determine the type of zone. Practical guidance in annex D is provided to help determine the extent of a zone by taking into account different factors as following:

- grade of release

- effectiveness of ventilation
- degree of dilution
- availability of ventilation

It is to be noted that the API standards provide more of an example-based approach to determine the extent of a classified location around different equipment on offshore platforms. Whereas the IEC standard provides few examples showing the extent of classified locations based on calculations and a theory-based approach.

Even though the approach shown in IEC 60079 is different than the approach shown in API, it meets the API 500 and 505 on the topic of the extent of a location.

4.5 Recommendations for Determining Degree and Extent of Classified Locations – Common Applications

Table 15 provides the comparative assessment results for determining the degree and extend of classified locations. Subsequent discussions below provide an analysis of where the IEC 60079 Series does not meet API RP 500 and API RP 505.

Table 15: Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079	Assessment Results
Recommendations for Determining Degree and Extent of Classified Locations around equipment	8.1, 8.2.1, 8.2.2 and 8.2.3	Part 10-1 Annex E (Examples of hazardous area classification)	Type 2 – Meets
Recommendations for Determining Degree and Extent of Classified Locations – areas containing gas-fueled or diesel-fueled engines/turbines, batteries and flammable and combustible products	8.2.5, 8.2.6 and 8.2.7	No comparable Clause found in IEC	Type 3 - Does Not Meet

4.5.1 Recommendations for Determining Degree and Extent of Classified Locations around equipment

Section 8 (subsection 8.2.1, 8.2.2, 8.2.3) of API RP 500 and API RP 505 presents guidelines for classifying locations around equipment (storage tanks, marine terminals and paint storage, etc.) commonly found in many petroleum facilities. It provides examples showing the extent of classified locations around different equipment such as storage tanks, tank cars/tank trucks, vents and relief valves. Annex E of IEC

60079-10-1 provides examples of area classification for equipment such as pumps, breather valves in the open air, control valves and enclosed compressors handling natural gas. IEC 60079 meets this section of the API RP 500 and API RP 505.

4.5.2 Recommendations for Determining Degree and Extent of Classified Locations – areas containing gas-fueled or diesel-fueled engines/turbines, batteries and flammable and combustible products

Section 8.2.5 API RP 500 and API RP 505 provides basic guidance and examples of classified areas containing gas-fueled or diesel-fueled engines/turbines. Section 8.2.6 provides guidelines for classifying locations where batteries are installed. Also, Section 8.2.7 addresses area classification where flammable and combustible products are stored.

IEC 60079 does not provide any guidance on classifying specific areas that contain gas-fueled or diesel-fueled engines/turbines, locations containing batteries or paint products. Therefore, IEC 60079 does not meet these sections of API RP 500 and API RP 505.

4.6 Recommendations for Determining Degree and Extent of Classified Locations - Other locations

Table 16 provides a summary of the analysis of guidelines for classifying locations on specific installations. Subsequent discussions below provide an analysis of where the IEC 60079 Series does not meet the API RP 500 and API RP 505. Note, Section 13 of API RP 500 and API RP 505 is reserved for future use by the API and does not contain any recommended practices.

Table 16: Determine Degree and Extent of Classified Locations - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079	Assessment Results
Recommendations for Determining Degree and Extent of Classified Locations in Petroleum Refineries	9	No comparable Clause found in IEC	Type 3 - Does Not Meet
Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Land and on Marine Fixed Platforms	10	No comparable Clause found in IEC	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079	Assessment Results
Recommendations for Determining Degree and Extent of Classified Locations on Mobile Offshore Drilling Units (MODUs)	11	No comparable Clause found in IEC	Type 3 - Does Not Meet
Recommendations for determining degree and extent of Classified locations at drilling rigs and production Facilities on floating production units	12	No comparable Clause found in IEC	Type 3 - Does Not Meet
Recommendations for determining degree and extent of Classified locations at petroleum pipeline transportation Facilities	14	60079-10-1 Annex E (Examples of hazardous area classification)	Type 3 - Does Not Meet

4.6.1 Recommendations for Determining Degree and Extent of Classified Locations in Petroleum Refineries

Section 9 of API RP 500 and API RP 505 covers the guidelines for classifying locations for electrical installations around process and production equipment found in petroleum refineries. IEC 60079 does not provide any specific guidelines for classifying locations on specific installation such as petroleum refinery covered by Section 9 in API RP 500 and API RP 505. Therefore IEC 60079 does not meet recommendations in the API RP 500 and API RP 505 for this topic.

4.6.2 Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Land and on Marine Fixed Platforms

Section 10 of API RP 500 and API RP 505 provides guidelines for classifying locations for electrical installations around process and production equipment at Drilling Rigs and Production Facilities on Land and on Marine Fixed Platforms. IEC 60079 does not provide any specific guidelines for classifying locations for installation on Drilling Rigs and Production Facilities on floating production units covered by Section 10 in API RP 500 and API RP 505. As such, IEC 60079 does not meet recommendations provided in the API RP 500 and API RP 505 for this topic.

4.6.3 Recommendations for Determining Degree and Extent of Classified Locations on Mobile Offshore Drilling Units (MODUs)

Sections 11 of API RP 500 and API RP 505 provides the guidelines for classifying locations around drilling equipment found on MODUs. IEC standard 60079-10 doesn't provide any guidelines for classifying locations for electrical installations around drilling equipment on MODUs. Therefore IEC 60079 not meet recommendations in the API RP 500 and API RP 505 for this topic.

4.6.4 Recommendations for determining degree and extent of Classified locations at drilling rigs and production Facilities on floating production units

Section 12 of API RP 500 and API RP 505 provide guidelines for classifying locations for electrical installations at locations surrounding oil/gas drilling, workover rigs and facilities on floating production units. There are specific figures provided for different types of units such as a floating production storage and offloading, tension leg platform, and spar platforms. IEC standard 60079 doesn't cover any specific examples for classifying locations for electrical installations at locations typically found on floating production units. As such, IEC 60079 does not meet recommendations provided in API RP 500 and API RP 505 for this topic.

4.6.5 Recommendations for determining degree and extent of Classified locations at petroleum pipeline transportation Facilities

Section 14 of API RP 500 and API RP 505 provide guidance for classifying locations at pipeline transportation facilities handling flammable liquids, gases and vapor. Pipeline facilities are frequently operated by remote control without full time local attendance. This practice was one of the factors considered in developing the classification guidelines. Many figures are provided to aid the development of area classification drawings for the facility.

Annex E of IEC 60079-10-1 provides some examples of classifying locations around equipment such as pumps, breather valves in the open air, control valves and enclosed compressors handling natural gas. These examples show detailed methods of determining the extent of hazardous area.

IEC 60079 doesn't provide the type of specific examples as provided in API RP 500 and API RP 505. As such, IEC 60079 does not meet the recommendations provided in API RP 500 and API RP 505 for this topic.

4.7 Appendices in API RP 500 and API RP 505 and Annexes in IEC 60079

Additional information on sample calculations for adequate ventilation, procedures for classifying locations and alternate ventilation criteria are provided in the Appendix A through Appendix F of API RP 500 and API RP 505.

IEC 60079-10-1 provides several informative annexes such as Annex A though Annex K. These annexes provide information on ventilation, estimation of hazardous zones, schematic approach to classification of hazardous area.

Table 17 provides a summary of the analysis of additional information and methods covered in appendices of API RP 500 and API RP 505 and pertaining annexes in IEC. Subsequent discussions below provide an analysis of where the IEC 60079 Series does not meet the API RP 500 and API RP 505.

Table 17: Appendices in API RP 500 and API RP 505 and Annexes in the IEC 60079 - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079	Assessment Results
APPENDIX A - Sample calculation to achieve adequate ventilation of an enclosed area by natural means using Equations 1 and 2	Appendix A	60079-10-1 Annex C (Ventilation Guidance)	Type 2 - Meets
APPENDIX B - calculation of minimum air introduction rate to Achieve adequate ventilation using fugitive emissions	Appendix B	60079-10-1 Annex C (Ventilation Guidance)	Type 3 - Does Not Meet
APPENDIX C (API RP 505) —Preferred symbols for denoting class I, zone 0, Zone 1, and zone 2 hazardous (classified) areas	Appendix C	Part 10-1 Clause 3.3 (hazardous areas and zones)	Type 2 - Meets
APPENDIX C (API RP 500) - Development of Ventilation Criteria	Appendix C	No comparable Clause found in IEC	Type 3 - Does Not Meet
APPENDIX D - informative annex— an alternate method for Area classification	Appendix D	No comparable Clause found in IEC	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	International Standard IEC 60079	Assessment Results
APPENDIX E - procedure for classifying locations	Appendix E	Part 10-1 Annex F (Schematic approach to classification of hazardous area)	Type 1 - Exceeds
ANNEX F (API RP 505) - (informative). Alternate ventilation criteria (IEC 79-10, MOD)	Appendix F	Part 10-1 Annex C (Ventilation Guidance) Annex D (Estimation of hazardous zones)	Type 2 - Meets
APPENDIX F (API RP 500) - Preferred symbols for denoting Class I, Division 1 and Division 2 Hazardous (Classified) Locations	Appendix F	No comparable Clause found in IEC	Type 3 - Does Not Meet

4.7.1 Appendix A

Appendix A in API RP 500 and API RP 505 provides equations for calculating the opening area required to achieve the adequate ventilation by natural means. Similarly, Annex C of IEC 60079-10-1 provides means for assessing natural ventilation in building. It contains equations that can be used to calculate volume flow rate of air based on the effective areas of the upwind and downwind openings.

IEC 60079 has similar recommendations as in API RP 500 and API RP 505 and therefore meets the API standards for this topic.

4.7.2 Appendix B

Appendix B in API RP 500 and API RP 505 provides a recommended calculation technique to determine the required ventilation rate for an enclosed area by anticipating fugitive emissions from hydrocarbon handling equipment. Annex C of IEC 60079-10-1 provides information on fugitive emissions in terms of a definition and explanation in this annex. However, it does not provide any calculation techniques using fugitive emissions. As such, IEC 60079 does not meet API standards for this subject.

4.7.3 Appendix C

Appendix C of API RP 500 provides information about the evolution of the definition of 'adequate ventilation'. IEC 60079 doesn't contain any appendix or annex with comparable on evolution of adequate ventilation.

Appendix C of API RP 505 provides the preferred symbols for denoting Class I, Zone 0, Zone 1 and Zone 2. These symbols are derived from IEC standards. The preferred symbols are the same in API RP 505 and IEC 60079-10-1.

Based on the analysis, IEC 60079 does not meet the Appendix C of API 500. However, it should be noted that Appendix C of API RP 500 is for information purpose only. IEC 60079 meets the Appendix C of API RP 505.

4.7.4 Appendix D

Appendix D in API RP 500 and API RP 505 presents the point source concept for determining the extent of area classification and provides a detailed method for calculation. It also provides a means to evaluate the extent of classified areas in non-enclosed adequately ventilated locations based on the nature of potential flammable releases.

IEC 60079 provides information on classification by a source of release method which is the same as the point source method. IEC 60079-10-1 refers to Annex F which summarizes the source of release method.

The API standards provide a detailed calculation example using the point source method. The calculation based approach would be more precise than the schematic approach contained in IEC standard. Based on this, IEC 60079 does not meet the API RP 500 and API RP 505 on this topic.

4.7.5 Appendix E

Appendix E in API RP 500 and API RP 505 provides an outline of the basic procedure for classification of locations. There is a step by step questions-based approach provided to determine the classification of locations. Annex F of IEC 60079-10-1 provides the schematic approach classifying locations for continuous grade release, primary grade release and secondary grade release.

The schematic approach provided in the IEC standard is a more detailed approach than the basic procedure step by step approach provided in the API standards. Based on the analysis, IEC 60079 exceeds the API RP 500 and API RP 505 on this topic.

4.7.6 Appendix F

Appendix F of API RP 505 provides guidance to assess the degree of ventilation and to define the ventilation condition. It also provides explanations, examples and calculation for the design of artificial ventilation system. Annex C in IEC 60079-10-1 provides guidance on ventilation and dispersion conditions to determine the type of zone. It provides detailed guidance on assessment of artificial ventilation systems and natural ventilation arrangement for enclosed spaces. Annex D also provides a table which can be used to estimate the type of zone based on the grade of release and effectiveness of ventilation.

Appendix F of API RP 500 provides the preferred symbols for Class I hazardous locations. However, IEC 60079 doesn't cover the symbols for Class I Division 1 and Division 2 hazardous locations.

As indicated above, IEC 60079 meets the recommendation provided in appendix F of API RP 505, however it doesn't meet the information provided in the appendix F of API RP 500.

5. Summary Conclusion and Recommendations

5.1 Comparative Assessment Conclusions – IEC to API RP 14F and API RP 14FZ to IEC 61892

Based on the comparative assessments in the above sections, various sections of the IEC 61892 meet, exceed do not meet the API RP 14F and API RP 14 FZ.

IEC 61892 ***meets*** the requirements outlined in API RP 14F and API RP 14 FZ in the following subject areas:

- General Considerations and High Temperature Devices
- Protection Techniques (API RP 14FZ)
- Emergency Power
- Voltage Level Selection
- Wiring Considerations
- Circuit Protection, Grounding and Enclosures
- Requirements for Floating Facilities
- Electric Motors
- Transformers
- Lighting
- Battery-Powered DC Supply Systems
- Platform Safety Control System
- Gas Detection System
- Fire Detection System
- Communication Equipment
- Heat Trace Systems
- Fire Pumps
- Adjustable Frequency Controllers
- Submarine Cables
- Cargo Tanks for Floating Facilities
- Special Considerations

- System Checkout

On the other hand, the IEC standard ***exceeds*** the API recommend practices in the subject areas of:

- Switchboards
- Cargo Handling Rooms

The IEC standard ***does not meet*** the requirements outlined in the API recommend practices, in the subject areas of:

- Protection Techniques (API RP 14F)
- Marking of Electrical Equipment
- Prime Movers
- Conductor Selection
- Working Space
- Aid-to-Navigation Equipment
- Electric Oil-Immersion Heaters
- Electric Power-Operated Winches for Survival Craft
- Electric Power-Operated Watertight Doors
- Hull Mechanical Systems Controls
- General Alarm System
- Cathodic Protection System

5.2 Comparative Assessment Conclusions – IEC to API RP 500 and API RP 1505 to IEC 60079

Based on the comparative assessments in the above sections, various sections of the IEC 60079-10-1 meet, exceed do not meet the API RP 500 and API RP 505.

IEC 60079-10-1 ***meets*** the requirements outlined in API RP 500 and API RP 505in the following subject areas:

- Classification Criteria
- Extent of a Classified Location
- Recommendations for Determining Degree and Extent of Classified Locations around equipment
- APPENDIX A — Sample calculation to achieve adequate ventilation of an enclosed area by natural means using Equations 1 and 2
- APPENDIX C (API RP 505) — Preferred symbols for denoting class I, zone 0, Zone 1, and zone 2 hazardous (classified) areas
- ANNEX F (API RP 505) — (informative). Alternate ventilation criteria (IEC 79-10, MOD)

On the other hand, the IEC standard ***exceeds*** the API recommend practices in the subject area of:

- APPENDIX E — procedure for classifying locations

The IEC standard ***does not meet*** the requirements outlined in the API recommend practices, in the subject areas of:

- Basic Conditions for a Fire or Explosion
- Flammable and Combustible liquids, gases and vapors
- Recommendations for Determining Degree and Extent of Classified Locations – areas containing gas-fueled or diesel-fueled engines/turbines, batteries and flammable and combustible products
- Recommendations for Determining Degree and Extent of Classified Locations in Petroleum Refineries
- Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Land and on Marine Fixed Platforms
- Recommendations for Determining Degree and Extent of Classified Locations on Mobile Offshore Drilling Units (MODUs)
- Recommendations for determining degree and extent of Classified locations at drilling rigs and production Facilities on floating production units
- Recommendations for determining degree and extent of Classified locations at petroleum pipeline transportation Facilities
- APPENDIX B — calculation of minimum air introduction rate to Achieve adequate ventilation using fugitive emissions
- APPENDIX C (API RP 500) — Development of Ventilation Criteria
- APPENDIX D — informative annex—an alternate method for Area classification
- APPENDIX F (API RP 500) - Preferred symbols for denoting Class I, Division 1 and Division 2 Hazardous (Classified) Locations

5.3 Recommendations

The recommendations in this Section are based on the comparative assessment between API RP 14F, API RP 14FZ to IEC 61892 and API RP 500 and API RP 505 to IEC 60079:10-1.

The following recommendations are offered for BSEE's considerations;

1) BSEE should develop and/or revise the Electrical Potential Incidents of Non-Compliance that reference the API 14FZ and API 14F to incorporate sections of the IEC 61892 and the IEC 60079 that exceed the API RP 500 and API RP 505. New and/or revised PINC will be considered during Task 5 of this project.
2) BSEE may want consider incorporating the second edition of API RP 14FZ into regulation to align with the IEC.
3) For electrical standards not incorporated into regulation by reference, BSEE should consider developing an audit protocol that would enable BSEE inspectors and engineers to determine compliance with these standards. Development of an audit protocol will be considered during Task 5 of this project.

4) BSEE should provide training to inspectors and engineers on the IEC 61892 and the IEC 60079 so that they are familiar with the various provisions
5) BSEE should provide inspectors and engineers with a copy of this report so they can become familiar with the result of the analysis.
6) BSEE should obtain copies of the API and IEC standards referenced in this report for use by engineers and inspectors.
7) BSEE incorporates standards into federal regulation by reference in Title 30, Code of Federal Regulations Part 250.198. Since these regulations represent minimum requirements, adherence to other standards that exceed the comparable standards incorporated by reference into regulation, including international standards, should represent at least an equivalent level of safety. BSEE may want to consider incorporating into regulation clauses of the IEC 61892 and the IEC 60079:10-1 that exceed the comparable clauses of the API RP14 and 14FZ, as well as API RP 500 and API RP 505 identified in this report.

Appendix A. Analysis of API RP 14 and API RP 14F to IEC 61892

Table 18 provides a summary of the comparative assessment between API Standard 14 and 14FZ to the IEC 61892. This appendix contains the analysis for the following subjects:

- Scope, Applicability of NEC, References (Codes, Rules, Guides & standards from Industries, Government and Class Society), and Acronyms and Abbreviated Definitions
- Electrical Equipment for Hazardous (Classified) Locations
- Marking of Electrical Equipment
- Electrical Power Generating Stations
- Electrical Distribution Systems
- Electrical Equipment
- Special Systems
- Special Considerations
- System Checkout

Table 18: Comparative Assessment Results - API RP 14F and RP 14FZ to IEC 61892

No.	Section Title / Subject Issue	Baseline Standard API RP 14 and API RP 14FZ	IEC Standard IEC 61892	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	1.1	Part 1: Clause 1	Type 2 - Meets	Both API and IEC provide design guidance and considerations for electrical installations on offshore facilities. The IEC standard focuses on proper design, construction and installation of electrical system and equipment. API RP 14F & 14FZ were written specifically for offshore production platforms (upstream segment). The documents cover systems and equipment typically required and found on offshore production platforms. Not all the systems were covered in depth, but references were made to other publications if more detail information is needed for a particular system. For example, API RP 14C was referenced in the fire detection and gas detection systems.

No.	Section Title / Subject Issue	Baseline Standard API RP 14 and API RP 14FZ	IEC Standard IEC 61892	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
2	Applicability of NEC	1.2	Part 2 Part 6	Type 2 - Meets	NEC has detail requirements for specific electrical installations. Unless clearly stated in the API standard as a departure from the NEC, the requirements are expected to be followed. IEC standard is intended to be an international standard and therefore cannot refer to any specific national standard
3	References (Codes, Rules, Guides & standards from Industries, Government and Class Society)	2	All Parts, Clause 2	Type 2 - Meets	Similar to the U.S. regulations (33 CFR, 46 CFR, etc.) referenced by the API standard, normative references (SOLAS, IMO MODU Code, etc.) are required to be followed to cover other systems not specifically mentioned in IEC 61892.
4	Acronyms and Abbreviated Definitions	3	All parts, Clause 3	Type 2 - Meets	Terms and definitions provided are adequate to understand the standard.
5	Electrical Equipment For Hazardous Classified) Locations – General & High Temperature Devices	4 (4.1, 4.2)	Part 7, Clauses 11 thru. 23	Type 2 - Meets	The IEC standard provides more details in selection of electrical equipment in hazardous locations. For example, it include selection of equipment according to gas group, ignition and ambient temperatures, and external influences.

No.	Section Title / Subject Issue	Baseline Standard API RP 14 and API RP 14FZ	IEC Standard IEC 61892	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
6	Electrical Equipment For Hazardous Classified) Locations – Protection Techniques	4 4.3 thru 4.5	Part 7, Clauses 11 thru. 23	Type 3 - Does Not Meet (API RP 14F) Type 2 – Meets (API RP 14FZ)	API RP 14F/14FZ does not reference a specific standard for explosionproof, hermetically sealed devices or nonincendive types of protection. Other types of protections are referenced to ISA standards. API RP 14F only allows purged and explosionproof equipment in Division 1 areas. The IEC standard only has requirements for flameproof. Although both explosionproof and flameproof are intended to contain explosions within the equipment enclosure, the testing requirements for explosionproof are different from flameproof. Protection techniques listed in 14FZ are similar to those listed in the IEC standard.
7	Marking of Electrical Equipment	4.6 & 4.7 (14FZ only)	Part 7, Clause 7	Type 3 - Does Not Meet	Marking of electrical equipment can be found in IEC 60079-0. It should be noted that IEC equipment marking does not explicitly show the type of zone (0, 1 or 2) the equipment is certified for. Although all the information is presented on the marking, to determine whether the equipment is suitable for a particular zone, knowledge of which protection technique can be used on which type of zone is required.
8	Electric Power Generating Station - Prime Mover, Generators and Generator Packaging Consideration	5 (5.2, 5.3 & 5.4)	Part 2, Clause 10.4.2, Part 3, Clause 5	Type 3 - Does Not Meet	API provides typical requirements for control and protection of the prime mover and the generator that are easy to follow and understand. IEC on the other hand, include more technical information of the gen-set that maybe valuable to the detail design but not so easy to verify. NEMA MG1 and the IEC 60034 have the similar performance requirements.

No.	Section Title / Subject Issue	Baseline Standard API RP 14 and API RP 14FZ	IEC Standard IEC 61892	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
9	Electric Power Generating Station - Switchboards	5.5	Part 3: Clause 7 (7.4 and 7.5)	Type 1 - Exceeds	IEC standard requires the main busbar to be subdivided so that some services may be restored even a section of the bus is damaged.
10	Electric Power Generating Station - Floating Facilities only - Emergency Power	5.6	Part 2: Clause 4.3	Type 2 - Meets	Both API and IEC have the similar requirement.
11	Electrical Distribution Systems – Voltage Level Selection	6 (6.1, 6.2)	Part 2 & Part 4	Type 2 - Meets	Both API and IEC have the similar requirements.
12	Electrical Distribution Systems – Conductor Selection	6.3	Part 2 & Part 4	Type 3 - Does Not Meet	It should be noted that the minimum size of conductor allowed for paralleling is 1/0 by NEC article 310.10. Size 1/0 AWG is much larger than the 10mm2 (about 7 AWG).
13	Electrical Distribution Systems - Wiring Methods	6.4, 6.5, 6.5	Part 7, Clause 9.4.1	Type 2 - Meets	The requirements in the IEC standard clauses 13 through 16 are based on IEC standard 60079-14.
14	Electrical Distribution Systems - Wiring Considerations	6.7, 6.8	Part 4 & Part 7, Clauses 9.4, 9.5, 9.7	Type 2 - Meets	
15	Electrical Distribution Systems -Circuit Protection	6.9, 6.10, 6.11	Part 2	Type 2 - Meets	The IEC standard has different methods of grounding the equipment enclosure. Familiar with the grounding scheme (Part 2, Clause 6) is necessary to verify compliance. IEC allows use of 3-phase 4 –wire supply in impedance grounded system.
16	Electrical Distribution Systems -Working Spaces	6.12	Part 6, clause 9	Type 3 - Does Not Meet	The IEC standard does not have different working space requirements for different voltage levels. Also, the working space in the rear of equipment required by IEC is less than that required by API (2.5 feet).
17	Requirements for Floating Facilities	6.13	Part 5, clause 5	Type 2 - Meets	Both API and IEC have the same Inclination conditions.

No.	Section Title / Subject Issue	Baseline Standard API RP 14 and API RP 14FZ	IEC Standard IEC 61892	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
18	Electric Motors	7	Part 3: Clause 5	Type 2 - Meets	API Std. 541 is standard for form-wound squirrel cage induction motors, typically see in medium voltage applications. IEEE Std. 841 is for TEFC motors typically for low voltage but can include voltage up to 4000V.
19	Transformers	8	Part 3: Clause 6	Type 2 - Meets	Both ANSI and IEC standards for transformers are recognized and used worldwide.
20	Lighting	9	Part 3: Clause 10 Part 2: Clause 11	Type 2 - Meets	Both API and IEC have similar lighting level requirements. UL standard 1598A is mandated in 46 CFR Subchapter J for lighting fixtures in marine environment.
21	Battery-Powered DC Supply Systems	10	Part 3, Clause 8, 9 Part 6, Clause 11 Part 7, Clause 25	Type 2 - Meets	Battery chargers, UPS, VFD are categorized as semiconductor converters in the IEC standards.
22	Special Systems	11			
23	Platform Safety Control System	11.1	Part 2, Clause 12.12.1	Type 2 - Meets	It should be noted that API RP 14C is referenced by 30 CFR 250 in many places for platform safety systems.
24	Gas Detection System	11.2	Part 2, Clause 12.12.2 Part 7, Clause 5.5.1, 5.5.2, 5.5.3,	Type 2 - Meets	Chapter 9, clause 9.11.1 of IMO MODU Code stated "gas detection and alarm system should be provided to the satisfaction of the administration".
25	Fire Detection Systems	11.3	Part 2, Clause 12.12.2	Type 2 - Meets	No specific guidance provided and no specific standard being referenced in the IEC 61892 for the placement of detectors, and no mention of the use of fusible plug loops for fire detection. It should be noted that both IMO MODU Code and SOLAS have guidance for locating fire detectors in the accommodation, service spaces and machinery spaces, but not in the production/process areas.

No.	Section Title / Subject Issue	Baseline Standard API RP 14 and API RP 14FZ	IEC Standard IEC 61892	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
26	Aids-to-Navigation Equipment	11.4	Part 2, Clause 11.6 Part 6, Clause 12.3	Type 3 - Does Not Meet	It should be noted that the four days battery power may not satisfy USCG requirement in certain districts. For example, USCG eighth district typically requires 8 days battery power for manned platforms and 30 days for unmanned platforms.
27	Communications Equipment	11.5	Part 3, Clause 13 Part 2, Clause 12.15	Type 2 - Meets	Internal communication and radio communication requirements are provided in Chapter 11 of the IMO MODU Code and SOLAS.
28	Heat Trace System	11.6	Part 7, Clause 12.5 Part 6, Clause 14	Type 2 - Meets	API reference the IEEE 515 which provides test criteria to determine the suitability of heating devices and fittings that are used for commercial applications. The standard also includes detailed recommendations for the design, installation, and maintenance of electrical resistance heat tracing in these applications. IEC reference IEC 60519-10 and IEC 60079-30-2 with similar provisions for heat tracing.
29	Fire Pumps	11.7	Part 2, Clause 10.4.6.2 Part 7, Clause 9.1	Type 2 - Meets	
30	Adjustable Frequency Controllers	11.8	Part 3, Clause 8	Type 2 - Meets	IEC 61800 is the standard for design, construction and testing of AFDs.
31	Submarine Cables	11.9	Part 4	Type 2 - Meets	It should be noted that Submarine cables are excluded in both API and IEC standards.
32	Electric Oil-Immersion Heaters	11.1		Type 3 - Does Not Meet	The requirements provided in API are to prevent explosion. IEC standard covers only protection requirement.
33	Electric Power-Operated Winches for Survival Craft	11.11		Type 3 - Does Not Meet	Proper degree of protection (IP rating) is a general requirement for IEC standard.
34	Electric Power-Operated Watertight Doors	11.12		Type 3 - Does Not Meet	Requirements for Electric Power-Operated Watertight Doors can be found in SOLAS

No.	Section Title / Subject Issue	Baseline Standard API RP 14 and API RP 14FZ	IEC Standard IEC 61892	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
35	Hull Mechanical Systems Controls	11.13		Type 3 - Does Not Meet	Requirements for mechanical ventilation shutdown arrangement are provided in SOLAS, IMO MODU Code, and Class Society Rules.
36	Cargo Tanks of Floating Facilitie	11.14	Part 7, Sub-clause 4.8	Type 2 - Meets	API provides basic information such as types of electrical equipment allowed in the space and recommended automatic shutdown of submerged pumps for low liquid level.
37	Cargo Handling Rooms	11.15	Part 7, Sub-clause 4.8	Type 1 - Exceeds	API recommends minimum 6 air changes per hour for cargo handling room; IEC 60092-502 requires minimum of 20 air changes per hour ventilation requirement.
38	General Alarm System	11.16	Part 2, Sub-clause 12.15 Part 3, Clause 13.4	Type 3 - Does Not Meet	The IEC standard does not specify the general alarm system to have multiple tones for different types of alarm. It does not mention any sign that accompany the alarm speaker. The designer will have to refer to other IEC standards for guidance; for example the IMO Code on Alerts and Indicators.
39	Cathodic Protection	11.17		Type 3 - Does Not Meet	Section 11.17 of API RP14F and API 14 FZ include a detailed discussion of impressed current type of corrosion protection. This topic is not mentioned in IEC 61892
40	Special Considerations	12	PARTS 1, 3, 6, 7	Type 2 - Meets	
41	System Checkout	13	Part 6, Clause 18 Part 7, Clause 26, 27	Type 2 - Meets	

Appendix B. Analysis of API RP 500 and API RP 505 to IEC 60079

Table 19 provides a summary of the comparative assessment between API RP 500 and API RP 505 and the IEC 60079. This appendix contains the analysis for the following subjects:

- Scope, References (Codes, Rules, Guides & standards from Industries, Government and Class Society), Acronyms and Abbreviated Definitions
- Basic Conditions for a Fire or Explosion
- Flammable and Combustible Liquids, Gases, and Vapors
- Classification Criteria
- Extent of a Classified Location
- Recommendations for Determining Degree and Extent of Classified Locations
- Appendices

Table 19: Comparative Assessment Results

No.	Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	1	Part 10-1 Clause 1	Type 2 - Meets	Note: API RP 500 & API RP 505 are referenced by 30 CFR 250 as the standards for electrical area classification for offshore. IEC 60079-10 is referenced by IEC 61892 as the standard for area classification.
2	References (Codes, Rules, Guides & standards from Industries, Government and Class Society)	2	Part 10-1 Clause 2	Type 2 - Meets	It should be noted that the references listed in the API RP 500 & API RP 505 are informative only and should not to be considered a part of the RP except for those specifically referenced.
3	Acronyms and Abbreviated Definitions	3	Part 10-1 Clause 3	Type 2 - Meets	

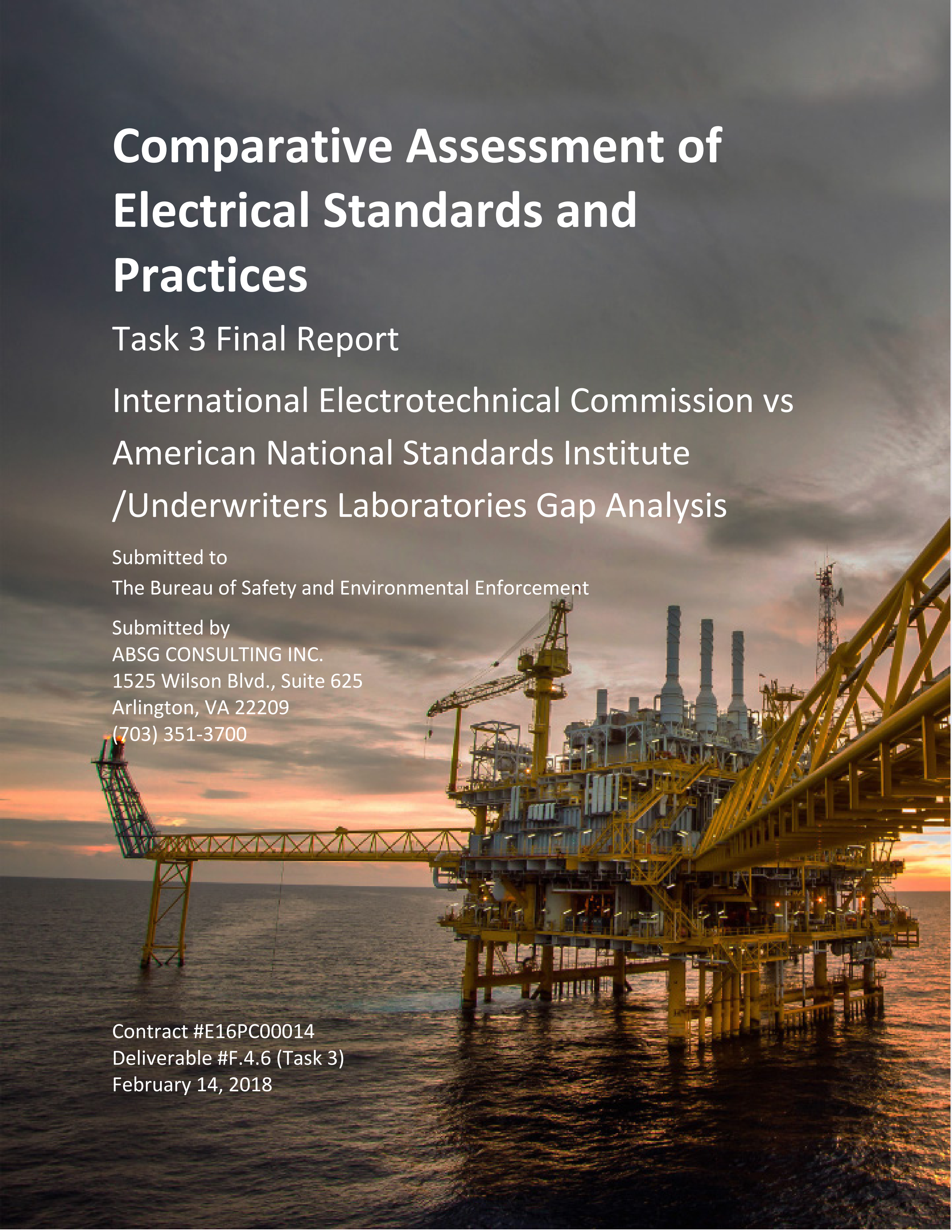
No.	Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
4	Basic Conditions for a Fire or Explosion	4	Part 10-1 Clause 4.1	Type 3 - Does Not Meet	IEC standard does not contain any information on the basic conditions for a fire/explosion. It is noted that information on basic fire conditions in API is information purpose only.
5	Flammable and Combustible Liquids, Gases, and Vapors	5		Type 3 - Does Not Meet	IEC standard does not provide any information on flammable and combustible liquids, gases and vapors.
6	Flammable and Combustible Liquids, Gases, and Vapors	5.5	Part 0 Clause 4.2 (Equipment Grouping)	Type 2 - Meets	Most of the hazardous areas on the oil and gas production platforms are Group D (which is equivalent to group IIA in IEC standard). It is to be noted that Class I does not appear in area classification based on IEC standard. Therefore, the gas group IIA, IIB or IIC and temperature class (T code) must be specified for the proper selection of electrical equipment.
7	Classification Criteria	6	Part 10-1 Clause 3 and Clause 5; Part 0 Clause 4	Type 2 - Meets	API RP 500 and API RP 505 both makes a provision for use of combustible gas detection equipment for certain scenarios, where as there is no provision in IEC for use of combustible gas detection equipment. From safety perspective, this can be viewed that IEC is more stringent as it does not allow the use of combustible gas detection equipment for purpose of reducing the Zone classification.API defines adequate ventilation as keeping the gas concentration below 25%. IEC standard doesn't define adequate ventilation as done in API. However, it provides detailed qualitative guidance on the assessment of ventilation and dilution and its influence on hazardous area.

No.	Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
8	Extent of a Classified Location	7	Part 10-1 Clause 8 (Extent of zone) and Annex D (Estimation of hazardous zones) Part 0 Clause 4	Type 2 - Meets	API provides more of an example-based approach to determine the extent of a classified location around different equipment. Whereas IEC standard provides examples showing the extent of classified locations based on calculations and charts which can be seen as a theory-based approach. This approach can provide more precise radius for extent of a classified location.
9	Recommendations for Determining Degree and Extent of Classified Locations – Common Applications	8.1, 8.2.1, 8.2.2 and 8.2.3	Part 10-1 Annex E (Examples of hazardous area classification)	Type 2 - Meets	
10	Recommendations for Determining Degree and Extent of Classified Locations – Common Applications	8.2.5, 8.2.6 and 8.2.7	Part 10-1 Annex E (Examples of hazardous area classification)	Type 3 - Does Not Meet	IEC 60079-10 does not have any guidance on classifying specific areas that contain gas-fueled or diesel-fueled engines/turbines or locations containing batteries or paint products. Where API RP 500 and API RP 505 both provide basic guidance on classifying locations that contain such equipment.
11	Recommendations for Determining Degree and Extent of Classified Locations in Petroleum Refineries	9	Part 10-1 Annex E (Examples of hazardous area classification)	Type 3 - Does Not Meet	There are guidelines provided in API RP 500 and API RP 505 for classifying locations around process and production equipment in petroleum refineries. However, this topic is not covered in IEC standard.
12	Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Land and on Marine Fixed Platforms	10	Part 10-1 Annex E (Examples of hazardous area classification)	Type 3 - Does Not Meet	API RP 500 and API RP 505 provide specific examples classifying locations around process and production equipment used on Drilling rigs and Production facilities on Land and on Marine fixed locations which is not covered by IEC standard.

No.	Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
13	Recommendations for Determining Degree and Extent of Classified Locations on Mobile Offshore Drilling Units (MODUs)	11	Part 10-1 Annex E (Examples of hazardous area classification)	Type 3 - Does Not Meet	IEC Standard does not cover guidelines in terms of specific examples for classifying locations around drilling equipment found on mobile drilling units whereas API RP 500 and API RP 505 both provide examples showing hazardous area classification for locations on drilling rigs.
14	Recommendations for determining degree and extent of Classified locations at drilling rigs and production Facilities on floating production units	12	Part 10-1 Annex E (Examples of hazardous area classification)	Type 3 - Does Not Meet	API RP 500 and API RP 505 provide specific examples classifying locations for electrical installations at locations around oil/gas drilling, workover rigs and facilities on floating production units which is not covered by IEC standard.
15	Reserved for future use	13			
16	Recommendations for determining degree and extent of Classified locations at petroleum pipeline transportation Facilities	14	Part 10-1 Annex E (Examples of hazardous area classification)	Type 3 - Does Not Meet	IEC 60079-10 provides some examples of hazardous area classification in Annex that can be used for petroleum pipeline transportation facilities. However, it doesn't provide the specific examples provided in API.
17	APPENDIX A—Sample calculation to achieve adequate ventilation of an enclosed area by natural means usingEquations 1 And 2		Part 10-1 Annex C (Ventilation Guidance)	Type 2 - Meets	
18	APPENDIX B—calculation of minimum air introduction rate to Achieve adequate		Part 10-1 Annex C (Ventilation Guidance)	Type 3 - Does Not Meet	API RP 500 and API RP 505 both provide detailed explanation and a recommended calculation technique to determine the ventilation rate by considering fugitive emissions from drilling/process equipment

No.	Section Title / Subject Issue	Baseline Standard API RP 500 and API RP 505	IEC Standard IEC 60079	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
	ventilation using fugitive emissions				where IEC standard doesn't contain this detail and technique.
19	APPENDIX C (API RP 505) —Preferred symbols for denoting class I, zone 0, Zone 1, and zone 2 hazardous (classified) areas		Part 10-1 Clause 3.3 (hazardous areas and zones)	Type 2 - Meets	
	APPENDIX C (API RP 500) —Development of Ventilation Criteria			Type 3 - Does Not Meet	Information provided in the baseline standard about the evolution of the definition of 'adequate ventilation' is for informational purposes.
20	APPENDIX D—informative annex—an alternate method for Area classification			Type 3 - Does Not Meet	API provides detailed calculation example which considers the point source method which can be more precise than the schematic approach contained in IEC standard.
21	APPENDIX E—procedure for classifying locations		Part 10-1 Annex F (Schematic approach to classification of hazardous area)	Type 1 - Exceeds	The schematic approach provided in IEC standard is more detailed approach than the basic procedure step by step approach provided in API.
22	ANNEX F (API RP 505) — (informative). Alternate ventilation criteria (IEC 79-10, MOD)		Part 10-1 Annex C (Ventilation Guidance) Annex D (Estimation of hazardous zones)	Type 2 - Meets	
23	APPENDIX F (API RP 500) - Preferred symbols for denoting Class I, Division 1 and Division 2 Hazardous (Classified) Locations			Type 3 - Does Not Meet	IEC standard does not cover the Division Classification method as covered in Task 1 analysis.

Appendix D. Task 3 Report: IEC vs. ANSI/UL Gap Analysis



Comparative Assessment of Electrical Standards and Practices

Task 3 Final Report

International Electrotechnical Commission vs American National Standards Institute /Underwriters Laboratories Gap Analysis

Submitted to
The Bureau of Safety and Environmental Enforcement

Submitted by
ABSG CONSULTING INC.
1525 Wilson Blvd., Suite 625
Arlington, VA 22209
(703) 351-3700

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1. Introduction

On September 16, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) Office of Offshore Regulatory Programs (OORP) contracted ABSG Consulting, Inc. (ABSG) to conduct the Comparative Assessment of Electrical Standards and Practices study (GS-00F-026A, #E16PC00014). BSEE currently incorporates various industry standards by reference into Title 30 Code of Federal Regulations (CFR) 250.198. BSEE considers it a priority to have an accurate understanding of the concepts detailed in these industry standards documents when conducting inspections of offshore oil and gas facilities to ensure compliance with regulations.

With more facilities and components being manufactured overseas to international standards, determining acceptable equivalencies between the domestic standards incorporated by reference (IBR) and the comparable international standards has become challenging. BSEE recognizes these challenges with many of the electrical standards IBR in 30 CFR 250.198. The purpose of this study was to conduct a gap analysis to compare domestic electrical standards (i.e., NEC, API, ANSI and UL standards) to international electrical standards (i.e., International Electrotechnical Commission standards). As part of this study the following comparative assessments were conducted:

- Task 1 –IEC vs. NEC standards
- Task 2 –IEC vs. API standards
- Task 3 –IEC vs. ANSI/UL standards
- Task 4 –Other gap analysis assessments
- Task 6 –United States vs International Accreditation Practices

Through this comparative gap analysis, BSEE may determine that some of the existing international electrical standards may be easier to follow by the offshore oil and gas industry, more robust, and easier to enforce. BSEE may use the results of this analysis to inform the policies and regulations associated with the electrical-related standards IBR. The ultimate goal of improved regulations is safer operations on the OCS, resulting in better protection of the environment and a reduction in the loss of life and property

This report presents the results of Task 3, the comparative assessment to determine if the International Electrotechnical Commission (IEC) series 60079 series meets, exceeds or does not meet the American National Standards Institute (ANSI) I Underwriters Laboratory (UL) Standards for Safety 674, 823, 844, 913, 1203 and 2225.

2. Methodology

ABSG conducted a comparative assessment to determine if the IEC 60079 series of standards meet, exceed or do not meet the ANSI/UL Standards 674, 823, 844, 913, 1203, and 2225. The latest editions of the IEC 60079 Series standards were used for this analysis along with the UL standards listed in Table 1. This report is structured to summarize the results of this comparative assessment for each of the UL standards listed. Each section includes a brief overview of the subject area, a table highlighting the assessment results and a discussion where there are differences between the international and domestic standards.

Table 1: UL Standards used for the comparative analysis with IEC 60079 series

Document Number	Title
UL 674 Ed. 5 May 31, 2011	Standard for Safety for Electric Motors and Generators for Use in Hazardous (Classified) Locations (Revised on May 19, 2017)
UL 823 Ed. 9 October 20, 2006	Standard for Safety for Electric Heaters for Use in Hazardous (Classified) Locations (Reaffirmed on April 22, 2016)
UL 844 Ed. 13 June 29, 2012	Standard for Luminaires for Use in Hazardous (Classified) Locations (including revisions through March 11, 2016)
UL 913 Ed. 8 December 06, 2013	Standard for Safety for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations (including revisions through October 16, 2015)
UL 1203 Ed. 5 November 22, 2013	Standard for Safety for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations (including revisions through October 16, 2015)
UL 2225 Ed. 4 September 30, 2013	Standard for Safety for Cables and Cable-Fittings for Use In Hazardous (Classified) Locations (including revisions through March 24, 2017)

The UL standards covered in this Report as listed in Table 1 are applicable to specific equipment and/or protection types. IEC 60079 series specify the requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres without limitation on specific equipment/components. Specific types of protection are addressed in different standards in the IEC 60079 series, separately. The comparative assessment is based on the scope of the UL standards and applicable IEC 60079 standards. The nonconformance/nonequivalence between UL standards and IEC 60079 standards caused by the scope limitation of the UL standards are not considered.

The comparative assessment is focused on Class I hazardous locations (flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors). Class II locations (combustible dust) and Class III locations (combustible fibers/flyings) are not covered in the scope of this assessment.

To conduct the analysis, ABSG developed a Standards Analysis Tool to facilitate the comparative assessment. The Standards Analysis Tool was used to map the domestic baseline standard (UL) to the comparable section of the international standard (IEC 60079 series of standards). The Standards Analysis

Tool incorporated an Impact Type criteria, which allowed for a side-by-side comparison of each section of the domestic baseline standard (UL) to the comparable section of the international standard (IEC 60079 series of standards). Lastly, the Standards Analysis Tool included an analysis section for the SME to provide comments on the impact category that was selected. The comments includes a justification of each designation (meets, exceeds, or does not meet) descriptions of similar provisions, additional requirements or shortfalls.

Summary versions of the completed analysis templates are provided in Appendices A through F as references in this report.

Table 2 provides a description of the Impact Type criteria used for the comparative assessment. The subject matter expert (SME) reviewed each section and assigned an impact category.

Table 2: Impact Type Criteria

Impact Category	Description
Type 1 - Exceeds	The International Electrotechnical Commission standards exceed the standards currently used by BSEE
Type 2 - Meets	The International Electrotechnical Commission standards meet the standards currently used by BSEE
Type 3 - Does Not Meet	The International Electrotechnical Commission standards does not meet the standards currently used by BSEE

3. UL 674 vs. IEC 60079 series

UL 674 *Standard for Safety for Electric Motors and Generators for Use in Hazardous (Classified) Locations* provides requirements for the construction, performance and marking of electrical motors and generators or other rotating machinery with the type of protection explosion-proof or dust-ignition-proof, intended for use in explosive atmospheres.

Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-14 and IEC 60079-10-1 as listed below:

- IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* specifies the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres.
- IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* contains specific requirements for the construction and testing of electrical equipment with the type of protection flameproof enclosure "d", intended for use in explosive gas atmospheres.
- IEC 60079-14 E*xplosive atmospheres – Part 14: Electrical installations design, selection and erection* contains the specific requirements for the design, selection, erection and initial inspection of electrical installations in, or associated with, explosive atmospheres
- IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* is concerned with the classification of areas where flammable gas or vapor hazards

may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas.

The scope of the comparative assessment between the UL 674 with IEC 60079 included the following topics:

- General
- Construction
- Performance Tests
- Marking

3.1 General

Table 3 provides the results of the comparative assessment for the general provisions. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standards. Note that some sections in the UL 674 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 674.

Table 3: Motor General - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 674	International Standard IEC 60079 Series	Assessment Results
Scope and application	1	Part 0, Clause 1 & 4 Part 1, Clause 1	Type 2 - Meets
Conditions for use	2	Part 0, Clause 1	Type 3 - Does Not Meet
Normative references	3	Part 0/1/14, Clause 2	Type 3 - Does Not Meet
Dated and Undated References	4	Part 0/1/14, Clause 2	Type 2 - Meets
Definitions	5	Part 0/1/14, Clause 3	Type 2 - Meets
Components	6	Part 0, Clause 6.1	Type 3 - Does Not Meet
Units of measurement	7	IEC uses Metric System	Type 2 - Meets
Terminology	8	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Zone and Group Equivalency	9	Part 0, Clause 4 Part 10-1, Clause 3	Type 2 - Meets

UL 674 covers electric motors and generators or submersible and nonsubmersible sewage pumps and systems as well as other rotating machinery installed in Class I, Division 1, Group B, C & D (equivalent to Class I, Zone 1, Group IIA and IIB, IIB+H2). The UL standard only addresses types of protection explosion-proof or dust-ignition-proof for the equipment aforementioned. All types of protection are contained in the IEC 60079 series.

3.1.1 Conditions for Use

The normal ambient conditions defined in UL 674 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL for the use in Canada, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, higher than 40 °C in UL 674.

The Division system for hazardous area classification employed in UL 674 is not used in IEC 60079 series. The equivalency between Division system and Zone System based on NFPA 70 *National Electric Code* (NEC) Article 500 and 505 are provided in the UL standard. The definitions and basis for the Zone (including Gas Groups) method classification in NEC Article 505 and IEC 60079-10-1 are very similar. The detailed analysis can be found in Task 1 Report. Please note that installation in Gas Group IIC containing acetylene is not in the scope of UL 674. Group IIB+H2 in the UL standard can be considered as Group IIC without acetylene in IEC 60079 series (refer to UL 1203, Sec. 6.3).

3.1.2 Normative References and Components

UL 674 does not employ any IEC standard for base requirements. Normative references in UL 674 are U.S., Canada and Mexico standards.

Both UL 674 and IEC 60079-0 standards require that electrical equipment and components in hazardous (classified) locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However IEC standards do not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing lab.

3.1.3 Terminology

Both UL and IEC standards provide adequate definitions of the terms used within the standards, except terms "motor" and "sewage pump" in Section 8 of UL 674 are for the use in this UL standard only. It shall be understood that the requirements for the motor also apply to a generator or a sewage pump motor in the UL standard.

Based on the above, it can be concluded that IEC can meet UL 674 from the scope and application aspects generally, where installation area ambient temperature is not less than -20 °C. For low atmospheric temperature installation, a case by case study may be needed.

3.2 Construction

This section focuses on the comparison of requirements of explosion-proof motor enclosure in UL 674 with flame-proof enclosure in IEC 60079-1 as well as 60079-0 and IEC 60079-14, as applicable. The results of the comparative assessment are summarized in Table 4. . Subsequent sections provide further analysis where the IEC does not meet the UL standards. Note that some sections in the UL 674 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 674.

Table 4: Motor Construction - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 674	International Standard IEC 60079 Series	Assessment Results
Enclosures	10.1 thru 10.4	Part 1, Clause 12.4, 12.7, & 15 Part 0, Clause 8.3	Type 3 - Does Not Meet
Joints in Enclosures	11.1 thru 11.5	Part 1, Clause 5.1, 5.2.1 thru 5.2.4	Type 3 - Does Not Meet
Holes in Enclosures	12	Part 0, Clause 9.3 Part 1, Clause 11	Type 2 - Meets
Shaft Opening	13	Part 1, Clause 5.2.2 & 8	Type 3 - Does Not Meet
Drain and Breather Plugs in Enclosure	14	Part 1, Clause 10	Type 2 - Meets
Air-Gap Gauge Plugs in Enclosure	15	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Devices with Operating Rods & Spindles	16	IEC 60079-1, Sec. 7	Type 2 - Meets
Protection Against Corrosion	17	IEC 60079-1, Sec. 5.1	Type 2 - Meets
Materials Applied to Joint Surfaces	18	IEC 60079-1, Sec. 5.1	Type 2 - Meets
Field-Wiring Connections	19	Part 1, Clause 13 Part 14, Clause 9, 10 & 11	Type 2 - Meets
Cord-Connected Motors	20	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Assemblies of Equipment	21	IEC 60079-14, Sec. 5	Type 2 - Meets
External fans and fan guards	22	IEC 60079-0, Sec. 17.1.2 & 17.1.3	Type 2 - Meets
Gasoline Submersible Motors	23	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Leakage Detectors	24	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Maximum External Surface Temperature	25	IEC 60079-0, Sec. 5.3.2.2	Type 2 - Meets
Devices for Limiting External Surface Temperatures	26	IEC 60079-0, Sec 30.3	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard UL 674	International Standard IEC 60079 Series	Assessment Results
Spacing	27	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Test Voltages and Test Conditions	28	IEC 60079-0, Sec 26.5	Type 2 - Meets
Instrumentation-Temperature Measurements	29	IEC 60079-0, Sec 26.6	Type 2 - Meets
Variable-Frequency Inverter-Driver Motors	30	IEC 60079-0 Annex D/E	Type 2 - Meets

3.2.1 Enclosure

The motor enclosures are made of metal materials. Comparisons show that enclosure material requirements are not consistent in IEC 60079 series and UL 674. UL 674 may be considered more stringent than IEC due to no allowance on zinc alloys as well as magnesium and its alloys in UL 674. Also UL 674 has detailed requirements for surface porosity in casting materials of enclosures without limitation on a specific material, whereas only cast iron quality is required not less than the quality 150 as defined by ISO 185 in IEC.

Both UL 674 and IEC 60079-1 require that enclosure strength shall be sufficient to withstand the stresses (pressure) resulting from internal explosion pressure test and over pressure test. The test requirements in UL and IEC can be considered equivalent. The comparisons of two tests between UL and IEC are included in Section 3.3 Performance Test. In addition, in UL 674, the ability of a motor enclosure to withstand internal explosion pressure can also be determined by calculations with the safety factors and minimum thickness of motor enclosure walls as specified. Similar requirements were not found in IEC.

Based on the analysis above, it can be concluded that IEC 60079-1 does not meet UL 674 from material aspect.

3.2.2 Joints in Enclosure

Though the contents in General section for enclosure joints in UL and IEC are not same, the related requirements can be found in the other sections. For example, metal joint surface average roughness 0.0064 mm maximum is specified in Sec. 11.1 General of UL, the same requirement is included in Clause 5.2 of IEC 60079-1.

Both UL and IEC provides the dimensional requirements for enclosure joints based on gas groups (B, C, D in UL / IIA, IIB, & IIC in IEC) and joint types (non-threaded joint or thread joint).

For non-threaded joint of enclosure in Group (C, D / IIA, IIB) locations, minimum required joint width in IEC and UL are the same, but UL gives maximum allowable joint gaps less than IEC under the same joint width ranges and enclosure volumes for the equivalent gas groups. For Group B (IIC) location, UL requirements are more conservative on the gaps or widths of joint for free internal volume 100 < V ≤ 500 and 1640 < V ≤ 2000 (V; unit: cm^3). Also width and gap of rabbet joint in UL cannot be satisfied by the IEC standard and no minimum cover thickness at the joint flange is specified in the IEC standard for Group IIC.

Per IEC 60079-1, two types of threaded joints National Pipe Thread (NPT) and cylindrical can be used for all gas groups (IIA, IIB, IIC). NPT shall conform to ANSI/ASME B1.20.1 *Pipe Threads, General Purpose, Inch* and cylindrical thread shall conform with ISO 965-1 *ISO general purpose metric screw threads -- Tolerances -- Part 1: Principles and basic data* and ISO 965-3 *ISO general purpose metric screw threads -- Tolerances -- Part 3: Deviations for constructional screw threads*. Both types require a minimum of five fully engaged threads. In UL 674, NPT is used for gas groups (B, C, D), but parallel threads based on ISO 965-1 and ISO 965-3 are only mentioned in the section for the enclosure in Group B location only. The exact minimum engaged thread numbers required are given per threaded section maximum diameter or the thread class of fit, but in no case less than five fully engaged threads. In addition, minimum length of threaded engagement specified for cylindrical threads, based on the enclosure volume are same in the IEC and UL standards.

Both UL 674 and IEC 60079-1 contain requirements for bolts in joint width. The required minimum flame path length (from inside or outside of enclosure to the nearest edge of bolt hole) in IEC is less than in UL under the same joint width ranges.

Based on the analysis above, IEC 60079-1 meets the requirements of UL 674 for threaded joints of enclosures, but IEC 60079-1 does not meet UL 674 for the requirements of non-threaded joint and bolts in joint width of enclosure.

3.2.3 Shaft Opening

Minimum length of joint and clearance (gap) for motor shaft opening depend on gas groups, shaft joint types (straight or labyrinth) and bearing types (sleeve or ball). For the same length of joints as well as same joint types and bearing types, the maximum allowable clearance (gap) for Group C & D locations in UL is less than equivalency Group IIA & IIB locations in IEC, thus UL 674 is more stringent. However the shaft opening for Group B locations is not covered in UL, but provided in IEC for Group IIC location.

Based on the comparable shafting opening dimensions, it may be considered that IEC 60079-1 does not meet UL 674.

3.3 Performance Tests

Twenty test procedures are defined in UL 674. Comparison analysis of these test procedures with IEC 60079-0 & 60079-1 defined tests is summarized in Table 5. No further analysis is provided for the tests included in UL but without equivalent requirements in IEC. . Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL 674. Note that some sections in UL 674 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 674.

Table 5: Motor Performance Tests - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 674	International Standard IEC 60079 Series	Assessment Results
Temperature Tests-General	31	Part 0, Clause 26.5	Type 2 - Meets
Temperature tests on sinewave power for single speed or multi-speed motors	32	Part 0, Clause 26.5	Type 3 - Does Not Meet
Temperature tests for Variable-Frequency Inverter-Driver Motors	33	Part 0, Annex D/E	Type 3 - Does Not Meet
Dielectric-voltage Withstand Test	34	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Explosion Test	36	Part 1, Clause 15.2.2 & 15.3	Type 2 - Meets
Over Pressure Test on Enclosures	37	Part 1, Clause 15.2.3	Type 2 - Meets
Test on Temperature-Limiting Devices for Limiting External Surface Temperature	38	Part 14, Clause 13.3 & 13.4	Type 2 - Meets
Secureness Test on Conduit Hubs	39	Part 1, C.3.3.1	Type 3 - Does Not Meet
Electrical-Resistance Test	40	Part 0, Clause 26.12	Type 1 - Exceeds
Accelerated-Aging Test on Bushing	41	Part 0, Clause 26.8	Type 2 - Meets
Cord-Pull Test	42	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Rough-Usage Test	43	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Drop Test	44	Part 0, Clause 26.4.3	Type 2 - Meets
Gasoline-Leakage Test	45	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Non-Metallic Fans and Fan Guards Test	46	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard UL 674	International Standard IEC 60079 Series	Assessment Results
Pull Test on Tubes	47	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Sealing Compounds Test	48	IEC 60079-1, Annex C.3	Type 3 - Does Not Meet
Low Ambient-Duty Motors	49	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Grounding-Continuity test	50	Part 0, 26.12	Type 1 - Exceeds

3.3.1 Temperature Tests on Sinewave Power for Single Speed or Multi-speed Motors

The exterior surface of a motor shall not exceed the marked operating temperature or temperature class (T-code). Covering the test methods for normal temperature, overload, overload to burnout, single phasing, locked-rotor, 72 hour locked-rotor, air test per UL 674, which is more stringent than IEC 60079-0 requirement that the test to determine maximum surface temperature shall be performed under the most adverse ratings with an input voltage between 90 % and 110 % of the rated voltage or 110 % of the rated current of the electrical equipment.

3.3.2 Temperature tests for Variable-Frequency Inverter-Driver Motors

Test methods for variable-frequency invertor-drive (VFID) motor under normal temperature, overload, overload to burnout, single phasing, locked-rotor air test conditions are provided in UL 674. Thermal test for the motor with the particular converter required by IEC 60079-0 is same as discussed in 3.3.1. UL 674 test requirements for VFID motor are more stringent than IEC.

3.3.3 Secureness Test on Conduit Hubs

Torque on the conduit required for the test per IEC 60079-1 is less than UL 674 under the same conduit sizes. IEC 60079-1 does not meet UL 674.

3.3.4 Electrical-Resistance Test

UL 674 requires the electrical resistance test to determine the resistance of the grounding path at threaded joint surfaces not exceeding 0.003 Ω by adding a direct or alternating current of 50 amperes. Also UL has requirements on resistance of the grounding path between ground conductor and dead metal parts of portable motor. Earth continuity test in IEC 60079-0 is not only limited at threaded joint surfaces and the resistance between the earth plates or parts of earth plates is tested by passing a direct current of 10 A to 20 A between the earth plates. The resistance for non-metallic material shall not exceed 0.005 Ω. In addition, IEC has more detailed requirements for the test, including materials, parts, assembly of test sample and test time & temperature, etc. Therefore IEC60079-0 exceeds the requirement in UL 674.

3.3.5 Sealing Compounds Test

This test required by UL is to determine sealing compound resistance to chemicals and to be tested to 13 chemicals, whereas IEC 60079-1 has no such detailed requirements. In this regard, IEC does not meet the requirements of UL 674.

3.3.6 Grounding-Continuity Test

Per UL 674, this test is a routine production-line test of manufacturer to check if grounding plug or conductor is electrically connected to dead metal parts of a motor. No detailed requirements are provided in UL. Earth continuity test in IEC 60079-0 includes the requirements on materials, parts, assembly of test sample and test time & temperature, etc. Therefore IEC60079-0 exceeds UL 674.

3.4 Marking

The results of the comparative assessment for marking requirements is summarized in Table 6. Subsequent sections provide further analysis where the IEC does not meet the UL standards.

Table 6: Marking - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 674	International Standard IEC 60079 Series	Assessment Results
Marking	51	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet

The UL 674 standard, Section 51, contains marking requirements, including:

- Manufacturer information
- Motor rating
- Rated ambient temperature
- Class, Division or Zone, Group rating e.g. "Class 1, Group D" and/or "Class 1, Zone 1, Group IIA"
- Maximum external operating temperature or temperature class (T Code)
- Terminal Box Info

The IEC 60079-0, Section 29 requires that marking are mainly to cover:

- Manufacturer information
- Name or mark of the certificate issuer and certificate reference
- Ex marking
    - Symbol (e.g. Ex d)
    - Group (e.g. IIA)
    - Temperature class (e.g. T6);
    - Equipment protection level (e.g. Ga)

- Ambient Temperature (e.g. Ta or Tamb)

In general the marking in both standards are providing similar information as listed here. The IEC marking doesn't indicate Zone whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in the IEC are not employed by UL. Although it may be considered that IEC does not meet UL for marking due to difference between 2 standards, it should have no negative affect on the safety level of equipment operation.

3.5 Summary Conclusions

Based on the comparative assessments in the above sections, various sections of the IEC 60079 series meet, exceed, or do not meet the requirements of UL 674.

IEC 60079 series ***meets*** the requirements outlined in UL 674 in the following subject areas:

- Scope and applications
- Dated and Undated References
- Definitions
- Units of measurement
- Zone and Group Equivalency
- Holes in enclosures
- Drain and Breather Plugs in Enclosure
- Devises with Operating rods and Spindles
- Protection Against Corrosion
- Materials Applied to Joint Surfaces
- Field-Wiring Connections
- Assemblies of Equipment
- External fans and fan guards
- Maximum External Surface Temperature
- Devices for Limiting External Surface Temperatures
- Test Voltages and Test Conditions
- Instrumentation-Temperature Measurements
- Variable-Frequency Inverter-Driver Motors
- Temperature Tests – General
- Explosion Test
- Over Pressure Test on Enclosures
- Accelerated-Aging Test on Bushing
- Test on Temperature-Limiting Devices for Limiting External Surface Temperature
- Drop Test

The IEC standard ***does not meet*** the requirements outlined in the UL 674, in the subject areas of:

- Conditions for use

- Normative references
- Components
- Enclosures
- Joints in Enclosures
- Shaft Opening
- Temperature tests on sinewave power for single speed or multi-speed motors
- Temperature tests for Variable-Frequency Inverter-Driver Motors
- Secureness Test on Conduit Hubs
- Sealing Compounds Test
- Marking
- Requirements with no equivalent requirements in IEC 60079
    - Terminology
    - Construction
        - Air-Gap Gauge Plugs in Enclosure
        - Cord-Connected Motors
        - Gasoline Submersible Motors
        - Leakage Detectors
        - Spacing
    - Performance Tests
        - Dielectric-voltage Withstand Test
        - Cord-Pull Test
        - Rough-Usage Test
        - Gasoline-Leakage Test
        - Non-Metallic Fans and Fan Guards Test
        - Pull Test on Tubes
        - Low Ambient-Duty Motors

The IEC standard ***exceeds*** the requirements outlined in the UL 674, in the subject areas of:

- Electrical-Resistance Test
- Ground-Continuity Test

4. UL 823 vs. IEC 60079 Series

UL 823 *Standard for Safety for Electric Heaters for Use In Hazardous (Classified) Locations* provides requirements for the construction, performance and marking of portable and fixed electrical heaters with the type of protection explosion-proof or dust-ignition-proof and dust-tight, intended for use in explosive atmospheres.

Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-14 and IEC 60079-10-1 as listed below:

- IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* specifies the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres.
- IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* contains specific requirements for the construction and testing of electrical equipment with the type of protection flameproof enclosure "d", intended for use in explosive gas atmospheres.
- IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection* contains the specific requirements for the design, selection, erection and initial inspection of electrical installations in, or associated with, explosive atmospheres
- IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* is concerned with the classification of areas where flammable gas or vapor hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas.

The scope of the comparative assessment between the UL 823 with IEC Standard 60079 included the following topics:

- General
- Construction
- Performance tests
- Heaters for Class I, Division 2, Group A, B, C & D locations
- Manufacturing and production tests
- Marking

4.1 General

Table 7 provides the results of the comparative assessment for the general provisions. Subsequent sections provide further analysis where the IEC does not meet the UL standard. Note that some sections in the UL 823 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 823.

Table 7: Heater General - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 823	International Standard IEC 60079 Series	Assessment Results
Scope	1	Part 0, Clause 1 & 4	Type 2 - Meets
Scope - Atmospheric Conditions General Components	1.7 2 3	Part 1, Clause 1 Part 0, Clause 6.1 Part 0, Clause 6.1	Type 3 - Does Not Meet
Units of measurement	4	IEC uses Metric System	Type 2 - Meets
Undated References	5	Part 0/1/14, Clause 2	Type 2 - Meets
Enclosure Types	6	IEC 60079-0/-1/-14	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard UL 823	International Standard IEC 60079 Series	Assessment Results
Class I, Zone and Group Equivalency	7	Part 0, Clause 4 Part 10-1, Clause 3	Type 2 - Meets
Glossary	8	Part 0/1/14, Clause 3	Type 2 – Meets

4.1.1 Scope

UL 823 covers portable and fixed electric heaters installed in Class I, Division 1, Group A, B, C & D (equivalent to Class I, Zone 1, Group IIA and IIB (IIB+H2) & IIC). The UL standard only addresses types of protection explosion-proof or dust-ignition-proof and dust-tight and is applicable to electric air heaters, hot-water or steam radiators, electric hot plates and paint heaters rated 600 volts or less. All types of protection are contained in IEC 60079 series.

The normal ambient conditions defined in UL 823 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but no maximum temperature is specified in UL 823.

Both UL and IEC standards require that electrical heaters and components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However IEC 60079-0 does not require compliance with industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing lab.

Both IEC and UL standards have requirements on protecting equipment from ingress of liquid/solid foreign objects. However, type 4X enclosure in UL 823 is watertight corrosion-resistant enclosure and is required to be manufactured from corrosion-resistant materials. There are no equivalent enclosures identified by IP rating in IEC. Also UL 823 requires heaters with Type 7 enclosures to meet the applicable requirements for indoor Class I locations. Enclosures marked as Type 7 per UL can be used in explosive gas atmospheres accordingly. Such enclosure type is not employed by IEC 60079.

The Division system for hazardous area classification employed in UL 823 is not used in IEC 60079 series. The equivalency between the Division system and Zone System based on NEC Article 500 and 505 are provided in the UL standard. The definitions and basis for the Zone (including Gas Groups) method classification in NEC Article 505 and IEC 60079-10-1 are very similar. The detailed analysis can be found in Task 1 Report. Please note that Group IIB+H2 in the UL standard can be considered as Group IIC without acetylene in IEC 60079 series (refer to UL 1203, Sec. 6.3).

Both UL and IEC standards provide adequate definitions of the terms used within the standards.

Based on the above, it can be concluded that IEC can meet UL 823 from the scope and application aspects generally, where installation area ambient temperature is not less than -20 °C. For low atmospheric temperature installation, a case by case study may be needed.

4.2 Construction

This section focuses on the comparison of requirements of explosion-proof heater enclosure in UL 823 with flame-proof enclosure in IEC 60079-1 as well as 60079-0 and IEC 60079-14, as applicable. The results of the comparative assessment are summarized in Table 8. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standards. Note that some sections in the UL 823 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 823.

Table 8: Heater Construction - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 823	International Standard IEC 60079 Series	Assessment Results
Construction-All Heaters	9	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Enclosure - Materials	10.1	Part 1, Clause 12.4 & 12.7 Part 0, Clause 8.3	Type 3 - Does Not Meet
Enclosure - Thickness	10.2	No equivalent requirements	Type 3 - Does Not Meet
Joints in Enclosure - General	11.1	Part 1, Clause 5.1 & 5.2	Type 2 - Meets
Joints in Enclosure - Cemented Joint	11.2	Part 1, Clause 6 Part 0, Sec. 12	Type 2 - Meets
Joints in Enclosure - Joints with flamepaths Class I, Group A, B, C and D	11.3	Part 1, Clause 5.4 & 8.1.3	Type 2 - Meets
Joints in Enclosure - Class I, Group C and D locations	11.4	Part 1, Clause 5.2.1 thru 5.2.4 & 8.1.3	Type 3 - Does Not Meet
Joints in Enclosure - Class I, Group B Locations	11.5	Part 1, Clause 5.2.1 thru 5.2.4	Type 3 - Does Not Meet
Joints in Enclosure - Class I, Group A locations	11.6	Part 1, Clause 5.3	Type 2 - Meets
Joints in Enclosure - Threaded joints	11.7	Part 1, Clause 5.3	Type 2 - Meets
Joints in Enclosure - Shaft Opening	11.8	Part 1, Clause 5.2.2 & 8	Type 3 - Does Not Meet
Holes in Enclosure - Class I Locations	12.1	Part 1, Clause 13 Part 14, Clause 9, 10 & 11	Type 2 - Meets
Hot-water or Steam Radiators	13	Part 14, Clause 13	Type 2 - Meets
Supply Connections - Fixed Heaters	14.1 & 14.2	Part 1, Clause 13 & Annex C	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard UL 823	International Standard IEC 60079 Series	Assessment Results
Supply connections - Portable Heaters	14.4	See Parts/Clauses for 11.1 – 11.8 of UL 823 above	See results for 11.1 – 11.8 of UL 823 above
Cord Clamp Securing of threaded joints Hooks and Handles Casters and Wheels External Metal Parts	14.5 14.6 15 16 17	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Bonding and Grounding	18	Part 0, Clause 15	Type 1 - Exceeds
Temperature-Limiting Devices	19	Part 14, Clause 13.3 & 13.4	Type 2 - Meets
Protection Against Corrosion	20	Part 0, Clause 15.4 Part 1, Clause 5.1	Type 2 - Meets
Materials applied to joint surfaces	21	Part 1, Clause 5.1	Type 2 - Meets

4.2.1 Enclosure (Materials)

The heater enclosure housing can be made of metal materials or nonmetallic materials. Comparisons show that enclosure metal material requirements are not consistent in IEC 60079 series and UL 823. UL 823 may be considered more stringent than IEC due to no allowance on zinc alloys as well as magnesium and its alloys in this UL standard. Also UL 823 has maximum limit of copper content of alloy (30%) less than required by IEC (60%) for use in Class I, Group A (equivalent to Group IIC containing acetylene).

Per UL 823, nonmetallic materials shall comply with the requirements in Section 32, Non-Metallic Enclosure Materials Tests. The comparisons of non-metallic material test between UL and IEC are covered in Section 4.3 of this Report.

Based on the above, it can be concluded that IEC does not meet UL 823 from material aspect.

4.2.2 Joint in Enclosures (Class I, Group C and D locations)

For non-threaded joints of enclosures, width and clearance of the joints required by UL 823 are provided in a figure which shows a near linearization of width and clearance, with a minimum width limit to 3/4" (19.1mm) and maximum clearance 0.045" (0.11mm). Comparison with minimum width and maximum clearance in Table 2 of IEC60079-1 shows that UL requirements on joint width and/or clearance (gap) are more stringent than IEC, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group.

Bolts in joint width are accepted with conditions, such as minimum joint length and flame path length (from inside or outside of enclosure to the nearest edge of bolt hole) and maximum diametrical clearance between bolt and bolt hole in UL 823. The IEC standard does not have such limitation. Where the bolt in joint width is provided, the required minimum flame path length in IEC 60079-1 is less than in UL823 under the same joint width ranges.

IEC 60079-1 does not meet UL 823 for the requirements of non-threaded joint and bolts in joint width of enclosure in Dr. C & D locations.

4.2.3 Joints in Enclosures (Class I, Group B locations)

Minimum required non-threaded joint width in the IEC and UL standards are the same. However, for free internal volume (V cm^3) of enclosure 100 < V ≤ 500 and 1640 < V ≤ 2000, UL 823 gives maximum allowable joint gaps less than IEC 60079-1 under the same joint width ranges and enclosure volumes for the equivalent gas groups. Also width and gap of rabbet joint in UL cannot be satisfied by IEC 60079-1, Table 3 and no minimum thickness of cover thickness at the joint flange is specified in IEC.

Similar as in Group C & D locations, bolts in joint width in Group B locations are also accepted with conditions in UL, which is not required by IEC. Where the bolt in joint width is provided, the required minimum width of joint and/or minimum flame path length (distance from inside of enclosure to nearest edge of bolt hole) in IEC 60079-1 less than UL 823.

IEC 60079-1 does not meet UL 823 for the requirements of non-threaded joint and bolts in joint width of enclosure.

4.2.4 Joints in Enclosures (Shaft Openings)

Minimum length of joint and clearance (gap) for shaft opening depend on gas groups, shaft joint types (straight or labyrinth) and bearing types (sleeve or ball). For the same length of joints as well as same joint types and bearing types, the maximum allowable clearance (gap) for Group C & D locations in UL 823 is less than equivalency Group IIA & IIB locations in IEC 60079-1, therefore the UL standards is more stringent.

IEC 60079-1, Table 3 for Group IIC enclosure is applied to free internal volume more than 2000 cm^3 whereas Group A & B enclosure with shaft opening in UL 823 is limited to free internal volume of 30 in^3 (500 cm^3) or less. UL 823 also requires that shaft opening in an enclosure for Group A & B locations shall have a path length not less than 1” (25.4 mm) and maximum clearance 0.045" (0.11 mm), which more stringent than IEC 60079-1.

Based on the comparisons, it is concluded that IEC 60079-1 does not meet UL 823 for shafting opening requirements.

4.2.5 Supply Connections (Portable Heaters)

UL 823 requires that portable heaters shall have provisions for connection of flexible cords and seals between heater and terminal enclosure. Terminal enclosures in Class I locations shall have metal-to-metal joints in accordance with Section 11.1 through 11.8 of the standard. See Table 8 of this report for the comparative assessment results of “joints in enclosure” requirements in 11.1-11.8 of UL 823 with IEC.

4.2.6 Bonding and Grounding

Bonding and grounding requirements in IEC 60079-1 and UL 823 are similar, except that minimum cross-sectional area of earthing conductor are specified based on phase conductors in the IEC standard, which are not found in UL 823. Thus it is considered that IEC 60079-1 exceeds the requirements of UL 823 for bonding and grounding.

4.3 Performance Tests

Sixteen test procedures are defined in UL 823. Comparison analysis of these test procedures with IEC 60079-0 & 60079-1 defined tests are summarized in Table 9. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standard. Note that some sections in the UL 674 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 674.

Table 9: Heater Performance Tests - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 823	International Standard IEC 60079 Series	Assessment Results
Temperature Tests	22	Part 0, Clause 26.5	Type 1 - Exceeds
Accelerated-Aging Test on Bushing	23	Part 0, Clause 26.8	Type 2 - Meets
Strain-Relief Test	24	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Rough-Usage Test	25	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Drop Test	26	Part 0, Clause 26.4.3	Type 2 - Meets
Overturning Test	27	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Stability Test	28	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Dielectric-voltage Withstand Test	29	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Thermal-Cutoff test	30	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Low-Water Cutoff Test	31	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard UL 823	International Standard IEC 60079 Series	Assessment Results
Non-Metallic Enclosure Material Tests	32	Part 0, Clause 7 & 26.7	Type 3 - Does Not Meet
Explosion Test	33	Part 1, Clause 15.2.2 & 15.3	Type 2 - Meets
Hydrostatic Pressure Test	34	Part 1, Clause 15.2.3	Type 2 - Meets
Secureness of Conduit Hubs Test	36	Part 1, C.3.3.1	Type 3 - Does Not Meet
Resistance Test - Leakage test on factory-Installed conduit seals	37.2	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Resistance Test - Electrical-resistance test	37.1, 37.3 & 37.4	IEC 60079-0, Sec. 26.12	Type 1 - Exceeds
Resistance Test - Tests on joint gaskets	37.5	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

4.3.1 Temperature tests

UL 823 requires heater surface temperature to be tested at rated frequency and voltage specified in Table 22.1. Maximum temperatures for all heaters are specified in Table 22.2. Exterior surface temperature of a heater for use when Class I & Class II conditions may exist simultaneously is determined by maximum temperature specified in Table 22.3 for Class II heaters. IEC 60079-0 requires that the test to determine maximum surface temperature shall be performed under the most adverse ratings with an input voltage between 90% and 110% of the rated voltage of the electrical heater. The T-class is determined by maximum surface temperature in IEC 60079-0, Clause 26.5.1.3.

The maximum voltage for the test is equal to the rated value in UL 823, lower than 110% of the rated voltage required by IEC 60079-0. Also the T-class is determined by maximum surface temperature in the IEC standard. Therefore IEC 60079-exceeds the temperature test requirement UL 823.

4.3.2 Non-Metallic Enclosure Material Tests

In UL 823 tests include material chemical compatibility, accumulation of static electricity and sealing compounds. Requirements for the tests in IEC 60079-0 are more than in UL 823, except chemical resistance test. For chemical compatibility test, UL 823 requires the compatibility to 13 chemicals to be tested, whereas IEC 60079-0 has no such detailed requirements. In this regard, it is considered that IEC60079-0 does not meet the requirements of UL 823.

4.3.3 Secureness of Conduit Hubs Test

The torque specifications for conduit required by IEC 60079-1 is less than UL 823 under the same conduit sizes. Therefore IEC 60079-1 does not meet the requirement of UL 823 for secureness of conduit hubs.

4.3.4 Resistance Test

UL 823 requires the electrical resistance test to determine the resistance of the grounding path at threaded joint surfaces not exceeding 0.003 Ω by adding a direct or alternating current of 50 amperes. Also UL has requirements on resistance of the grounding path between ground conductor and dead metal parts of portable equipment. Earth continuity test in IEC 60079-0 is not limited to the specific joint types or equipment. The resistance between the earth plates or parts of earth plates is tested by passing a direct current of 10 A to 20 A between the earth plates. The resistance for non-metallic material shall not exceed 0.005 Ω. In addition, IEC has more detailed requirements for the test, including materials, parts, assembly of test sample and test time & temperature, etc. Therefore IEC60079-0 exceeds the requirement in UL 823.

4.4 Heaters for Class I, Division 2, Group A, B, C & D locations

Per Sections 38-43 of UL 823, a heater for use in Class I, Division 2 locations shall comply with the requirements for a heater for use in ordinary locations (see Sections 2 and 3 in Table 7) and other requirements on enclosures, supply connections, corrosion protection, and temperature test as below.

The heater enclosure for an arcing or sparking part shall meet the requirements for an enclosure in Class I, Division 1 locations (refer to Sections 10, 11 and 12 of UL 823). The requirements for other enclosures are general, such as, the strength and rigidity necessary to resist mechanical damage and impact, etc., except that the minimum thicknesses are specified for different material enclosures. The requirements for supply connections, corrosion protection and temperature test of the heaters in Class I, Division 2 locations are referred to Sections 14, 20 and 22 of UL 823 for Division 1 locations. See Tables 8 and 9 for the related assessments.

4.5 Manufacturing and production tests

According to Sections 51-54 of UL 823, heaters shall be subjected to the production-line tests including hydrostatic pressure test, air-leakage test, dielectric voltage-withstand test and bonding test. The requirements of hydrostatic pressure test, dielectric voltage-withstand test and bonding test are similar as Sections 33, 29 and 37.3 & 37.4, respectively. See Table 9 of this Report for the comparative assessment results of the related tests. The air-leakage test is for heater element sheath and no equivalent requirements are found in IEC 60079.

4.6 Marking

The results of the comparative assessment for marking requirements is summarized in Table 10. Subsequent sections provide further analysis where the IEC standard does not meet the UL standard.

Table 10: Marking - Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 823	International Standard IEC 60079 Series	Assessment Results
Marking	51	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet

UL 823, Section 51 contains marking requirements including:

- Manufacturer info
- Heater rating
- Rated ambient temperature
- Max. operating pressure
- Class, Division or Zone, Group rating e.g. "Class 1, Group D" and/or "Class 1, Zone 1, Group IIA"
- Maximum external operating temperature or temperature class (T Code)
- Terminal Box Info
    - Factory-installed conduit seal
- Grounding

IEC 60079-0, Section 29, requires that marking include:

- Manufacturer info
- Name or mark of the certificate issuer and certificate reference
- Ex marking
    - Symbol (e.g. Ex d)
    - Group (e.g. IIA)
    - Temperature class (e.g. T6);
    - Equipment protection level (e.g. Ga)
    - Ambient Temperature (e.g. Ta or Tamb)

In general the marking in both standards are providing similar information as listed here. IEC marking doesn’t indicate Zone whereas UL marking requires the Zone 0, 1 or 2 provided on the label. Ex Symbols and equipment protection levels in IEC are not employed by UL. Therefore it may be considered that IEC 60079-0 does not meet the requirements UL 823 for marking due to differences between the two standards.

4.7 Summary Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079 series either meet, exceed, or does not meet the UL 823.

IEC 60079 series ***meets*** the requirements outlined in UL 823 in the following subject areas:

- Scope (except ambient temperature lower than -20 °C)
- Units of measurement
- Updated References
- Class I, Zone and Group Equivalency
- Glossary
- Joints in Enclosure – General
- Joints in Enclosure – Cemented Joint
- Joints in Enclosure - Joints with flamepaths Class I, Group A, B, C and D
- Joints in Enclosure - Class I, Group A locations
- Joints in Enclosure - Threaded joints
- Holes in Enclosure - Class I Locations
- Hot-water or Steam Radiators
- Supply Connections - Fixed Heaters
- Temperature-Limiting Devices
- Protection Against Corrosion
- Materials applied to joint surfaces
- Drop Test
- Explosion Test
- Accelerated-Aging Test on Bushing
- Hydrostatic Pressure Test

The IEC standard ***does not meet*** the requirements outlined in the UL 823, in the subject areas of:

- Scope – Atmospheric Conditions
- Enclosure Types
- Enclosure – Materials
- Joints in Enclosure - Class I, Group C and D locations
- Joints in Enclosure - Class I, Group B Locations
- Joints in Enclosure - Shaft Opening
- Non-Metallic Enclosure Material Tests
- Secureness of Conduit Hubs Test
- Marking
- Requirements with no equivalent requirements in IEC 60079
    - Construction
        - Construction-All Heaters
        - Enclosure – Thickness
        - Cord Clamp
        - Securing of threaded joints
        - Hooks and Handles

    - Casters and Wheels
    - External Metal Parts
  - Performance Tests
    - Strain-Relief Test
    - Rough-Usage Test
    - Overturning Test
    - Stability Test
    - Dielectric-voltage Withstand Test
    - Thermal-Cutoff test
    - Low-Water Cutoff Test
    - Resistance Test - Leakage test on factory-Installed conduit seals
    - Resistance Test - Tests on joint gaskets

The IEC standard ***exceeds*** the requirements outlined in the UL 674, in the subject areas of:
- Bonding and Grounding
- Temperature Tests
- Resistance Test - Electrical-resistance test

5. UL 844 vs. IEC 60079 series

UL 844 *Standard for Luminaires for Use in Hazardous (Classified) Locations* covers requirements for the construction, performance and marking of fixed and portable luminaires for installation and use in hazardous (classified) locations.

Based on the scope of UL 844, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-14 and IEC 60079-10-1 as listed below:

- IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* specifies the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres.
- IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* contains specific requirements for the construction and testing of electrical equipment with the type of protection flameproof enclosure "d", intended for use in explosive gas atmospheres.
- IEC 60079-14 E*xplosive atmospheres – Part 14: Electrical installations design, selection and erection* contains the specific requirements for the design, selection, erection and initial inspection of electrical installations in, or associated with, explosive atmospheres
- IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* is concerned with the classification of areas where flammable gas or vapor hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas.

The scope of the comparative assessment between the UL 844 with IEC 60079 included the following topics:

- General
- Luminaires for Class I, Division 1 locations
- Luminaires for Class I, Division 2 locations
- Portable Luminaires
- Manufacturing and Production Tests
- Marking

5.1 General

Table 11 provides the results of the comparative assessment for the general provisions. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standard. Note that some sections in the UL 844 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 844.

Table 11: UL 844 to IEC 60079 - General - Comparative Assessment Results

Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-7/-14 Section #	Assessment Results
Scope	1.1 1.2	IEC 60079-0, Sec. 1 & 4 IEC 60079-1, Sec. 1	Type 2 - Meets
Scope (Atmospheric Conditions)	1.3	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet
General	2.1	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet
General (low-pressure sodium lamps)	2.2	IEC 60079-0, Sec. 21.4 IEC 60079-14, Sec. 5.12	Type 1 - Exceeds
Components	3	IEC 60079-0, Sec. 0	Type 3 - Does Not Meet
Units of Measurement	4	IEC uses Metric System	Type 2 - Meets
Undated References	5	IEC 60079-0/-1/14, Sec. 2	Type 2 - Meets
Class, Zone and Group Equivalency	6	IEC 60079-0, Sec. 4 IEC 60079-10-1, Sec. 3	Type 2 - Meets
Luminaires Subject to Deposits of Combustible-Paint Residue	7	No equivalent requirements in 60079	Type 3 - Does Not Meet
Enclosure Types	8	IEC 60079-0/-1-14	Type 3 - Does Not Meet

5.1.1 Scope

UL 844 covers portable and fixed luminaires installed in Class I, Division 1, Group A, B, C & D (equivalent to Class I, Zone 1, Group IIA and IIB (IIB+H2) & IIC). Luminaires and all types of protection are contained in IEC 60079 series.

Division system for hazardous area classification employed in UL 844 is not used in IEC 60079 series. The equivalency between Division system and Zone System based on NEC Article 500 and 505 (NFPA 70) are provided in the UL standard. The definitions and basis for the Zone (including Gas Groups) method classification in NEC Article 505 and IEC 60079-10-1 are very similar. The detailed analysis can be found in Task 1 Report. Group IIB+H2 in the UL 844 can be considered as Group IIC without acetylene in IEC 60079 series (refer to UL 1203, Section 6.3).

The ambient conditions defined in UL 844 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -25 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but no maximum temperature is specified in UL 844.

5.1.2 General

Both UL and IEC standards require that electrical luminaires and components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas). However IEC does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing lab.

In accordance with IEC standards, high-pressure sodium lamps may be used, but lamps containing free metallic sodium (for example, low-pressure sodium lamps) are not permitted for use in hazardous areas. Further low-pressure sodium lamps shall not be transported unprotected through a hazardous area per IEC. UL 844 is silent on high-pressure sodium lamps and only prohibits luminaire with low-pressure sodium lamps to be used in Division 1 hazardous locations. Accordingly it can be considered that IEC 60079 exceeds UL 844 on the requirement of application of sodium lamps

5.1.3 Enclosure Types

Both IEC and UL standards have requirements on protecting equipment from ingress of liquid/solid foreign objects. However, type 4X enclosure in UL 844 is watertight corrosion-resistant enclosure and is required to be manufactured from corrosion-resistant materials. There are no equivalent enclosures identified by IP rating in IEC. Also UL 844 requires the heater with Type 7 enclosure to meet the applicable requirements for indoor Class I location. Enclosure marked as Type 7 per UL can be used in explosive gas atmospheres accordingly. Such enclosure type is not employed by IEC 60079.

5.2 Luminaire for Class I, Division 1

This section focuses on the comparison of requirements of construction and performance tests of luminaires for Class I, Division 1 installation in UL 844 with IEC 60079-1 and 60079-0 and IEC 60079-14, as applicable. The results of the comparative assessment are summarized in Tables 13 and Table 14. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standard. Note that some sections in the UL 844 are not contained in the IEC 60079 standards. In these subject areas, the IEC 60079 does not meet the UL 844.

5.2.1 Construction

Table 12 provides the results of the comparative assessment for the construction of luminaire to be used in Class I, Division 1 locations. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standard. Note that some sections in the UL 844 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 844.

Table 12: UL 844 to IEC 60079 – Luminaire for Class I Division 1 – Construction Comparative Assessment Results

Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Enclosure Materials	9	IEC 60079-1, Sec. 12.4 & 12.7 IEC 60079-0, Sec. 8.3	Type 3 - Does Not Meet
Enclosure Thickness (Class I Locations)	10.1	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Joints in Enclosures (Class I Locations) General	11.1	IEC 60079-1, Sec. 5.1 Sec. 5.4 & 8.1.3 IEC 60079-0, Sec. 6.5	Type 3 - Does Not Meet
Luminaires (Class I, Group C and D locations) - Straight and rabbet Joints	11.2 11.2.1/11.2.2	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet
- Threaded joints	11.2.3	IEC 60079-1, Sec. 5.3	Type 2 - Meets
- Labyrinth joint	11.2.4	IEC 60079-1, Sec. 8.1.3	Type 2 - Meets
- Bolts in joint width	11.2.5	IEC 60079-1, Sec. 5.2.4	Type 3 - Does Not Meet
Luminaires (Class I, Group B locations	11.3.2 to 11.3.4	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet

Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
- Threaded joint	11.3.5 & 11.3.6	IEC 60079-1 Sec. 5.3	Type 2 - Meets
Luminaires (Class I, Group A locations)	11.4	IEC 60079-1 Sec. 5.3	Type 2 - Meets
Holes in Enclosure Luminaires for Class I Locations	13.1	IEC 60079-1, Sec. 11 IEC 60079-0, Sec. 9.3	Type 2 - Meets
Shaft Openings General Luminaires for Class I Locations	14.1 & 14.2	IEC 60079-1, Sec. 5.2.2 & 8	Type 3 - Does Not Meet
Guards of Luminaires for Class I and II Locations	15	IEC 60079-0, Sec. 21.2	Type 1 - Exceeds
Nonmetallic External Parts	16	IEC 60079-0, Sec. 7.4	Type 1 - Exceeds
Supply Connections Luminaires for Class I Locations	17.1	IEC 60079-1, Sec. 13 IEC 60079-1, Annex C	Type 2 - Meets
Leads	17.3	No equivalent requirements	Type 3 - Does Not Meet
Disconnecting Means	18	IEC 60079-0 Sec. 21	Type 2 - Meets
Protection Against Corrosion	19	IEC 60079-0, Sec. 15.3 IEC 60079-1, Sec. 5.1	Type 2 - Meets
Materials Applied to Joint Surfaces	20	IEC 60079-1, Sec. 5.1	Type 2 - Meets
Fuses	21	IEC 60079-0, Sec. 19	Type 3 - Does Not Meet
Grounding and Bonding	22	IEC 60079-0, Sec. 15	Type 1 - Exceeds
Porosity in Enclosure Materials	23	IEC 60079-1, Sec. 12	Type 3 - Does Not Meet
Luminaires for Wet Locations	24	IEC 60079-0 Sec. 26.5.2	Type 3 - Does Not Meet

Enclosure Materials

The luminaire enclosure housing can be made of metal materials or nonmetallic materials. Comparisons show that enclosure metal material requirements are not consistent in IEC 60079 series and UL 844. UL 844 may be considered more stringent than IEC 60079 due to no allowance on zinc alloys as well as magnesium and its alloys in the UL standard. Also UL 844 has maximum limit of copper content of alloy

(30%) less than required by IEC (60%) for use in Class I, Group A (equivalent to Group IIC containing acetylene).

Per UL 844, nonmetallic materials shall comply with the requirements in Section 35, Non-Metallic Enclosure Materials Tests. The comparisons of non-metallic material tests between UL and IEC are covered in Section 5.2.2 of this Report.

Based on the above assessment, it can be concluded that IEC 60079 does not meet UL 823 from material aspect.

Joints in Enclosures for Class I Locations

Luminaires for Class I, Group C and D locations

UL 844 provides the requirement for width and clearance of joints in Figure 11.2 for lamp enclosure and Figure 11.3 for enclosures other than lamp enclosure in. Comparisons with minimum width and maximum clearance in Table 2 of IEC 60079-1 shows that UL 844 requirements on joint width and/or clearance (gap) are more stringent than IEC.

Bolts in joint width is accepted with conditions, such as minimum joint length and flame path length (from inside or outside of enclosure to the nearest edge of bolt hole) and maximum diametrical clearance between bolt and bolt hole in UL 844. IEC 60079-1 does not have such limitation. Where the bolt in joint width is provided, the required minimum flame path length in IEC is less than in UL under the same joint width ranges.

IEC 60079-1 does not meet UL 844 for the requirements of non-threaded joint and bolts in joint width of enclosure in Group C & D locations.

Luminaires for Class I Group B locations

Minimum required non-threaded joint width in IEC and UL standards are same. However, where free internal volume (V cm^3) of enclosure $100 < V \leq 500$ and $1640 < V \leq 2000$, UL 844 gives maximum allowable joint gaps less than IEC 60079-1 under the same joint width ranges and enclosure volumes for the equivalent gas groups. Also width and gap of rabbet joint in UL 844 cannot be satisfied by IEC 60079-1, Table 3 and no minimum thickness of cover thickness at the joint flange is specified in the IEC standard.

Similar as in Group C & D locations, bolts in joint width in Group B locations is also accepted with conditions in UL 844, which is not required by IEC 60079-1. Where the bolt in joint width is provided, the required minimum width of joint and/or minimum flame path length (distance from inside of enclosure to nearest edge of bolt hole) in IEC 60079-1 less than UL 844.

IEC 60079-1 does not meet UL 844 for the requirements of non-threaded joint and bolts in joint width of enclosure in Group B locations.

Shaft Openings - Luminaires for Class I Locations

UL 844 requires a shaft opening in an enclosure shall be of the metal-to-metal type for Class I locations. No specific opening type is required in IEC 60079-1. Minimum length of joint and maximum clearance (gap) specified in Figure 11.3 of UL 844 are more stringent than the values listed in Tables 2 & 3 in IEC 60079-1 for the same type joints and gas groups. Further a path length not less than 1” (25.4 mm) and maximum clearance 0.045" (0.11 mm) are required by UL 844. In addition, UL 844 also has requirements to path dimensions of shaft opening in an enclosure provided with a venting section, where the same is not found in IEC 60079-1.

Based on the comparison, it is concluded that IEC 60079-1 does not meet UL 844 requirements for shafting opening.

Guards of Luminaires for Class I and II Locations

UL844 requires a guard, if used, shall be attached to the luminaire so that its position is maintained and no more details are provided. IEC 60079-1 has supplementary requirements for luminaires indicating that light-transmitting cover may be provided with an additional guard and the impact tests are to be applied dependent on the size of the openings in a guard. This may be considered as additional requirements that exceed the requirements in UL 844.

Nonmetallic External Parts

Both UL 844 and IEC 60079-0 have requirements to ensure no danger of ignition due to electrostatic charges for nonmetallic external parts. In addition to material selection (low surface resistance determined by testing), IEC 60079-0 provides more methods than UL 844 to avoid a build-up of electrostatic charge on equipment as following:

- by limitation of the surface area of non-metallic parts of enclosures;
- by limitation of a non-metallic layer bonded to a conductive surface;
- by provision of a conductive coating;
- by marking the equipment with instructions to minimize the risk from electrostatic discharge, etc.

Accordingly IEC 60079-0 exceeds UL 844 for this requirement.

Fuses

Fuses provided in a luminaire for Class I locations shall be subjected to overload and short-circuit tests to determine adverse effects caused by opening of the fuses in explosive gas- or vapor-air mixtures. The similar requirements are not included in IEC 60079-0 and does not meet the requirement in UL 844.

Grounding and Bonding

Bonding and grounding requirements in IEC 60079-1 and UL 844 are similar, except that minimum cross-sectional area of earthing conductor are specified based on phase conductors in IEC, which are not found in UL. Thus it is considered that IEC 60079-1 exceeds the requirements of UL 844 for bonding and grounding.

Porosity in Enclosure Materials

UL 844 has detailed requirements for surface porosity in castings materials of enclosure without limitation on a specific material, whereas only cast iron quality is required not less than the quality 150 as defined by ISO 185 in IEC 60079-0. The allowable sizes of porosities are specified in UL 844 depends on their locations on the enclosure. The similar approach is not find in IEC 60079-0. Therefore it is concluded that IEC 60079-0 does not meet the requirement in UL 844.

Luminaires for Wet Locations

Luminaires marked as "Suitable for Wet Locations" or "Suitable for Locations Having Deposits of Readily Combustible-Paint Residue" shall be subjected to Thermal Shock Test per UL 844. Thermal Shock Test for glass parts of luminaires are also required by IEC 60079-0. Comparisons of thermal shock tests defined by UL and IEC show that UL test requirements cannot be satisfied by IEC 60079-0 (see Thermal Shock Test in Section 5.2.2 of this Report). Also NEMA enclosure ratings for luminaires at wet locations are not employed by IEC. Consequently IEC 60079-0 does not meet the requirement of UL 844.

5.2.2 Performance Tests

Table 13 provides the results of the comparative assessment for the performance test of luminaire to be used in Class I, Division 1 locations. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standard. Note that some sections in the UL 844 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 844.

Table 13: UL 844 to IEC 60079 – Luminaire for Class I Division 1 – Performance Test Comparative Assessment Results

Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Temperature Test	25	IEC 60079-0, Sec. 26.5	Type 1 - Exceeds
Explosion tests	26	IEC 60079-1, Sec. 15.2.2 Sec. 15.3	Type 2 - Meets
Test on Luminaires with Fuses	27	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Hydrostatic Pressure Test	28	IEC 60079-1, Sec. 15.2.3	Type 2 - Meets
Thermal Shock Test	30	IEC 60079-0, Sec. 26.5.2	Type 3 - Does Not Meet
Rust-resistance Test	31	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Secureness of Conduit Hubs Test	32	IEC 60079-1, C.3.3.1	Type 3 - Does Not Meet

Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Vibration Test	33	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Electrical Resistance test	34	IEC 60079-0, Sec. 26.12	Type 1 - Exceeds
Non-Metallic Enclosure Material Tests - Class I	35	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet
Tests on Sealing Compounds	36	IEC 60079-1, Annex C.3	Type 3 - Does Not Meet
Leakage Test on Factory-Installed Conduit Seals	38	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

Temperature Test

UL 844 requires a luminaire surface temperature is to be tested at a rated voltage to bring the lamp wattage up to within 5 percent of its nominal value. The luminaire shall not attain a temperature on the exterior of the enclosure higher than specified in Table 25.1. IEC 60079-0 requires that the test to determine maximum surface temperature shall be performed under the most adverse ratings with an input voltage between 90 % and 110 % of the rated voltage or 110 % of the rated current of the electrical equipment. The T-class is determined by maximum surface temperature in IEC 60079-0. Therefore IEC 60079-0 exceeds the requirement in UL 844.

Thermal Shock Test

Thermal shock test for luminaires are required by both IEC 60079-0 and UL 844 with different methods. IEC 60079-0 requires glass parts of luminaires and windows of electrical equipment shall withstand, without breaking, a thermal shock caused by a jet of water of about 1 mm diameter at a temperature (10 ± 5) °C sprayed on them when they are at not less than the maximum service temperature, whereas UL 844 requires that approximately 1-3/4 ounces (0.052L) of ice water at a temperature not greater than 1.1°C (34°F) is to be splashed against the area of the light transmission part having the highest temperature. There shall be no cracking or breaking of the light transmission part as a result of the test.

From the assessment, the test condition based on temperature requirements in UL8 44 is worse than IEC 60079-0. Also noted that neither the distance from which the jet of water is applied, nor the pressure of application are considered to have a significant effect on the results as indicated in the Note of thermal shock test in IEC 60079-0. Therefore it is concluded that IEC 60079-0 does not meet UL 844 for this test.

Secureness of Conduit Hubs Test

The torque specifications for conduit required by IEC 60079-1 is less than UL 844 under the same conduit sizes. Therefore IEC 60079-1 does not meet the requirement of UL 844 for secureness of conduit hubs.

Electrical Resistance Test

UL 844 requires the electrical resistance test to determine the resistance of the grounding path at threaded joint surfaces not exceeding 0.003 Ω by adding a direct or alternating current of 50 amperes. Earth continuity test in IEC 60079-0 is not only limited at threaded joint surfaces and the resistance between the earth plates or parts of earth plates is tested by passing a direct current of 10 A to 20 A between the earth plates. The resistance for non-metallic material shall not exceed 0.005 Ω. In addition, IEC has more detailed requirements for the test, including materials, parts, assembly of test sample and test time & temperature, etc. Therefore IEC60079-0 exceeds the requirement in UL 844.

Non-Metallic Enclosure Material Tests - Class I

Non-Metallic Enclosure Material Tests in UL 844 includes material chemical compatibility and accumulation of static electricity. Requirements for the tests set by IEC 60079-0 are more than in UL 844. However, for chemical compatibility test, UL 844 requires the compatibility to 13 chemicals to be tested on material samples and complete end products, whereas IEC 60079-0 has no such detailed requirements. In this regard, does not meet the requirements of UL 844.

Tests on Sealing Compounds

This test required by UL is to determine sealing compound resistance to chemicals and to be tested to 13 chemicals, whereas IEC 60079-1 has no such detailed requirements. In this regard, IEC does not meet the requirements of UL 844.

5.3 Luminaires for Class I, Division 2, Group A, B, C & D Locations

Per Sections 39-42 of UL 844, a luminaire for use in Class I, Division 2 locations shall comply with the requirements for a luminaire for use in ordinary locations (see Section 2.1 and 3 in Table 11) and other requirements on enclosures, supply connections, wet location installation, corrosion protection, and temperature test as specified in this standard. See below.

The enclosure for an arcing or sparking part shall meet the requirements for an enclosure in Class I, Division 1 locations (refer to Sections 9-14 of UL 844). The requirements for other enclosures focus on the strength and rigidity to resist mechanical damage and impact, etc. The requirements for supply connection, wet location installation, corrosion protection and temperature test of the luminaires in Class I, Division 2 locations are referred to Sections 17, 24, 19 and 25 of UL 844 for Division 1 locations. See Tables 12 and 13 of this report for the related sections analyses.

5.4 Portable Luminaires

UL 844, Part IV/Section 50 to 71 covers requirements on portable luminaries for indoor use in hazardous (classified) locations, Class I, Division 1, Groups A, B, C and D, and Class II, Division 1, Groups F and G, in accordance with the NEC. The portable luminaries shall comply with the applicable requirements in this standard for construction, testing and marking of fixed installation, except as modified by Part IV.

IEC 60079 series do not have specific Part/Section for portable luminaires, except IEC 60079-14, Section 5.12 for selection of portable luminaires. The requirements in Section 5.12 of IEC 60079-14 are limited to temperature class based on the locations which the portable luminaires may be brought in and low-pressure sodium lamps which shall not be transported unprotected through a hazardous area owing to the risk of ignition due to free sodium from a broken lamp.

In general, comparisons of portable luminaires between UL 844 and IEC 60079 can be covered by Sections 5.2 and 5.6 of this report for the fixed installations, as applicable.

5.5 Manufacturing and production Tests

According to Sections 72 & 73 of UL 844, luminaires shall be subjected to the production-line tests including bonding test and hydrostatic pressure test. See Section 5.2.2 of this Report for the Comparative Assessment Results of the related tests.

Marking

Table 14 provides the results of the comparative assessment for the general provisions. Subsequent sections provide further analysis where the IEC does not meet the UL standard.

Table 14: UL 844 to IEC 60079 –Marking - Comparative Assessment Result

Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Marking	74	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet

5.6 Marking

UL 844, Section 74 contains marking requirements including:

- Manufacturer info
- Luminaire rating
- Rated ambient temperature
- Class, Division or Zone, Group rating e.g. "Class 1, Group D" and/or "Class 1, Zone 1, Group IIA"
- Maximum external operating temperature or temperature class (T Code)
- Self-ballasted or not

- Grounding

IEC 60079-0, Section 29, requires that marking include:

- Manufacturer info
- Name or mark of the certificate issuer and certificate reference
- Ex marking
    - Symbol (e.g. Ex d)
    - Group (e.g. IIA)
    - Temperature class (e.g. T6);
    - Equipment protection level (e.g. Ga)
    - Ambient Temperature (e.g. Ta or Tamb)

In general the marking in both standards are providing similar information as listed here. IEC marking doesn't indicate Zone 0, 1 or 2 whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in IEC are not employed by UL. Therefore it may be considered that IEC 60079-0 does not meet the requirements UL 844 for marking due to differences between the two standards.

5.7 Summary Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079 series meet, exceed, or does not meet the UL 823.

IEC 60079 series ***meets*** the requirements outlined in UL 844 in the following subject areas:

- Scope
- Units of Measurement
- Updated References
- Class, Zone and Group Equivalency
- Luminaires (Class I, Group C and D locations) – threaded joints
- Luminaires (Class I, Group C and D locations) – labyrinth joints
- Luminaires (Class I, Group B locations) – Threaded joint
- Luminaires (Class I, Group A locations)
- Holes in Enclosure Luminaires for Class I Locations
- Supply connections luminaires for Class I locations
- Disconnecting Means
- Protection Against Corrosion
- Materials Applied to Joint Services
- Explosion Tests
- Hydrostatic Pressure Test

The IEC standard ***does not meet*** the requirements outlined in the UL 844, in the subject areas of:

- Scope (Atmospheric Conditions)
- General

- Components
- Enclosure Types
- Enclosure Materials
- Joints in Enclosures (Class I Locations) General
- Luminaires (Class I, Group C and D locations) – straight and rabbet joints
- Luminaires (Class I, Group C and D locations) – bolts in joint width
- Luminaires (Class I, Group B locations)
- Shaft Opening General
- Fuses
- Porosity in Enclosure Materials
- Luminaires for Wet Locations
- Thermal Shock Test
- Secureness of Conduit Hubs Test
- Non-Metallic Enclosure Material Tests – Class I
- Tests on Sealing Compounds
- Marking
- Requirements with no equivalent requirements in IEC 60079
  - Luminaires Subject to Deposits of Combustible-Paint Residue
  - Construction
    - Enclosure Thickness (Class I Locations)
    - Leads
  - Performance Tests
    - Test on Luminaires with Fuses
    - Rust-resistance Test
    - Vibration Test
    - Leakage Test on Factory-Installed Conduit Seals

The IEC standard ***exceeds*** the requirements outlined in the UL 844, in the subject areas of:

- General (low-pressure sodium lamps)
- Guards of Luminaires for Class I and II Locations
- Nonmetallic external parts
- Grounding and Bonding
- Temperature Test
- Electrical Resistance Test

6. UL 913 vs. IEC 60079 Series

UL 913 *Standard for Safety for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and Ill, Division 1, Hazardous (Classified) Locations* is to provide requirements for the construction, testing and marking of electrical apparatus, or parts of such apparatus, having circuits that are not capable of causing ignition in Division 1 Hazardous (Classified) Locations as defined in NEC Article 500.

Based on the scope of this UL standard, the comparative assessment was conducted IEC 60079-0 & IEC 60079-11 as listed below:

- IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* specifies the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres.
- IEC 60079-11 *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"* specifies the construction and testing of intrinsically safe apparatus intended for use in an explosive atmosphere and for associated apparatus, which is intended for connection to intrinsically safe circuits which enter such atmospheres.

The scope of the comparative assessment between UL 913 with IEC 60079 included the following topics:

- General
- Marking
- Reference Standards

6.1 General

Table 15 provides the results of the comparative assessment for the general provisions. Subsequent sections provide further analysis where the IEC does not meet the UL standard. Note that some sections in the UL 913 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 913.

Table 15: UL 913 to IEC 60079 - General - Comparative Assessment Results

Section Title / Subject Issue	UL 913 Baseline Standard Section #	IEC Standard 60079-0/-11 Section #	Assessment Result
Scope	1.1 to 1.2 1.3	IEC 60079-0, Sec. 1 & 4 IEC 60079-11, Sec. 1	Type 2 - Meets
Scope (Atmospheric Conditions)	1.5	IEC 60079-0, Sec. 1	Type 2 - Meets
Undated References	2	IEC 60079-0/-11, Sec. 2	Type 2 - Meets
Units of Measurement	3	IEC uses Metric System	Type 2 - Meets
Components	4	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet
General (Hazardous (Classified) locations)	5.1 5.4	IEC 60079-11, Sec. 1	Type 2 - Meets
General (Skilled person)	5.2	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

Section Title / Subject Issue	UL 913 Baseline Standard Section #	IEC Standard 60079-0/-11 Section #	Assessment Result
General (unclassified (ordinary) locations)	5.3	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet
General (Construction and Testing)	5.5 to 5.7	IEC 60079-0, IEC 60079-11	See Task 4 Report for the results of comparative assessment of ISA 60079-0 to IEC-60079-0 and ISA 60079-11 to IEC 60079.

6.1.1 Scope

UL 913 covers intrinsically safe apparatus and parts of apparatus for installation and use in Class I, Class II & III, Division 1 as well as Groups IIIA, IIIB & IIIC, Zone 20 locations in accordance with the requirements of the NEC. The requirements in UL 913 also apply to associated apparatus located outside of Hazardous (Classified) Locations whose design and construction may influence the intrinsic safety of an electrical circuit within the hazardous (classified) locations. Apparatus and parts of apparatus, installation locations and type of protection in UL 913 are contained in IEC 60079 series.

The ambient conditions defined in UL 913 and IEC 60079-0 are similar. Noted that ambient temperature range is given as –20 °C to +60 °C in IEC, while ambient temperature is provided in UL 913 as 40 °C without range in Section 1.5. However the ambient temperature range for UL 913 may be considered as –25 °C to +40 °C per marking requirement in Section 10.1 of UL 913 that ambient temperature is to be marked for a temperature range other than - 25 °C to +40 °C. Therefore normal atmospheric conditions defined in UL 913 can be covered by IEC 60079-0.

6.1.2 Components

UL 913 requires components to meet standards for components commonly used in electrical equipment provided in Appendix B. Both UL 913 and IEC 60079-0 standards require that electrical components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However IEC standards do not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on components be verified by the testing lab.

6.1.3 General

General Requirements

IEC 60079-11 and UL 913 have similar requirements on intrinsically safe apparatus incapability of causing an explosion in the surrounding explosive atmospheres and protection types suitable for the hazardous locations where they are intended to be installed.

Both UL and IEC standards indicates that electrical equipment and components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified).However IEC does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing lab.

Construction and Testing

UL 913 requires intrinsically safe apparatus for Class I, Division 1, Group A, B, C & D shall comply with the applicable requirements in UL 60079-0 and UL 60079-11 for Group IIA, IIB, and IIC, level of protection "ia". UL 60079-0 and UL 60079-11 contain identical requirements, and identical publication dates as ANSI/ISA 60079-0 and ANSI/ISA 60079-11, respectively. Comparisons of ANSI/ISA 60079 Series with IEC 60079 Series are covered in Task 4 and the results of the comparative assessment of ISA 60079-0 to IEC-60079-0 and ISA 60079-11 to IEC 60079-11 in the Task 4 Report can be considered equivalent to the results of UL 913 compared with IEC 60079.

6.2 Marking

Table 16 provides the results of the comparative assessment for the general provisions. Subsequent sections provide further analysis where the IEC does not meet the UL standard.

Table 16: UL 913 to IEC 60079 –Marking - Comparative Assessment Result

Section Title / Subject Issue	UL 913 Baseline Standard Section #	IEC Standard 60079-0/-11 Section #	Assessment Result
Marking –Minimum - Intrinsic Safe - Others	10.1 10.2 10.3 to 10.5	IEC 60079-0,Sec. 29 IEC 60079-11, Sec. 12.1 IEC 60079-0, Sec. 29.14 IEC 60079-11, Sec. 12.2 & 12.3	Type 3 - Does Not Meet Type 2 – Meets Type 2 - Meets

Minimum Marking

UL 913 contains minimum marking requirements including:

- Manufacturer info
- Hazardous location Class and Group
- Maximum surface temperature or temperature class (T Code)
- Rated ambient temperature range other than -25 to +40 °C
- Maximum nonhazardous location voltage for shunt diode and similar protective barrier
- Control drawing number

IEC 60079-11 requires intrinsically safe apparatus and associated apparatus shall carry at least the minimum marking specified in IEC 60079-0, which are mainly include:

- Manufacturer info
- Name or mark of the certificate issuer and certificate reference
- Ex marking
  - Symbol (e.g. Ex d)
  - Group (e.g. IIA)
  - Temperature class (e.g. T6);
  - Equipment protection level (e.g. Ga)
  - Ambient Temperature (e.g. Ta or Tamb)

In addition to the minimum marking requirements, the marking for intrinsically safe apparatus and associated apparatus shall include the following per UL 913:

- Indication for intrinsically safe apparatus
- maximum input voltage, maximum input current, maximum internal capacitance, maximum internal inductance and maximum input power
- Warning markings
- Other protection type and its characteristics
- Maximum rms, AC or DC

Also IEC 60079-11, Section 12.1 provides marking requirements for intrinsically safe apparatus and associated apparatus:

- Symbol Ex ia, Ex ib or Ex ic (or ia or ib or ic, if Ex is already marked)
- All relevant parameters, for example Um, Li, Ci, Lo, Co
- IP rating
- Certification number

Both UL 913 and IEC 60079 require that terminals, terminal boxes, and plugs and receptacles, etc. for connection to intrinsically safe circuits shall be clearly identified and clearly distinguishable. Both standards also have similar marking requirements including warnings for batteries used to power apparatus, such as no replacement of batteries and charging of batteries in hazardous areas.

In general, the marking in both standards provide similar information. Ex Symbols and equipment protection level in IEC are not included in UL 913. UL/ISA 60079 series use AEx. Intrinsically safe apparatus for Class I, Div. 1, Group A, B, C & D covered in UL 913 are required to meet UL/ISA-60079-0/-11. One major difference in marking between ISA 60079 and IEC 60079 is that the ISA standard requires marking to indicate Class and Division/Zone, whereas IEC 60079 does not. Therefore IEC 60079 does not meet the marking requirements of UL 913.

6.3 Reference Standards

Table 17 provides the results of the comparative assessment for the reference standards. Subsequent sections provide further analysis where IEC 60079 does not meet UL 913.

Table 17: UL 913 to IEC 60079 –Reference Standard - Comparative Assessment Result

Section Title / Subject Issue	UL 913 Baseline Standard Section #	IEC Standard 60079-0/-11 Section #	Assessment Result
Reference Standards	Appendix B	IEC 60079-0, Sec. 2 IEC 60079-11, Sec. 2	Type 3 - Does Not Meet

The References in Appendix B of UL 913 are all UL Standards for Equipment for Ordinary Locations, as well as for Hazardous Locations Standards. References adopted by IEC are IEC and ISO standards, except ANSI/UL 746B & 746C in IEC 60079-0 and ANSI/UL 248-1 in IEC 60079-1, which are also listed in Appendix B of UL 913.

6.4 Summary Conclusions

Based on the comparative assessments in the above sections, various sections of the IEC 60079 series meet, exceed, or does not meet the UL 913.

IEC 60079 series ***meets*** the requirements outlined in UL 913 in the following subject areas:

- Scope and Atmospheric Conditions
- Undated References
- Units of Measurement
- General (Hazardous (Classified) locations)
- Marking (Intrinsic Safe)
- Marking (Others)

The IEC standard ***does not meet*** the requirements outlined in the UL 844, in the subject areas of:

- Components
- General (unclassified (ordinary) locations)
- General Marking - Minimum
- Reference Standards
- Requirements with no equivalent requirements in IEC 60079
  - General (Skilled person)

For comparisons of construction and testing of intrinsically safe apparatus for Class I, Division 1, Group A, B, C & D between UL and IEC, see the Task 4 Report for results of the comparative assessment of ISA 60079-0 to IEC-60079-0 and ISA 60079-11 to IEC 60079-11.

7. UL 1203 vs. IEC 60079 Series

UL 1203 *Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use In Hazardous (Classified) Locations* provides requirements for the construction, performance and marking of explosion-proof or dust-ignition-proof equipment for use in explosive atmospheres.

Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-14 and IEC 60079-10-1 as listed below:

- IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* specifies the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres.
- IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* contains specific requirements for the construction and testing of electrical equipment with the type of protection flameproof enclosure "d", intended for use in explosive gas atmospheres.
- IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection* contains the specific requirements for the design, selection, erection and initial inspection of electrical installations in, or associated with, explosive atmospheres
- IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* is concerned with the classification of areas where flammable gas or vapor hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas.

The scope of the comparative assessment between the UL 1203 with the IEC Standard 60079 included the following topics:

- General
- Explosion-proof equipment
- Manufacturing and production tests
- Marking
- Industrial Control Equipment
- Switches
- Circuit Breaker
- Outlet Boxes and Fittings
- Receptacle-Plug Combinations
- Electrical Operated Valves
- Tests on Polymeric Valve Enclosures

7.1 General

Table 18 provides the results of the comparative assessment for the general provisions. Subsequent sections provide further analysis where the IEC does not meet the UL standards.

Table 18: UL 1203 to IEC 60079 –General - Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Scope	1.1 to 1.5	IEC 60079-0, Sec. 1 & 4 IEC 60079-1, Sec. 1 IEC 60079-31, Sec. 1	Type 2 - Meets
Scope (Atmospheric Conditions)	1.6	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet
Scope (ordinary locations)	1.7	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet
Components	2	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet
Units of Measurement	3	IEC uses Metric System	Type 2 - Meets
Undated References	4	IEC 60079-0/-1/14, Sec. 2	Type 2 - Meets
Enclosure Types	5	IEC 60079-0/-1/-14	Type 3 - Does Not Meet
Class I, Zone and Group Equivalency	6	IEC 60079-0, Sec. 4 IEC 60079-10-1, Sec. 3 IEC 60079-10-2, Sec. 3 & 6	Type 2 - Meets
Glossary	7	IEC 60079-0/-1/14, Sec. 3	Type 2 - Meets

7.1.1 Scope and Components

UL 1203 covers explosion-proof equipment installed in Class I, Division 1, Group A, B, C & D (equivalent to Class I, Zone 1, Group IIA, IIB & IIC). Equipment and types of protection in UL 1203 are contained in IEC 60079 series.

The Division system for hazardous area classification employed in UL 1203 is not used in IEC 60079 series. The equivalency between Division system and Zone System based on NEC Article 500 and 505 are provided in the UL standard. The definitions and basis for the Zone (including Gas Groups) method classification in NEC Article 505 and IEC 60079-10-1 are very similar. The detailed analysis can be found in Task 1 Report.

The ambient conditions defined in UL 1203 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but no maximum temperature is specified in UL 1203.

Both UL and IEC standards indicate that electrical equipment and components in hazardous (classified) locations also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However IEC 60079-0 does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing lab.

7.1.2 Enclosure Types

Both IEC and UL standards have requirements on protecting equipment from ingress of liquid/solid foreign objects. However, type 4X enclosure in UL 1203 is watertight corrosion-resistant enclosure and is required to be manufactured from corrosion-resistant materials. There are no equivalent enclosures identified by IP rating in IEC.

7.2 Explosion-proof Equipment

This section focuses on the comparison of requirements of construction and performance tests of explosion-proof equipment for Class I, Division 1, Group A, B, C & D (equivalent to Class I, Zone 1, Group IIA, IIB & IIC) installation in UL 1203 with IEC 60079-1 and 60079-0 and IEC 60079-14, as applicable. The results of the comparative assessment are summarized in Tables 20 and Table 21. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standard. Note that some sections in the UL 1203 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 1203.

7.2.1 Construction

Table 19 provides the results of the comparative assessment for the construction of explosion-proof equipment to be used in Class I, Division 1 locations. Note that some sections in the UL 1203 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet or exceeds the UL 1203.

Table 19: UL 1203 to IEC 60079 –Explosion Proof Equipment – Construction Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Enclosure Material	8	IEC 60079-1, Sec. 12.4 & 12.7 IEC 60079-0, Sec. 8.3	Type 3 - Does Not Meet
Enclosure Thickness	9	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Joints in Enclosure General	10.1	IEC 60079-1, Sec. 5.1 & 5.2	Type 2 - Meets
Cemented Joints	10.2	IEC 60079-1, Sec. 6 IEC 60079-0, Sec. 12	Type 2 - Meets
Joints with flamepaths Class I, Group A, B, C and D	10.3	IEC 60079-1, Sec. 5.4 & 8.1.3	Type 2 - Meets
Class I, Group C and D locations	10.4	IEC 60079-1, Sec. 5.2.1 thru 5.2.4 & 8.1.3	Type 3 - Does Not Meet

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Cylindrical joints Groups A, B, C, and D	10.4.4	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet
Class I, Group B locations General	10.5	IEC 60079-1, Sec. 5.2.1 thru 5.2.4	Type 3 - Does Not Meet
Threaded joints	10.6	IEC 60079-1, Sec. 5.3	Type 2 - Meets
Shaft Openings General	11	IEC 60079-1, Sec. 5.2.2 & 8	Type 3 - Does Not Meet
Holes in Enclosure	12	IEC 60079-1, Sec. 11 IEC 60079-0, Sec. 9.3	Type 2 - Meets
Drain and Breather Fittings in Enclosure	13	IEC 60079-1, Sec. 10	Type 2 - Meets
Supply Connections - Fixed equipment conduit and cable entries	14.1	IEC 60079-1, Sec. 13	Type 1-Exceeds
Supply connections - Cord-connected portable equipment	14.2	See Parts/Sections for 10.1-10.6 of UL 1203	See Parts/Sections for 10.1-10.6 of UL 1203
Protection Against Corrosion	15	IEC 60079-0, Sec. 15.3 IEC 60079-1, Sec. 5.1	Type 2 - Meets
Materials applied to joint surfaces	16	IEC 60079-1, Sec. 5.1	Type 2 - Meets
Devices Having Coated Threaded Joint Surfaces	17	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Porosity in Enclosure Materials	18	IEC 60079-1, Sec. 12	Type 3 - Does Not Meet
Polymeric Enclosures	19	IEC 60079-0, Sec. 7	Type 2 - Meets

Enclosure Materials

The equipment enclosure housing can be made of metal materials or nonmetallic materials. Comparisons show that enclosure metal material requirements are not consistent between the IEC 60079 series and UL 1203. UL 1203 may be considered more stringent than IEC 60079 due to no allowance on zinc alloys as well as magnesium and its alloys in this UL standard. Also UL 1203 has maximum limit of copper content of alloy (30%) less than required by IEC (60%) for use in Class I, Group A (equivalent to Group IIC containing acetylene).

In UL 1203 nonmetallic materials shall comply with the requirements in Section 33, Non-Metallic Enclosure Materials Tests. The comparisons of non-metallic material tests between UL 1203 and IEC are covered in Section 7.3 of this report.

Based on the above, it can be concluded that IEC 60079 does not meet the requirements of UL 1203 from the material aspect.

Joint in Enclosures (Class I, Group C and D Locations)

For non-threaded joint of enclosure, width and clearance of joint required are given by a figure which shows a near linearization of width and clearance and to be followed with a minimum width limit to 3/4" (19.1 mm) and maximum clearance 0.045" (0.11 mm) in UL 1203. Comparisons with minimum width and maximum clearance in Table 2 of IEC60079-1 shows that UL requirements on joint width and/or clearance (gap) are more stringent than IEC, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group.

UL 1203 requires a labyrinth joint to consist of not less than 3 adjacent segments where the path changes direction not less than 2 times, which has the same requirement as the multi-step joint in IEC 60079-1.

Bolts in joint width is accepted with conditions, such as minimum joint length and flame path length (from inside or outside of enclosure to the nearest edge of bolt hole) and maximum diametrical clearance between bolt and bolt hole in UL 1203. IEC 60079-1 does not have such limitation. Where the bolt in joint width is provided, the required minimum flame path length in IEC 60079-1 is less than in UL 1203 under the same joint width ranges.

IEC60079-1 does not meet UL 1203 for the requirements of non-threaded joint and bolts in joint width of enclosure in Group C & D locations.

Cylindrical joints Groups A, B, C, and D

For a flamepath having a cylindrical cross-section, the joint path length is not less than 1” (25.4 mm) and maximum diametrical clearances for 1” and 1-1/4” length of path specified in UL 1203 are less than IEC 60079-1. For flamepath lengths greater than 1” but less than 1-1/4”, the joint path length and clearances are follow the same requirements for Class I, Group C and D Locations. Comparisons show that UL 1203 requirements on joint width and/or clearance (gap) of cylindrical joints are more stringent than IEC 60079-1, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group. IEC does not meet UL at this point.

Joint in Enclosures (Class I, Group B Locations)

Minimum required non-threaded joint width in IEC 60079-1 and UL 1203 are same. However, where free internal volume (V cm^3) of enclosure $100 < V \leq 500$ and $1640 < V \leq 2000$, UL 1203 gives maximum allowable joint gaps less than IEC 60079-1 under the same joint width ranges and enclosure volumes for the equivalent gas groups. Also width and gap of rabbet joint in UL 1203 cannot be satisfied by IEC 60079-1, Table 3 and no minimum thickness of cover thickness at the joint flange is specified in the IEC standard.

Similar as in Group C & D locations, bolts in joint width in Group B locations are also accepted with conditions in UL 1203, which is not required by IEC 60079-1. Where the bolt in joint width is provided, the required minimum width of joint and/or minimum flame path length (distance from inside of enclosure to nearest edge of bolt hole) in IEC 60079-1 is less than UL 1203.

IEC 60079-1 does not meet UL 1203 for the requirements of non-threaded joint and bolts in joint width of enclosure.

Shaft Openings

A shaft opening in an enclosure shall be of the metal-to-metal, metal-to-polymeric, or polymeric-to-ceramic type. Opening types are not specified in IEC60079-1.

Minimum length of joint and clearance (gap) for shaft opening depend on gas groups, shaft joint types (straight or labyrinth) and bearing types (sleeve or ball). For the same length of joints as well as same joint types and bearing types, the maximum allowable clearance (gap) for Group C & D locations in UL 1203 is less than equivalency Group IIA & IIB locations in IEC 60079-1, thus UL 1203 is more stringent.

IEC 60079-1, Table 3 for Group IIC enclosure is applied to free internal volume more than 2000 cm^3, whereas Group A & B enclosure with shaft opening in UL is limited to free internal volume of 30 in^3 (500 cm^3) or less. UL 1203 also requires that shaft opening in an enclosure for Group A & B locations shall have a path length not less than 1” (25.4 mm) and maximum clearance 0.045" (0.11 mm), which is more stringent than IEC 60079-1.

In addition, the joint path length and clearance (gap) of shaft openings in UL 1203 also depends on shaft speed (less or more than 100 rpm). Rotating speed (rpm) is not a parameter for consideration of opening requirements in IEC 60079-1.

Based on the comparisons, it is concluded that IEC 60079-1 does not meet the requirements of UL 1203 for shafting opening.

Supply Connections - Fixed equipment conduit and cable entries

NPT threaded connections per ANSI/ASME B1.20.1 are accepted by both IEC 60079-1 and UL 1203. Explosion tests for conduit entry is required by UL 1203 and enclosure flameproof test shall be carried out with conduit sealing device per IEC 60079-1. In addition to conduit entries, IEC 60079-1 also covers cable glands for threaded holes. Conduit sizes and conduit stop throat diameters are specified in UL 1203. For conduit seals, the minimum length of compound required by IEC 60079-1 is more than UL1203. Both IEC and UL standards have similar test requirements for compounds. IEC 60079-1 covers more types of sealing than UL 1203.

Bonding and grounding requirements in IEC 60079-1 and UL 1203 are similar, except that minimum cross-sectional area of earthing conductor are specified based on phase conductors in IEC, which are not found in UL.

Accordingly overall IEC 60079-1 exceeds UL 1203 for conduit requirements.

Porosity in Enclosure Materials

UL 1203 has detailed requirements for surface porosity in castings materials of enclosure without limitation on a specific material, whereas only cast iron quality is required not less than the quality 150 as defined by ISO 185 in IEC 60079-1. The allowable sizes of porosities are specified in UL 1203 depends on their locations on the enclosure. The similar approach is not found in IEC 60079-1. Therefore it is concluded that IEC 60079-1 does not meet the requirements of UL 1203 for porosity of enclosure materials.

7.3 Performance Tests

Table 20 provides the results of the comparative assessment for the performance test of explosion-proof equipment to be used in Class I, Division 1 locations. Note that some sections in the UL 1203 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet or exceeds the UL 1203.

Table 20: UL 1203 to IEC 60079 –Performance Tests - Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Temperature Test	20	IEC 60079-0, Sec. 26.5	Type 1 - Exceeds
Explosion tests	21	IEC 60079-1, Sec. 15.2.2 Sec. 15.3	Type 2 - Meets
Hydrostatic Pressure Test	22	IEC 10079-1, Sec. 15.2.3	Type 2 - Meets
Leakage Test on Factory-Installed Conduit Seals	23	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Tests for Glass Parts - Thermal-shock test	25.1	IEC 60079-0, Sec. 26.5.2	Type 2 - Meets
Tests for Glass Parts - Impact test	25.2	IEC 60079-0, Sec. 26.4	Type 1 - Exceeds
Secureness of Conduit Hubs Test	26	IEC 60079-1, C.3.3.1	Type 3 - Does Not Meet
Tests on Joint Gaskets	27	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Electrical Resistance Test	28	IEC 60079-0, Sec. 26.12	Type 1 - Exceeds
Accelerated-Aging Test on Bushing	29	IEC 60079-0, , Clause 26.8, 26.9	Type 2 - Meets
Strain-Relief Test	30	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Rough-Usage Test	31	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Drop Test	32	IEC 60079-0, Sec. 26.4.3	Type 2 - Meets

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Non-Metallic Enclosure Material Tests	33	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet
Chemical Resistance Tests on Sealing and Cementing Compounds	34	IEC 60079-1, Annex C.3	Type 3 - Does Not Meet

Temperature Test

UL 1203 requires equipment surface temperature is to be tested at an ambient of 40 °C or higher depending on ambient temperature which equipment is to be used. Exterior surface temperature shall not exceed 100 °C or maximum operating temperature or operating temperature class (T Code).

IEC 60079-0 requires that the test to determine maximum surface temperature shall be performed under the most adverse ratings with an input voltage between 90 % and 110 % of the rated voltage or 110 % of the rated current of the electrical equipment. The measured maximum surface temperature shall not exceed the marked temperature or temperature class, less 5 K for temperature classes T6, T5, T4 and T3 (or marked temperatures ≤200 °C), and less 10 K for temperature classes T2 and T1 (or marked temperatures >200 °C).

Based on the above, it can be considered that IEC 60079-0 exceeds UL 1203 for temperature test.

Tests for Glass parts - Impact Test

For the impact test, UL 1203 and UL 60079-0 have different requirements on the test weight and falling height. The drop energy derived from the weight and height in UL is less than maximum drop energy for the test of light-transmitting parts in IEC. No test numbers and test temperature are specified for impact test in UL. IEC requires that the impact test are made on at least two samples and the test shall be carried out at the upper and lower test temperatures specified per maximum and minimum service temperatures. Therefore it can be considered that IEC 60079-0 exceeds UL 1203.

Secureness of Conduit Hubs Test

Torque specifications on the conduit required for the test per IEC 60079-1 is less than required by UL 1203 under the same conduit hub sizes. Therefore IEC 60079-1 does not meet the requirements of UL 1203 for torque specification for conduit hubs.

Electrical- Resistance Test

UL 1203 requires the electrical resistance test to determine the resistance of the grounding path at threaded joint surfaces not exceeding 0.003 Ω by adding a direct or alternating current of 50 amperes. Earth continuity test in IEC 60079-0 is not only limited at threaded joint surfaces and the resistance between the earth plates or parts of earth plates is tested by passing a direct current of 10 A to 20 A between the earth plates. The resistance for non-metallic material shall not exceed 0.005 Ω. In addition, IEC 60079-0 has more detailed requirements for the test, including materials, parts, assembly of test sample, test time and temperature. Therefore IEC60079-0 exceeds the requirement in UL 1203.

Non-Metallic Enclosure Material Tests

Non-Metallic Enclosure Material Tests in UL 1203 includes material chemical compatibility and accumulation of static electricity. Requirements for the tests set by IEC 60079-0 are more than in UL 1203. However, for chemical compatibility test, UL 1203 requires the compatibility to 13 chemicals to be tested on material samples and complete end products, whereas IEC 60079-0 has no such detailed requirements. In this regard, it is considered that IEC 60079-0 does not meet the requirements of UL 1203.

Chemical Resistance Tests on Sealing and Cementing Compounds

This test required by UL 1203 is to determine sealing and cementing compound resistance to chemicals and to be tested to 13 chemicals, same as required by chemical test for non-metallic enclosure materials (see above). Also the adhesive bond strength of formed-in-place RTV silicone rubber is used as a measure of the retention of physical properties of specimens. IEC 60079-0 has no the same requirements and does not meet UL 1203.

7.4 Manufacturing and production Tests

According to Sections 58 & 59 of the UL 1203, equipment shall be subjected to the production-line tests including bonding test and hydrostatic pressure test. See Table 21 in Section 7.2.2 of this Report for the Comparative Assessment Results of the related tests.

7.5 Marking

Table 21 provides the results of the comparative assessment for the marking provisions. Subsequent sections provide further analysis where IEC 60079-0 does not meet UL 1203.

Table 21: UL 1203 to IEC 60079 –Marking - Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
MARKINGS	60	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet

UL 1203, Section 60 contains marking requirements including:

- Manufacturer info
- Electrical rating
- Rated ambient temperature
- Max. operating pressure
- Class, Division or Zone, Group rating e.g. "Class 1, Group D" and/or "Class 1, Zone 1, Group IIA"

- Maximum external operating temperature or temperature class (T Code)
- Terminal Box Info including temperature marking
- Grounding

IEC 60079-0, Section 29, requires that marking include:

- Manufacturer info
- Name or mark of the certificate issuer and certificate reference
- Ex marking
    - Symbol (e.g. Ex d)
    - Group (e.g. IIA)
    - Temperature class (e.g. T6);
    - Equipment protection level (e.g. Ga)
    - Ambient Temperature (e.g. Ta or Tamb)

In general the marking in both standards are providing similar information as listed here. IEC 60079-0 marking doesn't indicate Class, Division or Zone, which are required by UL 1203. Ex Symbols and equipment protection level in IEC are not employed by UL. Accordingly, it may be considered that IEC 60079-0 does not meet UL 1203 for marking due to difference between the two standards,

7.6 Industrial Control Equipment

Table 22 provides the results of the comparative assessment for the industrial control equipment provisions. Subsequent sections provide further analysis where IEC 60079 does not meet UL 1203. Note that some sections in the UL 1203 are not contained in the IEC 60079 standards. In these subject areas, the IEC 60079 series does not meet UL 1203.

Table 22: UL 1203 to IEC 60079 –Industrial Control Equipment - Comparative Assessment Result

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
General	61		See Previous Sections 7.1 through 7.4 of this report
Construction -Holes	62	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
No-Load	63	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Markings	64	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

Per UL 1203, industrial control equipment shall comply with the applicable requirements of Sections 1 to 60 of UL 1203 as discussed in Sections 7.1 – 7.4 in this report and additional requirements in Sections 62 through 64. The control devices shall also comply with the applicable requirements in UL 508 *Standard for Industrial Control Equipment*. The same specific requirements are not covered by IEC 60079 series. In these subject areas, it is considered that the IEC 60079 series does not meet the requirements of UL 1203.

7.7 Switches

Table 23 provides the results of the comparative assessment of provisions for switches. Subsequent sections provide further analysis where the IEC does not meet the UL standards. Note that some sections in the UL 1203 are not contained in the IEC 60079 standards. In these subject areas, the IEC 60079 series does not meet UL 1203.

Table 23: UL 1203 to IEC 60079 –Switches - Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
General	65		See Previous Sections 7.1 through 7.4 of this report
Construction	66 to 69	IEC 60079-0, Sec. 18 IEC 60079-1, Sec. 17	Type 3 - Does Not Meet
Ratings	70	IEC 60079-0, Sec. 18 IEC 60079-1, Sec. 17	Type 3 - Does Not Meet
Markings	71	IEC 60079-1, Sec. 17	Type 3 - Does Not Meet

Per UL 1203, switches shall comply with the applicable requirements of Sections 1 to 60 of UL 1203 as discussed in Sections 7.1 through 7.4 in this report and additional requirements in Sections 66 through 71.

7.7.1 Construction

The thickness of sheet-metal diaphragm, spacing through air from each terminal and insulating barrier or liner that is used to provide spacing required by UL 1203 are not met by IEC 60079 series.

7.7.2 Ratings

Additional "T" rating at 125 volts and additional "L" rating at 120 or 125 volts for switches in UL 1203 are not used by IEC 60079 series.

7.7.3 Markings

Marking "T" or "L" on a switch for the control of tungsten-filament lamps in UL 1203 are not required by IEC 60079 series.

7.8 Circuit Breakers

Table 24 provides the results of the comparative assessment for the circuit breaker provisions. Subsequent sections provide further analysis where the IEC does not meet the UL standards. Note that some sections in the UL 1203 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 1203.

Table 24: UL 1203 to IEC 60079 –Circuit Breaker - Comparative Assessment Result

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
General	72		See Previous Sections 7.1 through 7.4 of this report
Construction	73 - 74	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Markings	75	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

UL 1203 requires circuit breakers to comply with the applicable requirements of Sections 1 to 60 of UL 1203 as discussed in Sections 7.1 through 7.4 in this report and additional requirements in Sections 73 through 75. The circuit breakers shall also comply with the applicable requirements in UL 489 Standard for *Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures*. The same specific requirements are not covered by IEC 60079 series. In these subject areas, it is considered that the IEC 60079 series does not meet the requirements of UL 1203.

7.9 Outlet Boxes and Fittings

Table 25 provides the results of the comparative assessment for the outlet boxes and fitting provisions. UL 1203 requires outlet boxes and fittings to comply with the applicable requirements of Sections 1 to 60 of UL 1203 as discussed in Sections 7.1 – 7.4 in this report and additional requirements in Sections 77 to 102.

Table 25: UL 1203 to IEC 60079 –Outlet Boxes and Fitting - Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
General	76	IEC 60079-0, Sec. 16 Appendix A IEC 60079-14, Sec. 10	Type 2 - Meets
Construction, Performance Tests & Marking	77 to 102	IEC 60079-0, Sec. 16 Appendix A IEC 60079-14, Sec. 10	Type 2 - Meets

7.10 Receptacle-Plug Combinations

Table 26 provides the results of the comparative assessment for the receptacle-plug combination provisions. UL 1203 requires receptacle-plug combinations to comply with the applicable requirements of Sections 1 to 60 of UL 1203 as discussed in Sections 7.1 through 7.4 in this report and additional requirements in Sections 103 through 131. The IEC 60079 series of standards do not have equivalent requirements.

Table 26: UL 1203 to IEC 60079 –Receptacle-Plug Combination - Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Part IX- Receptacle-Plug Combinations	103 to 131	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

7.11 Electrical Operated Valves

Table 27 provides the results of the comparative assessment for the electrical operated valves provisions. UL 1203 requires electrical operated valves to comply with the applicable requirements of Sections 1 to 60 of UL 1203 as discussed in Sections 7.1 through 7.4 in this report and additional requirements in Sections 132 through 138. The IEC 60079 series of standards do not have equivalent requirements.

Table 27: UL 1203 to IEC 60079 –Electrical Operated Valves - Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Part X- Electrically Operated Valves	132 to 138	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

7.12 Tests on Polymeric Valve Enclosures

Table 28 provides the results of the comparative assessment for the tests on polymeric valve enclosures provisions.

Table 28: UL 1203 to IEC 60079 –Tests on Polymeric Valve Enclosures - Comparative Assessment Results

Section Title / Subject Issue	UL 1203 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Assessment Results
Part XI - Tests On Polymeric Valve Enclosures	139 to 152	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet

Per UL 1203, tests on polymeric valve enclosure shall comply with the applicable requirements of Sections 20 to 34 of UL 1203 for explosion-proof equipment as discussed in Section 7.3 in this report and additional requirements in Sections 139 through 152 in the UL standard. The comparison results of non-metallic enclosure material test, explosion tests and hydrostatic pressure tests, etc. can be found in Table 20 of the standard. A valve whose electrical enclosure has no internal volume is required to be hydrostatically tested at the pressure specified (from 600 psi to 6000 psi) depending on Groups and conduit size of fittings to the enclosures. The IEC 60079 series of standards do not have equivalent requirements.

7.13 Summary Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079 series meet, exceed or do not meet the UL 1203.

IEC 60079 series ***meets*** the requirements outlined in UL 1203 in the following subject areas:

- Scope
- Units of Measurement
- Updated References
- Class I, Zone and Group Equivalency
- Glossary
- Joints in Enclosure (General)
- Cemented Joints
- Joints with flamepaths Class I, Group A, B, C and D
- Threaded joints
- Holes in Enclosure
- Drain and Breather Fittings in Enclosure
- Protection Against Corrosion
- Materials applied to joint surfaces
- Polymeric Enclosures
- Explosion Test
- Hydrostatic Pressure Test
- Tests for Glass Parts - Thermal-shock test
- Accelerated-Aging Test on Bushing
- Drop Test

The IEC standard ***does not meet*** the requirements outlined in the UL 1203, in the subject areas of:

- Scope (Atmospheric Conditions)
- Scope (Ordinary Locations)
- Components
- Enclosure Types

- Enclosure Material
- Class I, Group C and D locations
- Cylindrical joints Groups A, B, C, and D
- Class I, Group B locations General
- Shaft Openings General
- Porosity in Enclosure Materials
- Leakage Test on Factory-Installed Conduit Seals
- Secureness of Conduit Hubs Test
- Tests on Joint Gaskets
- Non-Metallic Enclosure Material Tests
- Chemical Resistance Tests on Sealing and Cementing Compounds
- Marking
- Switches
    - Construction
    - Ratings
    - Markings
- Outlet Boxes and Fittings
    - General requirements
    - Construction, performance tests and marking
- Part XI-Tests On Polymeric Valve Enclosures
- Requirements with no equivalent requirements in IEC 60079
    - Construction
        - Enclosure Thickness
        - Devices Having Coated Threaded Joint Surfaces
    - Performance Tests
        - Leakage Test on Factory-Installed Conduit Seals
        - Tests on Joint Gaskets
        - Strain-Relief Test
        - Rough-Usage Test
    - Industrial Control Equipment
        - Construction –Holes
        - No-Load
        - Markings
    - Circuit Breakers
        - Construction
        - Markings
    - Part IX-Receptacle-Plug Combinations
    - Part X-Electrically Operated Valves

The IEC standard ***exceeds*** the requirements outlined in the UL 1203, in the subject areas of:

- Supply Connections - Fixed equipment conduit and cable entries
- Temperature Tests
- Tests for Glass Parts – Impact Test
- Electrical Resistance Test

8. UL 2225 vs. IEC 60079 Series

UL 2225 *Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations* contains requirements for the construction, performance and marking of cables and cable fittings intended for use in explosive atmospheres. Based on the scope of this UL standard, the comparative assessment was conducted with IEC 60079-0, IEC 60079-1, IEC 60079-7 as listed below:

- IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General requirements* specifies the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres.
- IEC 60079-1 *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"* contains specific requirements for the construction and testing of electrical equipment with the type of protection flameproof enclosure "d", intended for use in explosive gas atmospheres.
- IEC 60079-7 *Explosive atmospheres – Part 7: Equipment protection by increased safety "e"* specifies the requirements for the design, construction, testing and marking of electrical equipment and Ex Components with type of protection increased safety "e" intended for use in explosive gas atmospheres.

The scope of the comparative assessment between the UL 2225 with the IEC Standard 60079 included the following topics:

- General
- Cables
- Cable Sealing Fittings
- AEx Cable Fittings and Extra-Hard Usage Cord Connectors
- Marking

8.1 General

Table 29 provides the results of the comparative assessment for the general provisions. Subsequent sections provide further analysis where the IEC does not meet the UL standards.

Table 29: UL 2225 to IEC 60079 –General - Comparative Assessment Results

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1-/7 Section #	Assessment Results
Scope	1.1 to 1.10	IEC 60079-0, Sec. 1 & 4 IEC 60079-1, Sec. 1 IEC 60079-7, Sec. 1	Type 2 - Meets

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1-/7 Section #	Assessment Results
Scope (Atmospheric Conditions)	1.11	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet
Units of Measurement	2	IEC uses Metric System	Type 2 - Meets
Undated References	3	IEC 60079-0/-1/-7, Sec. 2	Type 2 - Meets
Glossary	4	IEC 60079-0, Sec. 3	Type 2 - Meets

8.1.1 Scope

UL 2225 covers the following types of cables and cable fittings for use in hazardous locations classified in accordance with the NEC:

- Type MC-HL metal-clad cable in Class I, Div. 1, Group A, B, C & D (equivalent to Class I, Zone 1, Group IIA, IIB IIC)
- Type ITC-HL instrumentation tray cable in Class I, Div. 1 , Group A, B, C & D (equivalent to Class I, Zone 1, Group IIA, IIB, IIC)
- Type TC-ER-HL tray cable in Class I, Zone 1, Group IIA, IIB, IIC
- Explosion proof and dust-ignition proof cable sealing fittings in class I, Div. 1 & 2, Group A, B, C & D
- Explosionproof and dust-ignitionproof cable sealing fittings for use on mobile offshore oil rig and drilling platforms, and other marine vessels.
- Increased safety "e" cable fittings and flameproof "d" cable sealing fittings in Class I, Zone 1, Group IIA, IIB, IIC
- Increased safety "e" cable fittings and flameproof "d" cable sealing fittings for use in Class I, Zone 1 locations on mobile offshore oil rig and drilling platforms, and other marine vessels
- Increased safety "e" cord connectors and flameproof "d" cord connectors for use only with extra-hard usage cord in Class I, Zone 1

For the cable fittings for use on mobile offshore oil rig and drilling platforms, and other marine vessels (items 5 & 7 above), evaluation for conformity to 46 CFR 111.105 “Hazardous Locations” & 111.60 “Wiring Materials and Methods” and other requirements in 46 CFR 110 to 113 (Subchapter J—Electrical Engineering”, as applied by the authority having jurisdiction are also in the scope of UL 2225.

IEC 60079 series contain requirements on all types of protection and hazardous locations included in UL 2225, except evaluation for conformity to 46 CFR.

The normal ambient conditions defined in UL 2225 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but no maximum temperature is specified in UL 2225.

8.2 Cables

Table 30 provides the results of the comparative assessment for performance and marking provisions. Subsequent sections provide further analysis where the IEC does not meet the UL standard. Note that some sections in the UL 2225 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 2225.

Table 30: UL 2225 to IEC 60079 –Cables - Comparative Assessment Results

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1-/7 Section #	Assessment Results
Part I- Cables - Construction - General	5	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Performance	6 to 10	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Marking -General	11	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet

Sections 5 to 11 in UL 2225 focus on the construction, test and marking requirements for the specific types of cables -*MC-HL metal-clad cable, ITC-HL instrumentation tray cable and TC-ER-HL tray cable* for use in Class I, Zone 1 hazardous locations. All cables shall comply with UL 1569 *Standard for Metal-Clad Cables*, UL 2250 *Standard for Instrumentation Tray Cable*, and UL 1277 *Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members*, as applicable and requirements in UL 2225. The same specific types of cables are not covered by IEC 60079 series. In these subject areas, it is considered that the IEC does not meet the requirements of UL 2225.

8.3 Explosionproof Cable Sealing Fittings

This section provides the comparison of requirements of construction and performance tests of explosionproof sealing fittings for hazardous location installation in UL 2225 with IEC 60079-0, 60079-1, IEC 60079-7 and IEC 60079-14, as applicable. The results of the comparative assessment are summarized in Tables 28 and Table 29. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standard. Note that some sections in the UL 2225 are not contained in IEC 60079 standards. In these subject areas, the IEC does not meet the UL 2225.

8.3.1 Construction

Table 31 provides the results of the comparative assessment for the construction of explosionproof sealing fittings to be used in hazardous locations.

Table 31: UL 2225 to IEC 60079 – Explosionproof Sealing Fittings - Construction Comparative Assessment Results

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1/-7 Section #	Assessment Results
General	12	IEC 60079-0, Sec. 16.3 IEC 60079-1, Sec. 13.1	Type 3 - Does Not Meet
Materials	13	IEC 60079-0, Sec. 8.3 & Annex A.2 IEC 60079-1, Sec. 12.4 & 12.7	Type 3 - Does Not Meet
Bonding Continuity	14	IEC 60079-0, Sec. 15	Type 3 - Does Not Meet
Joints	15	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet
Supply Connections for Flameproof "d" and Exploslonproof Fittings	16	IEC 60079-1, Sec. 13	Type 2 - Meets
Seal	17	IEC 60079-1, Annex C	Type 2 - Meets
Protection Against Corrosion	18	IEC 60079-0, Sec. 15.3 IEC 60079-1, Sec. 5.1	Type 2 - Meets
Materials Applied to Joint Surfaces	19	IEC 60079-1, Sec. 5.1	Type 2 - Meets

General

UL 2225 requires that cable sealing fittings shall comply with the applicable construction requirements in UL 514B *Standard for Conduit, Tubing, and Cable Fittings*. For the fittings for explosionproof equipment, UL 1203 *Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use In Hazardous (Classified) Locations* is to be met. These two UL standards are not referenced in IEC 60079 series. The comparative assessment of UL 1203 to IEC 60079 is included in Section 7 of this Report.

In addition, cable sealing fittings to seal cables with optical fiber members shall be subjected to special investigation per UL 2225, and the same is not addressed by IEC.

Materials

UL 2225 has material requirements for the cable sealing fittings same as explosionproof equipment enclosure (UL 1203, Sec. 8), which requires that the cable sealing fitting shall be made of ferrous materials, copper, brass, bronze, or aluminum or its alloys containing not less than 80 percent aluminum. A metal such as zinc or magnesium, or their alloys shall not be used.

IEC 60079 does not have the detailed material requirements on the cable fittings. Where a cable sealing fitting could be considered as a part of enclosure and constructed with the same material as flameproof enclosure in IEC 60079, comparisons show that enclosure metal material requirements are not equivalent IEC 60079 series and UL 2225. UL 2225 may be considered more stringent than IEC 60079 due to no allowance on zinc alloys as well as magnesium and its alloys in UL 2225.

UL 2225 requires non-metallic sealing fitting material shall comply with the requirements in Section 28, Non-Metallic Materials Tests. The comparisons of non-metallic material tests between UL and IEC are covered in Section 8.3.2 of this report.

Based on the above, it can be concluded that IEC 60079 does not meet the requirements of UL 2225 for materials.

Bonding Continuity

UL 2225 references UL 514B *Standard for Conduit, Tubing, and Cable Fittings* for bonding continuity requirements. IEC 60079-0 Section 15 has requirements regarding earthing and bonding conductors. It is noted that the U.S standard UL 514B is not referenced in IEC 60079-0.

Joints

For a flamepath having a cylindrical cross-section, the joint path length is not less than 1” (25.4 mm) and maximum diametrical clearances for 1” and 1-1/4” length of specified in UL 2225 are less than IEC 60079-1. For flamepath lengths greater than 1” but less than 1-1/4” joints and other explosionproof joints in cable sealing fittings (e.g. threaded joints and rabbet joints, etc.), UL 2225 required that UL 1203 are to be complied with.

Comparisons show that UL 2225 requirements on joint width and/or clearance (gap) of cylindrical joints are more stringent than IEC 60079-1, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group. Also width and gap of rabbet joint in UL 2225 cannot be satisfied by IEC 60079-1. Noted that the requirements of threaded joints in IEC 60079-1 meet UL 2225, but it has to be considered in overall that IEC 60079-1 does not meet the requirements of UL 2225 for joints of cable sealing fittings.

8.3.2 Performance

Table 32 provides the results of the comparative assessment for the performance tests for explosionproof cable sealing fittings. Note that some sections in the UL 2225 are not contained in the IEC 60079 standards. In these subject areas, the IEC does not meet the UL 2225.

Table 32: UL 2225 to IEC 60079 – Explosionproof Sealing Fittings - Performance Comparative Assessment Results

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1-/7 Section #	Assessment Results
General	20	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet
Torque	21	IEC 10079-1, C.3.3.1	Type 3 - Does Not Meet
Resistance to Impact Test	22	IEC 60079-0, Sec. 26.4.2	Type 2 - Meets

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1-/7 Section #	Assessment Results
Explosion Tests	23	IEC 60079-1, Sec. 15.2.2 Sec. 15.3	Type 2 - Meets
Hydrostatic Pressure Tests	24	IEC 60079-1, Sec. 15.2.3	Type 2 - Meets
Leakage of Sealing Fittings Test	26	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
High Humidity Tests	27	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Non-Metallic Materials Tests	28	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet
Tests on Epoxy Sealing Compounds	29	IEC 60079-1, Annex C.3	Type 3 - Does Not Meet
Enclosure Types	30.1 – 30.3	IEC 60079-0/-1/-7	Type 3 - Does Not Meet
Degree of Protection (IP ratings)	30.4	IEC 60079-0, Sec. 1	Type 2 – Meets

General

Cable sealing fittings for use in hazardous locations shall comply with all the performance requirements in UL 514B Standard for Conduit, Tubing, and Cable Fittings, in addition to the requirements of UL 2225. UL 514B is not referenced in IEC.

Torque

Torque specifications on the conduit required for the test per IEC 60079-1 is less than required by UL 2225 under the same conduit hub sizes. Therefore IEC 60079-1 does not meet the requirements of UL 2225 for torque specification for conduit hubs.

Non-Metallic Materials Test

Non-Metallic Material Tests in UL 2225 includes material chemical compatibility and accumulation of static electricity. Requirements for the tests set by IEC 60079-0 are more than in UL 2225. However, for chemical compatibility test, UL 2225 requires the compatibility to 13 chemicals to be tested on material samples and 12 chemicals to be tested on complete end products, whereas IEC 60079-0 has no such detailed requirements. In this regard, it is considered that IEC 60079-0 does not meet the requirements of UL 2225.

Tests on Epoxy Sealing Compounds

This test required by UL 2225 is to determine sealing compound resistance to chemicals and to be tested to 13 chemicals, same as required by chemical test for non-metallic enclosure materials as describe in the previous sections. In this regard, it is considered that IEC 60079-0 does not meet the requirements of UL 2225.

Enclosure Types and Degree of Protection

Both enclosure types and Degree of Protection (IP) ratings are covered in Section 30 of UL 2225. It is required in UL 2225 that IP ratings shall comply with IEC 60529, same as requirements in IEC. UL 2225 also has requirements on enclosure type. For the most parts the degree of protection provided by an enclosure with IP code is comparable to the type rating of the enclosure in UL. However, there are enclosures with enclosure type rating 7, which can be used in explosive gas atmospheres, for which there are no equivalent enclosures identified by IP rating. Based on this analysis, IEC does not meet the requirement in UL for enclosure types.

8.4 AEx Cable Fittings and Extra Hard Usage Cord Connectors

UL 2225 also includes the requirements for the construction and testing of AEx flameproof "'d" and increased safety "e" cable fittings and cord connectors. Table 33 provides the results of the comparative assessment for the AEx cable fittings and extra hard usage cord connector construction provisions.

Table 33: UL 2225 to IEC 60079 – AEx cable fitting and extra hard usage cord connector - Comparative Assessment Results

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1-/7 Section #	Assessment Results
Construction			
All AEx Cable Fittings and Cord Connectors	32	See Parts/Sections for 12 & 14 of UL2225	Type 3 - Does Not Meet
Flameproof "d" Construction	33 34	See Parts/Sections for 15, 16, 17 & 19 of UL2225	See Parts/Sections for 15, 16, 17 & 19 of UL2225
Increased Safety "e" Construction		See Parts/Sections for 12 & 16 of UL2225	See Parts/Sections for 12 & 16 of UL2225

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1-/7 Section #	Assessment Results
Performance	36		
General	36.1	See Parts/Sections for 28 of UL2225	Type 3 - Does Not Meet
Unarmored cable fitting strain relief performance	36.2	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Strain relief test	36.3	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet
Mechanical strength	36.4	IEC 60079-1, Annex C.3.2	Type 1 – Exceeds
Flameproof fitting or connector		See Parts/Sections for Sections 21 – 24 & 26 of UL 2225	See Parts/Sections for Sections 21 – 24 & 26 of UL 2225
Increased safety fitting or connector performance	36.7	IEC 60079-0 Sec. 26.7 & 26.8 See Parts/Sections for Section 22 of UL 2225 IEC 60079-0, Sec. 1	Type 2 – Meets

8.4.1 Construction

Similar to UL 2225 Section 12 for explosionproof cable sealing, AEx cable fittings and cord connectors shall comply with the applicable construction requirements in UL 514B *Standard for Conduit, Tubing, and Cable Fittings*. Where requirements conflict, the requirements in UL 2225 shall apply. Flameproof "d" construction for AEx fittings and connectors are to follow Sections 15, 16, 17 and 19 for explosionproof cable sealing fittings. Metal Increased Safety "e" fittings and connectors shall be NPT or metric threads compliance with Section 16; or in accordance with UL 514B.

8.4.2 Performance Test

In general, non-metallic fittings and connectors shall comply with the requirements in Non-Metallic Materials Tests, Section 28 in UL 2225. Strain relief tests required in UL 2225 are not included in IEC 60079-1. For mechanical strength test, the torque applied to the fitting in UL 2225 is less than in IEC 60079-1.

Flameproof fitting or connector performance test for AEx fittings are referred to Sections 21 through 24 and 26 of UL 2225.

Increased safety fitting or connector performance test includes aging test for elastomeric materials, resistance to impact test and test for degree of protection (IP). During aging test, the heat temperature (100 ± 5°C) required by UL 2225 may be more or less than in IEC 60079-1, but duration hours (168) in UL are less than the IEC standard; and the cold temperature test (- 20 ± 2°C) in UL 2225 may be more or less than IEC 60079-1, but duration hours (48) in UL are longer. The resistance to impact test for increased safety fitting can be covered by Section 22. IP rating testing in UL and IEC are to follow the IEC 60529.

Based on the comparison results of sections mentioned above and the assessment results showed in Table 33, it may be considered that IEC 60079-1 meets UL 2225 requirements for AEx Cable Fittings and Extra Hard Usage Cord Connectors.

8.5 Marking

Table 34 provides the results of the comparative assessment for the marking. Subsequent sections provide further analysis where the IEC does not meet or exceeds the UL standards.

Table 34: UL 2225 to IEC 60079 – Cable sealing marking - Comparative Assessment Results

Section Title / Subject Issue	UL 2225 Baseline Standard Section #	IEC Standard 60079-0/-1/-7 Section #	Assessment Results
Marking (General)	37.1	IEC 60079-0, Sec. 29 & A.4	Type 2 - Meets
Marking (Class I, Div. 1 & 2)	37.2	IEC 60079-0, Sec. 29 & A.4	Type 3 - Does Not Meet
Marking (AEx)	37.3	IEC 60079-0, Sec. 29 & A.4	Type 3 - Does Not Meet

In general, the marking in both standards are providing similar information. IEC 60079-0 marking doesn't indicate Class & Division and Zone which are required in Sections 37.2 & 37.3 of UL 2225, respectively. Also Ex Symbols are used in IEC 60079-0, whereas AEx Symbols are used in UL 2225. Accordingly it may be considered that IEC 60079-0 does not meet UL 2225 for marking due to difference between the two standards.

8.6 Summary Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079 series meet, exceed or do not meet the UL 2225.

IEC 60079 series ***meets*** the requirements outlined in UL 2225 in the following subject areas:

- Scope
- Units of Measurement
- Undated References
- Glossary
- Explosionproof Sealing Fittings
  - Supply Connections
  - Seal
  - Protection Against Corrosion
  - Materials applied to joint surfaces
- Performance
  - Resistance to Impact Test
  - Explosion Test
  - Hydrostatic Pressure Test
- Degree of Protection (IP Ratings)
- AEx cable fitting and extra hard usage cord connectors
  - Increased safety fitting or connector performance
- Marking General

The IEC standard ***does not meet*** the requirements outlined in the UL 2225, in the subject areas of:

- Scope (Atmospheric Conditions)
- Explosionproof Sealing Fittings
  - Construction – General
  - Materials
  - Bonding Continuity
  - Joints
- Performance –
  - General
  - Torque Test
  - Non-Metallic Enclosure Material Tests
  - Tests on Epoxy Sealing Compounds
  - Enclosure Types
- AEx cable fitting and extra hard usage cord connector
  - Construction - All AEx Cable Fittings and Cord Connectors
  - Performance - General
- Marking Class I, Div. 1 and 1
- Marking (AEx)
- Requirements with no equivalent requirements in IEC 60079
  - Cables
    - Construction – General
    - Performance

        - Marking –General
    - Explosionproof Sealing Fittings – Performance
        - Leakage of Sealing Fittings Test
        - High Humidity Tests
    - AEx Cable Fittings and Extra Hard Usage Cord Connectors
        - Unarmored cable fitting strain relief performance
        - Strain relief test

The IEC standard ***exceeds*** the requirements outlined in the UL 2225, in the subject areas of:

- AEx cable fitting and extra hard usage cord connector
    - Performance - Mechanical Strength

9. Recommendations

The following recommendations are based on the comparative assessment of the between the ANSI/UL standards and the IEC60079. BSEE incorporates standards into federal regulation by reference in Title 30, Code of Federal Regulations Part 250.198. As these regulations represent minimum requirements, BSEE should consider incorporating various sections of the standards discussed in this report as outlined below.

The following recommendations are offered for BSEE's considerations;

1. BSEE should consider developing an audit protocol that would enable BSEE inspectors and engineers to determine compliance with the standards included in this comparative assessment. Development of an audit protocol will be considered during Task 5 of this project.
2. BSEE should provide training to inspectors and engineers on the ANSI/UL and the IEC 60079 so that they are familiar with the various provisions in these standards.
3. BSEE should provide inspectors and engineers with a copy of this report so they can become familiar with the result of the analysis.
4. BSEE should obtain copies of the ANSI/UL and IEC standards referenced in this report for use by engineers and inspectors.
5. Since these regulations represent minimum requirements, BSEE may want to consider incorporating clauses of the IEC 60079 that exceed the comparable sections of the ANSI/UL standards as discussed in this report. Likewise, BSEE may want to consider incorporating clauses of the ANSI/UL standards that exceed the comparable clauses of the IEC 60079, as discussed in this report.

Appendix A. Analysis of UL 674 and IEC 60079

Table 35 provides a summary of the comparative assessment between the UL 674 and the IEC 60079.

Table 35: Comparative Assessment Results - US 674 to IEC 60079

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	1	IEC 60079-0, Sec. 1 & 4 IEC 60079-1, Sec. 1 IEC 60079-31, Sec. 1	Type 2 - Meets	Scopes on the requirements of motors, generators and other rotating machinery installed in hazardous location covered in IEC and UL are similar though equipment/components and protection types in IEC are broader than UL.
2	Conditions for use	2.1 2.2	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet	Minimum ambient temperature -50 °C is specified in UL for the use in Canada, which is lower than -20 °C minimum temperature given in IEC 60079-0.
3	Conditions for use	2.4	IEC 60079-1, Sec. 15.2.2.1	Type 2 - Meets	UL requires that the test temperature must below ambient temperature, whereas test temperature in IEC is reflected in determine of reference pressure for explosion test. The reference pressure is to be determined at a temperature not higher than the minimum ambient temperature, or at normal ambient temperature but at increased pressure. Minor deviation on test temperature between IEC and UL.
4	Conditions for use	2.5	IEC 60079-0 Sec. 1 (note 1) & 5.1.1	Type 2 - Meets	Same max normal ambient temperature in UL & IEC
5	Conditions for use	2.6	IEC 60079-1 15.3.1	Type 2 - Meets	Internal ignition non-transmission (flame propagation) test at a temperature not less than the specified maximum ambient temperature is one of test conditions accepted in IEC, which is consistent with UL.

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
6	Normative references	3	IEC 60079-0/-1/14, Sec. 2	Type 3 - Does Not Meet	UL674 does not employ any IEC standard for base requirements. Standards referred by IEC and UL are not consistent
7	Dated and Undated References	4	IEC 60079-0/-1/14, Sec. 2	Type 2 - Meets	Same requirement in UL & IEC for applicable editions of dated and undated references
8	Definitions	5	IEC 60079-0/-1/14, Sec. 3	Type 2 - Meets	Terms and definitions in IEC are much more than in UL. Type 2 is given although only 2 terms (5.7 & 5.9) in UL covered in Sec. 3 of IEC 60079-1 (3.9 & 3.8).
9	Components	6	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet	Both IEC and UL require that components shall comply with standards for general use, as applicable.
10	Units of measurement	7	No equivalent requirements	Type 2 - Meets	IEC series use SI (metric) units as default. UL has 2 units systems - SI (metric) units & US (English) Units.
11	Terminology	8	No equivalent requirements	Type 3 - Does Not Meet	Both UL and IEC standards provide adequate definitions of the terms used within the standards, except terms "motor" and "sewage pump" in Section 8 of UL 674 are for the use in this UL standard only.
12	Zone and Group Equivalency	9	IEC 60079-0, Sec. 4 IEC 60079-10-1, Sec. 3 IEC 60079-10-2, Sec. 3 & 6	Type 2 - Meets	Groups and Zones in UL are based on NEC. Groups IIA, IIB, IIC for explosive gas atmosphere and IIIA, IIIB & IIIC for explosive dust atmosphere specified in IEC and NEC are similar. Zone 0 & 20 definitions in IEC and NEC are same, but Zone 1 & 21 and Zone 2 & 22 defined in NEC are more than in IEC. Division and Zone equivalency is demonstrated in UL. Gr. IIB+H2 in UL can be considered as Gr. IIC without acetylene (refer to UL 1203, Sec. 6.3) Group IIC containing acetylene (equivalent to Class 1, Gr. A) in IEC are not in scope of UL674.

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
13	Enclosures	10.1	IEC 60079-1, Sec. 12.4 & 12.7 IEC 60079-0, Sec. 8.3	Type 3 - Does Not Meet	Comparisons show that enclosure material requirements are not consistent in IEC and UL. UL may be considered more stringent than IEC due to no allowance on zinc alloys as well as magnesium and its alloys in UL. Gas atmospheres containing acetylene is not in UL 674 scope. No detailed requirements to portable motor and submersible sewage pump motor in IEC
14	Enclosure - Material	10.2	IEC 60079-1, Sec. 12.4	Type 3 - Does Not Meet	No detailed requirements to casting in IEC, except cast iron required to follow ISO 185
15	Enclosure - Thickness	10.3	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No requirement in IEC
16	Enclosure - Strength	10.4	IEC 60079-1 Sec. 15	Type 3 - Does Not Meet	In UL 674, the ability of a motor enclosure to withstand internal explosion pressure can also be determined by calculations with the safety factors and minimum thickness of motor enclosure walls as specified. Similar requirements were not found in IEC.
17	Joints in Enclosure	11.1	IEC 60079-1, Sec. 5.1	Type 3 - Does Not Meet	Though the contents in General section for enclosure joints in UL and IEC are not same, the related requirements can be found in the other sections.
18	General	11.1	IEC 60079-1, Sec. 5.2	Type 2 - Meets	maximum average roughness almost same in IEC & UL (0.0064mm)

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
19	Groups C & D locations - Non-threaded joints	11.2.1	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	For non-threaded joint, minimum required joint width in IEC & UL are same, but IEC gives maximum allowable joint gaps are more than UL under the same joint width ranges and enclosure volumes for the equivalent gas group.
20	Groups C & D locations - Thread joints	11.2.2	IEC 60079-1, Sec. 5.3	Type 2 - Meets	IEC requirements on threaded joint in Sec. 5.3 are not specified based on gas Group (IIA, IIB or IIC). It was found that they are almost same as UL requirements for Gr. A location and so thread joints for Gr. B, C & D in UL can be covered by this section of IEC. Threads are to follow the applicable standards, but no case is less than 5 fully engaged threads per IEC and UL. Minimum length of threaded engagement specified for cylindrical threads, based on enclosure volume (more than 100 cm3 or not) are same in IEC & UL. Threads are to follow the applicable standards, but no case less than 5 fully engaged threads.
21	Groups C & D locations - Bolts in joint width	11.2.3	IEC 60079-1, Sec. 5.2.4	Type 3 - Does Not Meet	The definitions of minimum flame path length in IEC and UL are similar. However the required minimum flame path length (l) in IEC is less than in UL under the joint width ranges as below: 9.5mm ≤ L < 12.5mm: l = 6mm (IEC) = 8mm (UL) 19mm ≤ L: l = 8 mm or 9mm (IEC) = 9.5mm or 12.7mm (UL)

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
22	Group B location - Non-threaded joints	11.3.1	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	UL requirements are more conservative on the gaps or width of joint for volume 100 < V ≤ 500 and 1640 < V ≤ 2000. Also width and gap of rabbet joint in UL cannot be satisfied by IEC Table 3; In addition, no minimum thickness of cover thickness at the joint flange is specified in IEC.
23	Group B location - Bolts in joint width	11.3.2	IEC 60079-1, Sec. 5.2.4	Type 3 - Does Not Meet	IEC has the required minimum width of joint and/or minimum flame path length less than UL.
24	Group B location - Thread joints	11.3.3	IEC 60079-1, Sec. 5.3	Type 2 - Meets	IEC requirements on threaded joint in Sec. 5.3 are not specified based on gas group (IIA, IIB or IIC). It was found that they are almost same as UL requirements for Gr. A location and so thread joints for Gr. B, C & D in UL can be covered by this section of IEC. Threads are to follow the applicable standards, but no case is less than 5 fully engaged threads per IEC and UL. Minimum length of threaded engagement specified for cylindrical threads, based on enclosure volume (more than 100 cm3 or not) are same in IEC & UL. Threads are to follow the applicable standards, but no case less than 5 fully engaged threads.
25	Class II location	11.4			Not in scope of BSEE task
26	Class I and II locations - Main poles and interpoles of D.C. motors	11.5		Type 3 - Does Not Meet	No equivalent section in IEC

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
27	Holes in Enclosure	12	IEC 60079-1, Sec. 11 IEC 60079-0, Sec. 9.3	Type 2 - Meets	IEC and UL have similar requirements on the bottom thickness of bottomed hole. For the unbottomed holes, IEC and UL have the similar approach to maintain explosion (flame) proof properties of the enclosure In addition, the length and tolerance of (internal) thread on the hole for Gr. II enclosures are specified in IEC.
28	Shaft Opening	13	IEC 60079-1, Sec. 5.2.2 & 8	Type 3 - Does Not Meet	UL Tables 10 &11 give more stringent requirements on min. length of joint and max. clearance (gap) for Gr. C & D than Gr, IIA & IIB in IEC. Gr. IIC is not in scope of UL.
29	Drain and Breather in Enclosure	14	IEC 60079-1, Sec. 10	Type 2 - Meets	The general requirements for breathing and draining device in 2 standards are same, i.e. to withstand the pressure created by an internal explosion in the enclosure to which they are fitted. Threaded drain and breather plug are to comply with UL 674, Sec. 11. Impact type for threaded joint indicated in lines 20 & 24 is "meet".
30	Air-Gap Guage Plugs in Enclosure	15	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirement in IEC.
31	Devices with Operating Rods & Spindles	16	IEC 60079-1, Sec. 7	Type 2 - Meets	Two standards have the same requirements on the thread joints. Non-thread joints in IEC do not meet UL (see rows 36 & 39).

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
32	Protection Against Corrosion	17	IEC 60079-1, Sec. 5.1	Type 2 - Meets	Similar requirement in IEC & UL
33	Materials Applied to Joint Surfaces	18	IEC 60079-1, Sec. 5.1	Type 2 - Meets	IEC and UL have similar requirements on materials allowed or prohibited to be applied to joint surfaces. More than 0.008 mm thick electroplation is accepted with conditions in IEC, but not allowed in UL.
34	Field-Wiring Connections	19.1	IEC 60079-1, Sec. 13	Type 2 - Meets	Threaded connections are to comply with UL 674, Sec.11. Impact type for threaded joint indicated in lines 20 & 24 is "meet".
35	Field-Wiring Connections	19.2	IEC 60079-14, Sec. 9 & 10	Type 2 - Meets	Similar requirements on wiring lead sizes, ampacity, cable types, seals including compounds and nipples in IEC and UL.
36	Field-Wiring Connections	19.3	IEC 60079-14, Sec. 5.11	Type 2 - Meets	Similar requirements on terminal box in IEC & UL.
37	Cord-Connected Motors	20	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
38	Assemblies of Equipment	21	IEC 60079-14, Sec. 5	Type 2 - Meets	Same requirements on equipment selected for installation in hazardous area, i.e. equipment has suitable type of protection and T-Class (Code).
39	External fans and fan guards	22	IEC 60079-0, Sec. 17.1.2 & 17.1.3	Type 2 - Meets	Fan material requirements in IEC & UL are similar. The clearances between the fan impellor and its fan hood, the ventilation screens and their fasteners are specified in IEC, while the maximum size of opening in a guard or opening between guard and motor is specified in UL.
40	Gasoline Submersible Motors	23	No equivalent requirements	Type 3 - Does Not Meet	No specific requirements to submersible pumps motor in IEC
41	Leakage Detectors	24	No equivalent requirements	Type 3 - Does Not Meet	No specific requirements to submersible pumps motor in IEC

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
42	Maximum External Surface Temperature	25	IEC 60079-0, Sec. 5.3.2.2	Type 2 - Meets	The two standards have the same max surface temperatures specified for T1 thru T6 although no subclass is applied to IEC
43	Devices for Limiting External Surface Temperatures	26	IEC 60079-0, Sec 30.3	Type 2 - Meets	Equivalent requirements in IEC
44	Spacing	27.1	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
45	Test Voltages and Test Conditions	28	IEC 60079-0, Sec 26.5	Type 2 - Meets	UL requirements are covered by IEC
46	Instrumentation-Temperature Measurements	29	IEC 60079-0, Sec 26.6	Type 2 - Meets	UL requirements are covered by IEC
47	Variable-Frequency Inverter-Driver Motors	30	IEC 60079-0 Annex D/E	Type 2 - Meets	IEC and UL all require to follow specific standards for inverter motors.
48	Temperature Tests-General	31	IEC 60079-0, Sec. 26.5	Type 2 - Meets	Both IEC and UL cover test requirements to verify temperature limited by T-class (T-code) not exceeded.
49	Temperature tests on sinewave power for single speed or multi-speed motors	32	IEC 60079-0, Sec. 26.5	Type 3 - Does Not Meet	7 temperature tests required in UL more than 4 tests in IEC.
50	Temperature tests for Variable-Frequency Inverter-Driver Motors	33	IEC 60079-0 Annex D/E	Type 3 - Does Not Meet	IEC for converter only
51	Dielectric-voltage Withstand Test	34	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
52	Dust-Penetration Test	35	NA	NA	Not in the task scope

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
53	Explosion Test	36	IEC 60079-1, Sec. 15.2.2 Sec. 15.3	Type 2 - Meets	IEC and UL requirements are not exactly consistent. From the details summarized here, it can be seen that only explosion test number (3 or 5) in IEC is less than 10 required in UL. Others in IEC either meet UL or more stringent. Flame propagation test gas types, percentages of gas in air, test locations and number of ignitions (tests) are same in IEC & UL. No exception to explosion test and flame propagation test in IEC
54	Over Pressure Test on Enclosures	37	IEC 10079-1, Sec. 15.2.3	Type 2 - Meets	Static test methods in IEC and UL are similar. IEC has second method (dynamic) for over pressure test No exception to over pressure test in IEC
55	Test on Temperature-Limiting Devices for Limiting External Surface Temperature	38	Part 14, Clause 13.3 & 13.4	Type 2 - Meets	Both IEC & UL require to provide a device to prevent over temperature.
56	Secureness Test on Conduit Hubs	39	IEC 10079-1, C.3.3.1	Type 3 - Does Not Meet	Torque on the conduit required for the test per IEC 60079-1 is less than UL 674 under the same conduit sizes.
57	Electrical-Resistance Test	40	Part 0, Clause 26.12	Type 1 - Exceeds	IEC has more detailed requirements for the test, including materials, parts, assembly of test sample and test time & temperature, etc.
58	Accelerated-Aging Test on Bushing	41	IEC 60079-0 26.8, 26.9	Type 2 - Meets	required test temperature is the same in IEC & UL
59	Cord-Pull Test	42	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
60	Rough-Usage Test	43	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
61	Drop Test	44	IEC 60079-0, Sec. 26.4.3	Type 2 - Meets	IEC 60079-0 requires that equipment is dropped 4 times from the most unfavorable position at a height of at least 1 m onto a concrete surface, whereas UL 674 requires 10 times from a height of 0.9 m and the first 5 drops are from a horizontal platform and the remainders are from various angles. In addition IEC has test temperature requirements and UL does not. Overall it is considered drop tests per IEC and UL are equivalent.
62	Gasoline-Leakage Test	45	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
63	Non-Metallic Fans and Fan Guards Test	46	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
64	Pull Test on Tubes	47	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
65	Sealing Compounds Test	48	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
66	Low Ambient-Duty Motors	49	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
67	Grounding-Continuity test	50	IEC 60079-0, Sec. 26.12	Type 1 - Exceeds	Earth continuity test in IEC provides the detailed requirements including materials, parts, assembly of test sample and test time & temperature, etc.

No.	Section Title / Subject Issue	UL 674 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
68	Marking	51	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet	In general the marking in both standards are providing similar details as listed here. IEC marking doesn't indicate Zone 0, 1 or 2 whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in IEC are not employed by UL. Although it may be considered that IEC does not meet UL for marking due to difference between 2 standards, it should have no negative affect on the safety level of equipment operation.

Appendix B. Analysis of UL 823 and IEC 60079

Table 36 provides a summary of the comparative assessment between the UL 823 to IEC 60079.

Table 36: Comparative Assessment Results – UL 823 to IEC 60079

No.	Section Title / Subject Issue	UL 823 Baseline Standard	IEC Standard 60079-0/-1-/14	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
		Section #	Section #		
1	Scope	1.1 to 1.6	IEC 60079-0, Sec. 1 & 4 IEC 60079-1, Sec. 1 IEC 60079-31, Sec. 1	Type 2 - Meets	UL covers portable and fixed electric heaters installed in Class I, Div. 1, Gr. A, B, C & D (equivalent to Class I, Zone 1, Gr. IIA and IIB (IIB+H2) & IIC) with types of protection explosion-proof or dust-ignition-proof and dust-tight. All types of protection are contained in IEC 60079 series.
2	- Atmospheric Conditions	1.7	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet	The normal ambient conditions defined in UL 823 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but not specified in UL 823.
3	General	2	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet	Both UL and IEC standards require that electrical heaters in hazardous locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas) However IEC 60079-0 does not require compliance with industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing.

No.	Section Title / Subject Issue	UL 823 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
4	Components	3	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet	Both UL and IEC standards require that electrical components in hazardous locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas) However IEC 60079-0 does not require compliance with industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing.
5	Units of Measurement	4	No equivalent requirements in IEC 60079	Type 2 - Meets	IEC series use SI (metric) units as default. UL has 2 units systems - SI (metric) units & US (English) Units.
6	Undated References	5	IEC 60079-0/-1/14, Sec. 2	Type 2 - Meets	The latest edition of the referenced document is required to be applied in UL & IEC.
7	Enclosure Types	6	IEC 60079-0/-1/14	Type 3 - Does Not Meet	Both IEC and UL have requirements on protecting equipment from ingress of liquid/solid foreign objects. However, type 4X enclosure in UL is watertight corrosion-resistant enclosure and is required to be manufactured from corrosion-resistant materials. There are no equivalent enclosures identified by IP rating in IEC. Also UL 823 requires the heater with Type 7 enclosure to meet the applicable requirements for indoor Class I locations. Enclosures marked as Type 7 per UL can be used in explosive gas atmospheres accordingly. Such enclosure type is not employed by IEC 60079.

No.	Section Title / Subject Issue	UL 823 Baseline Standard	IEC Standard 60079-0/-1-/14	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
		Section #	Section #		
8	Class I, Zone and Group Equivalency	7	IEC 60079-0, Sec. 4 IEC 60079-10-1, Sec. 3 IEC 60079-10-2, Sec. 3 & 6	Type 2 - Meets	Groups and Zones in UL are based on NFPA 70. Groups IIA, IIB, IIC for explosive gas atmosphere and IIIA, IIIB & IIIC for explosive dust atmosphere specified in IEC and NFPA are similar. Zone 0 & 20 definitions in IEC and NEC are same, but Zone 1 & 21 and Zone 2 & 22 defined in NFPA are more than in IEC. Acetylene is not defined as a typical gas for Gr. IIC in IEC, but it is still one of gases included in IIC. It is same as Gr. IIC definition in NFPA 70. Group IIC is equivalent to both Class 1, Gr. A & B in UL.
9	Glossary	8	IEC 60079-0/-1/14, Sec. 3	Type 2 - Meets	Terms and definitions in IEC are much more than in UL. Type 2 is given although not all terms listed in Sec. 8 of UL covered in Sec. 3 of IEC 60079-1.
10	Construction-All Heaters	9	No equivalent requirements	Type 3 - Does Not Meet	UL requires that portable heater shall be of the hand-held type or shall be mounted on a movable base or stand with or without casters or wheels. No equivalent requirements in IEC
11	Enclosure	10.1	IEC 60079-1, Sec. 12.4 & 12.7 IEC 60079-0, Sec. 8.3	Type 3 - Does Not Meet	Comparisons show that enclosure material requirements are not consistent in IEC and UL. UL may be considered more stringent than IEC due to no allowance on zinc alloys as well as magnesium and its alloys in UL. Also max. limit of copper content of alloy in UL is less than in IEC.
12	Thickness	10.2	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC

No.	Section Title / Subject Issue	UL 823 Baseline Standard	IEC Standard 60079-0/-1-/14	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
		Section #	Section #		
13	Joints in Enclosure	11.1	IEC 60079-1, Sec. 5.1 Sec. 5.2	Type 2 - Meets	Type 1 given here is based on comparison of scopes in IEC and UL in general. IEC covers more types of enclosure joints and materials
14	Cemented Joint	11.2	IEC 60079-1, Sec. 6 IEC 60079-0, Sec. 12	Type 2 - Meets	No material test requirement to resistance to chemicals, impact and moisture in IEC (Data may be provided by manufacturer); Min width (length) of cemented joints in IEC less than in UL; However the tests required to determine mechanical strength of cemented joints by IEC are more than UL. Both 2 standards indicate that cement shall not be relied upon for mechanical security of the joint. Overall it is considered that IEC meets UL 823 at this point.
15	Joints with flamepaths Class I, Gr. A, B, C and D	11.3	IEC 60079-1, Sec. 5.4 8.1.3	Type 2 - Meets	IEC has requirements on gaskets similar to UL. The tests of labyrinth joints specified by IEC are more than UL. The construction of labyrinth joint per UL is same as the multi-step joint in IEC.
16	Class I, Group C and D locations	11.4.1	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	Comparisons show that UL requirements on joint width and/or clearance (gap) are more stringent than IEC, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group.

No.	Section Title / Subject Issue	UL 823 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
17	Class I, Group C and D locations	11.4.2	IEC 60079-1, Sec. 8.1.3	Type 2 - Meets	IEC has requirements on labyrinth joints similar to UL.
18	Class I, Group C and D locations	11.4.3	IEC 60079-1, Sec. 5.2.4	Type 3 - Does Not Meet	Bolts in joint width is accepted by UL with conditions as listed here. IEC has no similar requirements, but the required minimum flame path length (l) in IEC is less than in UL under the same joint width ranges. See below: 19mm ≤ L: l = 8 mm or 9mm (IEC) = 12.7mm (UL)
19	Class I, Group B locations	11.5.1	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	UL requirements are more conservative on the gaps or width of joint for volume 100 < V ≤ 500 and 1640 < V ≤ 2000. Also width and gap of rabbet joint in UL cannot be satisfied by IEC Table 3; In addition, no minimum thickness of cover thickness at the joint flange is specified in IEC.
20	Class I, Group B locations	11.5.2	IEC 60079-1, Sec. 5.2.4	Type 3 - Does Not Meet	Bolts in joint width is accepted by UL with conditions as listed here, which is not required by IEC. However IEC has the required minimum width of joint and/or minimum flame path length (distance from inside of enclosure to nearest edge of bolt hole) less than UL.
21	Class I, Group A locations	11.6	Part 1, Clause 5.3	Type 2 - Meets	Section 11.6 of UL for Class I, Group A locations focuses on enclosure thread joint requirements, which is covered in Sec. 11.7. See next line.

No.	Section Title / Subject Issue	UL 823 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
22	Threaded joints	11.7	IEC 60079-1, Sec. 5.3	Type 2 - Meets	IEC requirements on threaded joint in Sec. 5.3 are not specified based on gas group (IIA, IIB or IIC). It was found that they are almost same as UL requirements for Gr. A location and so thread joints for Gr. B, C & D in UL can be covered by this section of IEC. Threads are to follow the applicable standards, but no case is less than 5 fully engaged threads per IEC and UL. Minimum length of threaded engagement specified for cylindrical threads, based on enclosure volume (more than 100 cm3 or not) are same in IEC & UL.
23	Shaft Openings	11.8	IEC 60079-1, Sec. 5.2.2 & 8	Type 3 - Does Not Meet	IEC Table 3 for Gr. IIC enclosure is applied to free internal volume more than 2000 cm^3 whereas UL for Gr. A & B is limited to free internal volume of 30 in^3 (500 cm^3). A path length not less than 1” (25.4 mm) and maximum clearance 0.045" (0.11 mm) required by UL is more stringent than IEC. No specific opening type, such as metal-to-metal type in UL is mentioned in IEC. UL may have more stringent requirements on min. length of joint and clearance (gap) where the enclosures are within the scopes of both UL & IEC for Group C & D locations . UL has specified dimensions of Labyrinth type joint, but IEC has not. Labyrinth type may be accepted based on the tests in IEC.
24	Class II location	11.9			Not in scope of subject gap analysis

No.	Section Title / Subject Issue	UL 823 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
25	Holes in Enclosure Class I location	12.1	IEC 60079-1, Sec. 11 IEC 60079-0, Sec. 9.3	Type 2 - Meets	For the unbottomed holes, IEC and UL have the similar approach to maintain explosion (flame) proof properties of the enclosure. The minimum remaining thickness of bottomed hole in IEC is 3 mm, more than 1.6 mm required in UL. In addition, the length and tolerance of (internal) thread on the hole for Gr. II enclosures are specified in IEC per ISO standards.
26	Class II location	12.2			Not in scope of subject gap analysis
27	Hot-water or Steam Radiators	13	IEC 60079-14, Sec. 13	Type 2 - Meets	IEC has requirements for electric heating systems which can cover UL heater requirements, except excluding immersed heating element construction related to a specific type of heaters.
28	Supply Connections - Fixed Heaters	14.1	IEC 60079-1, Sec. 13	Type 2 - Meets	NPT thread per AISI/ASME B1.20.1 are accepted to both IEC & UL Explosion test for conduit entry is required by UL and enclosure flameproof test shall be carried out with conduit sealing device per IEC. In addition to conduit entries, IEC also covers cable glands for threaded holes. Conduit sizes and conduit stop throat diameters are specified in UL.

No.	Section Title / Subject Issue	UL 823 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
29	Conduit Seals	14.2	IEC 60079-1, Annex C	Type 2 - Meets	The minimum length of compound in IEC is more than in UL. Both IEC and UL have the test requirements to compounds.
30	Class II locations	14.3			Not in scope of subject gap analysis
31	Supply connections -Portable Heaters	14.4	See rows 13-23	See rows 13-23	See rows 13-23 for comparisons of joints in enclosure in UL 823/11.1 -11.8 with the related IEC clauses.
32	Cord Clamp Securing of threaded joints Hooks and Handles Casters and Wheels External Metal Parts	14.5 14.6 15 16 17	No equivalent requirements	Type 3 - Does Not Meet	No equivalent section in IEC
33	Bonding and Grounding	18	IEC 60079-0, Sec. 15	Type 1 - Exceeds	Minimum cross-sectional area of earthing conductor are specified based on phase conductors in IEC, which are not found in UL.
34	Temperature-Limiting Devices	19	IEC 60079-14, Sec. 13.3 & 13.4	Type 2 - Meets	Both IEC & UL require to provide a device to prevent over temperature.
35	Protection Against Corrosion	20	IEC 60079-0, Sec. 15.4 IEC 60079-1, Sec. 5.1	Type 2 - Meets	Similar requirement in IEC & UL
36	Materials applied to joint surfaces	21	IEC 60079-1, Sec. 5.1	Type 2 - Meets	IEC and UL have similar requirements on materials allowed or prohibited to be applied to to joint surfaces.

No.	Section Title / Subject Issue	UL 823 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
37	Temperature Test	22	IEC 60079-0, Sec. 26.5	Type 1 - Exceeds	The maximum voltage for the test is equal to the rated value in UL, lower than 110% of the rated voltage required by IEC. Also T-class is determined by maximum surface temperature in IEC. Therefore IEC exceeds UL.
38	Accelerated-Aging Test on Bushing	23	IEC 60079-0 26.8, 26.9	Type 2 - Meets	required test temperature is the same in IEC & UL
39	Strain-Relief Test	24	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
40	Rough-Usage Test	25	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
41	Drop Test	26	IEC 60079-0, Sec. 26.4.3	Type 2 - Meets	IEC 60079-0 requires that equipment is dropped 4 times from the most unfavorable position at a height of at least 1 m onto a concrete surface, whereas UL 674 requires 10 times from a height of 0.9 m and the first 5 drops are from a horizontal platform and the remainders are from various angles. In addition IEC has test temperature requirements and UL does not. Overall it is considered drop tests per IEC and UL are equivalent.
42	Overturning Test	27	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
43	Stability Test	28	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
44	Dielectric-voltage Withstand Test	29	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
45	Thermal-Cutoff test	30	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC
46	Low-Water Cutoff Test	31	No equivalent requirements	Type 3 - Does Not Meet	No equivalent requirements in IEC

No.	Section Title / Subject Issue	UL 823 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
47	Non-Metallic Enclosure Material Tests	32	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet	Requirements for the tests set by IEC are more than UL, except chemical resistance test. For chemical compatibility test, UL requires the compatibility to 13 chemicals to be tested, IEC requires only oils and grease, hydraulic liquids for mining applications. In this regard, it is considered that IEC does not meet UL.
48	Explosion tests	33	IEC 60079-1, Sec. 15.2.2 Sec. 15.3	Type 2 - Meets	IEC and UL requirements are not exactly consistent, but it appears that only test number (ignition number) "3 or 5" of IIA, IIB & IIC in IEC are less than 10 required per Table 31 in UL. Others are either equivalent or higher in IEC. Flame propagation test gas types, percentages of gas in air, test locations and number of ignitions (tests) are same in IEC & UL. No exception to explosion test and flame propagation test in IEC.
49	Hydrostatic Pressure Test	34	IEC 10079-1, Sec. 15.2.3	Type 2 - Meets	Overpressure test in IEC and hydrotest pressure in UL have the similar approach to set test pressure, i.e. determined by a factor times maximum explosion pressure. Test period is 10 seconds and acceptance criteria are same in both standards. Dynamic test in IEC is not found in UL . Radiator and conduit seal hydrotest are specific to the heater.
50	Dust-Penetration Test	35			Not in scope of subject gap analysis

No.	Section Title / Subject Issue	UL 823 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
51	Secureness of Conduit Hubs Test	36	IEC 10079-1, C.3.3.1	Type 3 - Does Not Meet	Torque on the conduit required for the test per IEC 60079-1 is less than UL 823 under the same conduit sizes.
52	Resistance Test-Electrical-resistance test	37.1, 37.3 & 37.4	IEC 60079-0, Sec. 26.12	Type 1 - Exceeds	IEC has more detailed requirements for the test, including materials, parts, assembly of test sample and test time & temperature, etc.
52	Resistance Test-Leakage test on factory-Installed conduit seals	37.2	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
52	Resistance Test-Tests on joint gaskets	37.5	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
53	Heaters for Class I, Div. 2, Gr. A, B, C & D locations	38-43	See Parts/Sections for 2, 3, 10, 11, 12, 14, 20 and 22 of UL 823	See Parts/Sections for 2, 3, 10, 11, 12, 14, 20 and 22 of UL 823	See Parts/Sections for 2, 3, 10, 11, 12, 14, 20 and 22 of UL 823
54	Heaters for Class II, Div. 2, Gr. A, B, C & D locations	44-50			Not in scope of subject gap analysis
55	Manufacturing and production tests	51-54	See Parts/Sections for 33, 29 and 37.3 & 37.4 of UL 823	See Parts/Sections for 33, 29 and 37.3 & 37.4 of UL 82	See Parts/Sections for 33, 29 and 37.3 & 37.4 of UL 82 The air-leakage test is for heater element sheath and no equivalent requirements are found in IEC 60079.

No.	Section Title / Subject Issue	UL 823 Baseline Standard	IEC Standard 60079-0/-1-/14	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
		Section #	Section #		
56	Markings	51	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet	In general the marking in both standards are providing similar details as listed here. IEC marking doesn't indicate Zone 0, 1 or 2 whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in IEC are not employed by UL. Although it may be considered that IEC does not meet UL for marking due to difference between 2 standards, it should have no negative affect on the safety level of equipment operation.

Appendix C. Analysis of UL 844 and IEC 60079

Table 37 provides a summary of the comparative assessment between the UL 844 to IEC 60079.

Table 37: Comparative Assessment Results – UL 844 to IEC 60079

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	1.1 to 1.2	IEC 60079-0, Sec. 1 & 4 IEC 60079-1, Sec. 1 IEC 60079-31, Sec. 1	Type 2 - Meets	UL covers portable and fixed luminaires installed in Class I, Div. 1, Gr. A, B, C & D (equivalent to Class I, Zone 1, Gr. IIA and IIB (IIB+H2) & IIC) with types of protection explosion-proof or dust-ignition-proof and dust-tight. All types of protection are contained in IEC 60079 series.
2	Scope (Atmospheric Conditions)	1.3	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet	Normal ambient conditions defined in UL 844 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -25 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but not specified in UL 844.
3	General	2.1	IEC 60079-0, Sec. 6.1	Type 3 - Does Not Meet	Both UL and IEC standards require that electrical components in hazardous locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas). However IEC does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing.

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
3	General (low-pressure sodium lamps)	2.2	IEC 60079-0, Sec. 21.4 IEC 60079-14, Sec. 5.12	Type 1 - Exceeds	Low-pressure sodium lamps are not allowed for use in hazardous area in IEC, but only prohibited in Div. 1 location in UL.
4	Components	3	IEC 60079-0, Sec. 0	Type 3 - Does Not Meet	Both UL and IEC standards require that electrical components in hazardous locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas). However IEC does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing.
5	Units of Measurement	4	No equivalent requirements 60079	Type 2 - Meets	IEC series use SI (metric) units as default. UL has 2 units systems - SI (metric) units & US (English) Units.
6	Undated References	5	IEC 60079-0/-1/14, Sec. 2	Type 2 - Meets	The latest edition of the referenced document is required to be applied in UL & IEC.
7	Class, Zone and Group Equivalency	6	IEC 60079-0, Sec. 4 IEC 60079-10-1, Sec. 3 IEC 60079-10-2, Sec. 3 & 6	Type 2 - Meets	Groups and Zones in UL are based on NFPA 70. Groups IIA, IIB, IIC for explosive gas atmosphere and IIIA, IIIB & IIIC for explosive dust atmosphere specified in IEC and NFPA are similar. Zone 0 & 20 definitions in IEC and NEC are same, but Zone 1 & 21 and Zone 2 & 22 defined in NFPA are more than in IEC. Acetylene is not defined as a typical gas for Gr. IIC in IEC, but it is still one of gases included in IIC. It is same as Gr. IIC definition in NFPA 70. Group IIC is equivalent to both Class 1, Gr. A & B in UL.

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
8	luminaires Subject to Deposits of Combustible-Paint Residue	7	No equivalent requirements 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
9	Enclosure Types	8	IEC 60079-0/-1/-14	Type 3 - Does Not Meet	Both IEC and UL have requirements on protecting equipment from ingress of liquid/solid foreign objects. However, type 4X enclosure in UL is watertight corrosion-resistant enclosure and is required to be manufactured from corrosion-resistant materials. There are no equivalent enclosures identified by IP rating in IEC. UL 844 requires the heater with Type 7 enclosure to meet the applicable requirements for indoor Class I location. Enclosure marked as Type 7 per UL can be used in explosive gas atmospheres accordingly. Such enclosure type is not employed by IEC 60079.
10	Enclosure Materials	9	IEC 60079-1, Sec. 12.4 & 12.7 IEC 60079-0, Sec. 8.3	Type 3 - Does Not Meet	Comparisons show that enclosure material requirements are not consistent in IEC and UL. UL may be considered more stringent than IEC due to no allowance on zinc alloys as well as magnesium and its alloys in UL. Also max. limit of copper content of alloy in UL is less than in IEC.
11	Enclosure Thickness Enclosures for Class I Locations	10.1	No equivalent requirements 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
12	Enclosures for Class II Locations	10.2			Not in scope of subject gap analysis

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
13	Joints in Enclosures for Class I Locations General	11.1	IEC 60079-1, Sec. 5.1 Sec. 5.4 8.1.3 IEC 60079-0, Sec. 6.5	Type 3 - Does Not Meet	IEC does not cover the detailed requirements on gaskets similar as UL and also not prohibit the use "O" ring and adhesive.
14	Luminaires for Class I, Group C and D locations	11.2.1 11.2.2	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	Comparisons show that UL requirements on joint width and/or clearance (gap) are more stringent than IEC, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group.
15		11.2.3	IEC 60079-1, Sec. 5.3	Type 2 - Meets	IEC requirements on threaded joint in Sec. 5.3 are not specified based on gas group (IIA, IIB or IIC). It was found that they are almost same as UL requirements for Gr. A location and so thread joints for Gr. B, C & D in UL can be covered by this section of IEC. Threads are to follow the applicable standards, but no case is less than 5 fully engaged threads per IEC and UL. Minimum length of threaded engagement specified for cylindrical threads, based on enclosure volume (more than 100 cm3 or not) are same in IEC & UL.
16		11.2.4	IEC 60079-1, Sec. 8.1.3	Type 2 - Meets	IEC has requirements on labyrinth joints similar to UL.

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
17		11.2.5	IEC 60079-1, Sec. 5.2.4	Type 3 - Does Not Meet	The definitions of minimum flame path length in IEC and UL are similar. However the required minimum flame path length (l) in IEC is less than in UL under the same joint width ranges. See below: 19mm ≤ L: l = 8 mm or 9mm (IEC) = 12.7mm (UL)
18	Luminaires for Class I, Group B locations	11.3.2 to 11.3.4	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	UL requirements are more conservative on the gaps or width of joint for volume 100 < V ≤ 500 and 1640 < V ≤ 2000. Also width and gap of rabbet joint in UL cannot be satisfied by IEC Table 3; In addition, no minimum thickness of cover thickness at the joint flange is specified in IEC.
19	- Threaded joint	11.3.5 & 11.3.6	IEC 60079-1 Sec. 5.3	Type 2 - Meets	IEC requirements on threaded joint in Sec. 5.3 are not specified based on gas Group (IIA, IIB or IIC). It was found that they are almost same as UL requirements for Gr. A location and so thread joints for Gr. B, C & D in UL can be covered by this section of IEC. Threads are to follow the applicable standards, but no case is less than 5 fully engaged threads per IEC and UL. Minimum length of threaded engagement specified for cylindrical threads, based on enclosure volume (more than 100 cm3 or not) are same in IEC & UL.

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
20	Luminaires for Class I, Group A locations	11.4	IEC 60079-1 Sec. 5.3	Type 2 - Meets	IEC requirements on threaded joint in Sec. 5.3 are not specified based on gas Group (IIA, IIB or IIC). It was found that they are almost same as UL requirements for Gr. A location and so thread joints for Gr. B, C & D in UL can be covered by this section of IEC. Threads are to follow the applicable standards, but no case is less than 5 fully engaged threads per IEC and UL. Minimum length of threaded engagement specified for cylindrical threads, based on enclosure volume (more than 100 cm3 or not) are same in IEC & UL.
21	Joints in Enclosures for Class II, Group E, F and G Locations	12			Not in scope of subject gap analysis
22	Holes in Enclosure Luminaires for Class I Locations	13.1	IEC 60079-1, Sec. 11 IEC 60079-0, Sec. 9.3	Type 2 - Meets	For the unbottomed holes, IEC and UL have the similar approach to maintain explosion (flame) proof properties of the enclosure. IEC provides more detailed requirements. The minimum remaining thickness of bottomed hole in IEC is 3 mm, more than 1.6 mm required in UL. In addition, the length and tolerance of (internal) thread on the hole for Gr. II enclosures are specified in IEC per ISO standards.
23	Luminaires for Class II Locations	13.2			Not in scope of subject gap analysis

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
24	Shaft Openings General Luminaires for Class I Locations	14.1 & 14.2	IEC 60079-1, Sec. 5.2.2 & 8	Type 3 - Does Not Meet	UL has more stringent requirements on min. Length of joint and max. clearance (gap) regardless free internal volume of enclosure and gas group. A path length not less than 1” (25.4 mm) and maximum clearance 0.045" (0.11 mm) required by UL is more stringent than IEC. No specific opening type, such as metal-to-metal type in UL is mentioned in IEC. UL has specified dimensions of Labyrinth type joint, but IEC has not. Labyrinth type may be accepted based on the tests in IEC.
25	Luminaires for Class II Locations	14.3			Not in scope of subject gap analysis
26	Guards of Luminaires for Class I and II Locations	15	IEC 60079-0, Sec. 21.2	Type 1 - Exceeds	Detailed test requirements for luminaire with guard are included in IEC.
27	Nonmetallic External Parts	16	IEC 60079-0, Sec. 7.4	Type 1 - Exceeds	IEC has more methods on avoidance of a build-up of electrostatic charge on external non-metallic materials.

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
28	Supply Connections Luminaires for Class I Locations	17.1	IEC 60079-1, Sec. 13	Type 2 - Meets	NPT thread per AISI/ASME B1.20.1 are accepted to both IEC & UL Explosion test for conduit entry is required by UL and enclosure flameproof test shall be carried out with conduit sealing device per IEC. In addition to conduit entries, IEC also covers cable glands for threaded holes. Conduit sizes and conduit stop throat diameters are specified in UL.
29	Supply Connections Luminaires for Class I Locations	17.1 (continued)	IEC 60079-1, Annex C	Type 2 - Meets	The minimum length of compound in IEC is more than in UL. Both IEC and UL have the test requirements to compounds. IEC covers more types of sealing than UL.
30	Luminaires for Class II Locations	17.2			Not in scope of subject gap analysis
31	Leads	17.3	No equivalent requirements	Type 3 - Does Not Meet	No equivalent section in IEC

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
32	Disconnecting Means	18	IEC 60079-0 Sec. 21	Type 2 - Meets	Both IEC & UL require to have a means of auto disconnection of all poles of lampholder. Condition on activation of disconnecting in IEC is more stringent than UL. Live parts are to be protected by an explosion-proof enclosure per UL. The same is not required by IEC. However IEC has more requirements on live parts protection.
33	Protection Against Corrosion	19	IEC 60079-0, Sec. 15.3 IEC 60079-1, Sec. 5.1	Type 2 - Meets	Similar requirement in IEC & UL
34	Materials Applied to Joint Surfaces	20	IEC 60079-1, Sec. 5.1	Type 2 - Meets	Electroplated joint surface is addressed in IEC, but not mentioned in UL.
35	Fuses	21	IEC 60079-0, Sec. 19	Type 3 - Does Not Meet	No fuse test requirement in IEC.
36	Grounding and Bonding	22	IEC 60079-0, Sec. 15	Type 1 - Exceeds	Minimum cross-sectional area of earthing conductor are specified in IEC, which are not found in UL.
37	Porosity in Enclosure Materials	23	IEC 60079-1, Sec. 12	Type 3 - Does Not Meet	UL 844 has detailed requirements for surface porosity in castings materials of enclosure without limitation on a specific material. The allowable sizes of porosities are specified in UL 844 depends on their locations on the enclosure. The similar approach is not find in IEC 60079-0.

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
38	Luminaires for Wet Locations	24	IEC 60079-0 Sec. 26.5.2	Type 3 - Does Not Meet	For Wet Locations, Thermal Shock Test for glass parts of luminaires are required by IEC 60079-0 and UL. Comparisons of thermal shock tests defined by UL and IEC show that UL test requirements cannot be satisfied by IEC 60079-0 (see Thermal Shock Test in Section 5.2.2 of this Report)
39	Temperature Test	25	IEC 60079-0, Sec. 26.5	Type 1 - Exceeds	The maximum voltage for the test is equal to the rated value in UL, lower than 110% of the rated voltage required by IEC. Also T-class is determined by maximum surface temperature in IEC. Therefore IEC exceeds UL.
40	Explosion tests	26	IEC 60079-1, Sec. 15.2.2 Sec. 15.3	Type 2 - Meets	IEC and UL requirements are not exactly consistent, but it appears that only test number (ignition number) "3 or 5" of IIA, IIB & IIC in IEC are less than 10 required per Table 31 in UL. Others are either equivalent or higher in IEC. Flame propagation test gas types, percentages of gas in air, test locations and number of ignitions (tests) are same in IEC & UL. No exception to explosion test and flame propagation test in IEC.
41	Test on Luminaires with Fuses	27	No equivalent requirements in 60079	Type 3 - Does Not Meet	No fuse test requirement in IEC.

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
42	Hydrostatic Pressure Test	28	IEC 60079-1, Sec. 15.2.3	Type 2 - Meets	Overpressure test in IEC and hydrotest pressure in UL have the similar approach to set test pressure, i.e. determined by a factor times maximum explosion pressure. Test period is 10 seconds and acceptance criteria are same in both standards. Dynamic test in IEC is not found in UL. Radiator and conduit seal hydrotest are specific to the heater.
43	Dust-Penetration Test	29			Not in scope of subject gap analysis
44	Thermal Shock Test	30	IEC 60079-0, Sec. 26.5.2	Type 3 - Does Not Meet	UL uses ice water with temperature 1.1C for the test, where test water temperature is (10 ± 5) ° C in IEC. Per IEC, neither the distance from which the jet of water is applied, nor the pressure of application are considered to have a significant effect on the results.
45	Rust-resistance Test	31	No equivalent requirements in 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
46	Secureness of Conduit Hubs Test	32	IEC 60079-1, C.3.3.1	Type 3 - Does Not Meet	The torque specifications for conduit required by IEC 60079-1 is less than UL 844 under the same conduit sizes.
47	Vibration Test	33	No equivalent requirements in 60079	Type 3 - Does Not Meet*	No equivalent requirements in IEC
48	Electrical Resistance test	34	IEC 60079-0, Sec. 26.12	Type 1 - Exceeds	Earth continuity test in IEC provides the detailed requirements including materials, parts, assembly of test sample and test time & temperature, etc.

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
49	Non-Metallic Enclosure Material Tests - Class I	35	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet	Requirements for the tests set by IEC are more than UL, except chemical resistance test. For chemical compatibility test, UL requires the compatibility to 13 chemicals to be tested, IEC requires only oils and grease, hydraulic liquids for mining applications. In this regard, it is considered that IEC does not meet UL.
50	Tests on Sealing Compounds	36	IEC 60079-1, Annex C.3	Type 3 - Does Not Meet	Sealing compounds mechanical strength test is required by IEC, in addition to leakage test.
51	Non-Metallic Enclosure Tests - Class II	37			Not in scope of subject gap analysis
52	Leakage Test on Factory-Installed Conduit Seals	38	No equivalent requirements in 60079	Type 3 - Does Not Meet*	No equivalent requirements in IEC
53	Part II - luminaires for Class I, Div. 2, Gr. A, B, C & D Locations	39 to 42	See Parts/Sections for 2.1, 3, 9-14, 17, 24, 19 and 25 of UL 844	See Parts/Sections for 2.1, 3, 9-14, 17, 24, 19 and 25 of UL 844	See Parts/Sections for 2.1, 3, 9-14, 17, 24, 19 and 25 of UL 844
54	Part III- luminaires for Class II, Div. 2, Gr. F & G and Class III Locations	43 to 49			Not in scope of subject gap analysis
55	Part IV - Portable Luminaires	50 to 71	No equivalent requirements in 60079	Type 3 - Does Not Meet	IEC standards do not have specific requirements for Portable Luminaires.
56	Part V - Manufacturing and production tests	72-73	See Parts/Sections for 72 & 73 of UL 844	See Parts/Sections for 72 & 73 of UL 844	See Parts/Sections for 72 & 73 of UL 844

No.	Section Title / Subject Issue	UL 844 Baseline Standard Section #	IEC Standard 60079-0/-1-/14 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
57	Marking	74	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet	In general the marking in both standards are providing similar details as listed here. IEC marking doesn't indicate Zone 0, 1 or 2 whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in IEC are not employed by UL.

Appendix D. Analysis of UL 913 and IEC 60079

Table 38 provides a summary of the comparative assessment between the UL 913 to IEC 60079.

Table 38: Comparative Assessment Results – UL 913 to IEC 60079

No.	Section Title / Subject Issue	Baseline Standard UL 913 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	1.1 to 1.2 1.3	IEC 60079-0, Sec. 1 & 4 IEC 60079-11, Sec. 1	Type 2 - Meets	Equipment/components and types of protection covered by UL are contained in IEC 60079 series. Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class II & III and Gr, I & III need not to be covered in the gap analysis.
2	Scope (Atmospheric Conditions)	1.5	IEC 60079-0, Sec. 1	Type 2 - Meets	Normal ambient conditions defined in UL 913 and IEC 60079-0 are similar, except temperature range. IEC 60079-0 specifies temperature range with maximum temperature 60 °C, while no temperature range is provided in UL913 and only ambient temperature 40 °C (104 °F) is listed in Sec. 1.5 of UL.
3	Undated References	2	IEC 60079-0/-11/14, Sec. 2	Type 2 - Meets	The latest edition of the referenced document is required to be applied in UL & IEC.
4	Units of Measurement	3	No equivalent requirements in 60079	Type 2 - Meets	Explanation for the use of value in UL standard. No comparison needed.
5	Components	4	IEC 60079-0, Sec. 6.1	Type 3 – Does Not Meet	Both UL and IEC standards require that electrical components in hazardous locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas). However IEC does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing.

No.	Section Title / Subject Issue	Baseline Standard UL 913 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
6	General	5.1 5.4	IEC 60079-11, Sec. 1	Type 2 - Meets	IEC and UL have similar requirements on intrinsically safe apparatus incapability of causing an explosion in the surrounding explosive atmospheres and protection in hazardous area.
7	General (unclassified (ordinary) locations)	5.3	IEC 60079-0, Sec. 6.1	Type 3 – Does Not Meet	Both UL and IEC standards require that electrical components in hazardous locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas). However IEC does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing.
8	General (Construction and Testing)	5.5 to 5.7	IEC 60079-0 & IEC 60079-11	Equivalent to results of comparative assessment of ISA 60079-0 to IEC-60079-0 and ISA 60079-11 to IEC 60079-11 in Task 4 Report	UL 60079-0/-11 contains identical requirements, and identical publication dates with ISA-60079-0/-11. Comparisons of ISA-60079 series with IEC 60079 Series are covered in Task 4. See Task 4 for results and conclusions.
9	Zone Equivalency	6			Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class II & III and Group I & III need not to be covered in the gap analysis.
10	Apparatus for Class II and Class III Locations	7			Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class II & III and Group I & III need not to be covered in the gap analysis.

No.	Section Title / Subject Issue	Baseline Standard UL 913 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
11	Dust-Tight Enclosure Test	8			Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class II & III and Group I & III need not to be covered in the gap analysis.
12	Dust Blanketing Temperature Test	9			Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class II & III and Group I & III need not to be covered in the gap analysis.
13	Marking	10.1	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet	In general the marking in both standards are providing similar details as listed here. IEC marking doesn't indicate Zone 0, 1 or 2 whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in IEC are not employed by UL.
14	Marking (Intrinsic Safe)	10.2	IEC 60079-11, Sec. 12.1	Type 2 - Meets	IEC and UL have similar requirements.
15	Marking (Others)	10.3 to 10.5	IEC 60079-0, Sec. 29.14 IEC 60079-11, Sec. 12.2 Sec. 12.3	Type 2 - Meets	IEC and UL have similar requirements.
16	Zone Equivalency Markings	11			Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class II & III and Group I & III need not to be covered in the gap analysis.

No.	Section Title / Subject Issue	Baseline Standard UL 913 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
17	Explanatory Material	Appendix A			Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class II & III and Gr, I & III need not to be covered in the gap analysis.
18	Reference Standards	Appendix B	IEC 60079-0, Sec. 2 IEC 60079-11, Sec. 2	Type 3 - Does Not Meet	The References in Appendix B of UL 913 are all UL Standards for Equipment for Ordinary Locations, as well as for Hazardous Locations Standards. References adopted by IEC are IEC and ISO standards.

Appendix E. Analysis of UL 1203 and IEC 60079

Table 39 provides a summary of the comparative assessment between the UL 1203 to IEC 60079.

Table 39: Comparative Assessment Results –UL 1203 to IEC 60079

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	1.1 to 1.5	IEC 60079-0, Sec. 1 & 4 IEC 60079-1, Sec. 1 IEC 60079-31, Sec. 1	Type 2 - Meets	Equipment/components and types of protection covered by UL are contained in IEC 60079 series. Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class and Gr, I & III need not to be covered in the gap analysis.
2	Scope (Atmospheric Conditions)	1.6	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet	The normal ambient conditions defined in UL 1203 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but not specified in UL 913.
3	Scope (ordinary locations)	1.7	IEC 60079-0, Sec. 6.1	Type 2 - Meets	Both UL and IEC standards require that electrical components in hazardous locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas). However IEC does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
4	Components	2	IEC 60079-0, Sec. 6.1	Type 3 – Does Not Meet	Both UL and IEC standards require that electrical components in hazardous locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (safe areas). However IEC does not require that the compliance with the industrial standard be verified, whereas UL standards for ordinary location have requirements on equipment be verified by the testing.
5	Units of Measurement	3	N/A	Type 2 - Meets	IEC series use SI (metric) units as default. UL has 2 units systems - SI (metric) units & US (English) Units.
6	Undated References	4	IEC 60079-0/-1/14, Sec. 2	Type 2 - Meets	The latest edition of the referenced document is required to be applied in UL & IEC.
7	Enclosure Types	5	IEC 60079-0/-1/-14	Type 3 - Does Not Meet	Both IEC and UL have requirements on protecting equipment from ingress of liquid/solid foreign objects. However, type 4X enclosure in UL is watertight corrosion-resistant enclosure and is required to be manufactured from corrosion-resistant materials. There are no equivalent enclosures identified by IP rating in IEC.
8	Class I, Zone and Group Equivalency	6	IEC 60079-0, Sec. 4 IEC 60079-10-1, Sec. 3 IEC 60079-10-2, Sec. 3 & 6	Type 2 - Meets	Groups and Zones in UL are based on NFPA 70. Groups IIA, IIB, IIC for explosive gas atmosphere and IIIA, IIIB & IIIC for explosive dust atmosphere specified in IEC and NFPA are similar. Zone 0 & 20 definitions in IEC and NEC are same, but Zone 1 & 21 and Zone 2 & 22 defined in NFPA are more than in IEC. Acetylene is not defined as a typical gas for Gr. IIC in IEC, but it is still one of gases included in IIC. It is same as Gr. IIC definition in NFPA 70. Group IIC is equivalent to both Class 1, Gr. A & B in UL.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
9	Glossary	7	IEC 60079-0/-1/14, Sec. 3	Type 2 - Meets	Terms and definitions in IEC are much more than in UL. Type 2 is given although not all terms listed in Sec. 8 of UL covered in Sec. 3 of IEC 60079-1.
10	PART 1- EXPLOSION-PROOF EQUIPMENT - CONSTRUCTION Enclosure Material	8	IEC 60079-1, Sec. 12.4 & 12.7 IEC 60079-0, Sec. 8.3	Type 3 - Does Not Meet	Comparisons show that enclosure material requirements are not consistent in IEC and UL. UL may be considered more stringent than IEC due to no allowance on zinc alloys as well as magnesium and its alloys in UL. Also max. limit of copper content of alloy in UL is less than in IEC.
11	Enclosure Thickness	9	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
12	Joints in Enclosure General	10.1	IEC 60079-1, Sec. 5.1 Sec. 5.2	Type 2 - Meets	Though the contents in General section for enclosure joints in UL and IEC are not same, the related requirements can be found in the other sections.
13	Cemented Joint	10.2	IEC 60079-1, Sec. 6	Type 2 - Meets	No material test requirement to resistance to chemicals, impact and moisture in IEC (Data may be provided by manufacturer); Min width (length) of cemented joints in IEC less than in UL; However the tests required to determine mechanical strength of cemented joints by IEC are more than UL. Both 2 standards indicate that cement shall not be relied upon for mechanical security of the joint. Overall it is considered that IEC meets UL 1203 at this point.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
14	Joints with flamepaths Class I, Gr. A, B, C and D	10.3	IEC 60079-1, Sec. 5.4 8.1.3	Type 2 - Meets	IEC has requirements on gaskets and labyrinth joints similar to UL.
15	Class I, Group C and D locations	10.4.1	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	Comparisons show that UL requirements on joint width and/or clearance (gap) are more stringent than IEC, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group.
16	Class I, Group C and D locations	10.4.2	IEC 60079-1, Sec. 8.1.3	Type 2 - Meets	IEC has requirements on labyrinth joints similar to UL.
17	Class I, Group C and D locations	10.4.3	IEC 60079-1, Sec. 5.2.4	Type 3 - Does Not Meet	The definitions of minimum flame path length in IEC and UL are similar. However the required minimum flame path length (l) in IEC is less than in UL under the same joint width ranges. See below: 19mm ≤ L: l = 8 mm or 9mm (IEC) = 12.7mm (UL)
18	Cylindrical joints Groups A, B, C, and D	10.4.4	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	UL requirements in this section are more conservative. Comparisons show that UL requirements on joint width and/or clearance (gap) are more stringent than IEC, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
19	Class I, Group B locations General	10.5.1	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	UL requirements are more conservative on the gaps or width of joint for volume 100 < V ≤ 500 and 1640 < V ≤ 2000. Also width and gap of rabbet joint in UL cannot be satisfied by IEC Table 3; In addition, no minimum thickness of cover thickness at the joint flange is specified in IEC.
20	Class I, Group B locations General	10.5.2	IEC 60079-1, Sec. 5.2.4	Type 3 - Does Not Meet	IEC has the required minimum width of joint and/or minimum flame path length (distance from inside of enclosure to nearest edge of bolt hole) less than UL.
21	Threaded joints	10.6	IEC 60079-1, Sec. 5.3	Type 2 - Meets	IEC requirements on threaded joint in Sec. 5.3 are not specified based on gas group (IIA, IIB or IIC). It was found that they are almost same as UL requirements for Gr. A location and so thread joints for Gr. B, C & D in UL can be covered by this section of IEC.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
22	Shaft Openings General	11.1	IEC 60079-1, Sec. 5.2.2 & 8	Type 3 - Does Not Meet	IEC Table 3 for Gr. IIC enclosure is applied to free internal volume more than 2000 cm^3 whereas UL for Gr. A & B is limited to free internal volume of 30 in^3 (500 cm^3). Rotating speed (rpm) is not a parameter for consideration of requirements in IEC. No specific opening type, such as metal-to-metal type in UL is mentioned in IEC. UL may have more stringent requirements on min. length of joint and clearance (gap) where the enclosures are within the scopes of both UL & IEC. The enclosure for Gr. C shall have labyrinth flame path per UL. UL has specified dimensions of Labyrinth type joint, but IEC has not. Labyrinth type may be accepted based on the tests in IEC.
23	Non-rotating shafts and shafts rotating at a speed of less than 100 rpm	11.2	IEC 60079-1, Sec. 5.2.2 & 8	Type 3 - Does Not Meet	Rotating speed (rpm) is not a parameter for consideration of requirements in IEC. UL may have more stringent requirements on min. length of joint and clearance (gap) where the enclosures are within the scopes of both UL & IEC.
24	Shafts rotating at a speed of 100 rpm or more	11.3	IEC 60079-1, Sec. 5.2.2 & 8	Type 3 - Does Not Meet	Rotating speed (rpm) is not a parameter for consideration of requirements in IEC. UL may have more stringent requirements on min. length of joint and clearance (gap) where the enclosures are within the scopes of both UL & IEC.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
25	Holes in Enclosure		IEC 60079-1, Sec. 11 IEC 60079-0, Sec. 9.3	Type 2 - Meets	IEC and UL have the similar requirements on the holes on an enclosure for securing a part. The bottom thickness of bottomed hole shall be sufficient to withstand internal explosion pressure determined by over pressure test. For the unbottomed holes, IEC and UL have the similar approach to maintain explosion (flame) proof properties of the enclosure. IEC provides more detailed requirements. The minimum remaining thickness of bottomed hole in IEC is 3 mm, more than 1.6 mm required in UL. In addition, the length and tolerance of (internal) thread on the hole for Gr. II enclosures are specified in IEC per ISO standards.
26	Drain and Breather Fittings in Enclosure	13	IEC 60079-1, Sec. 10	Type 2 - Meets	The general requirements for breathing and draining device in 2 standards are same, i.e. to withstand the pressure created by an internal explosion in the enclosure to which they are fitted. Threaded drain and breather plug are to comply with UL 1203, Sec. 10.6. Impact type for threaded joint indicated in lines 21 is "meet".

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
27	Supply Connections Fixed equipment conduit and cable entries	14.1.1	IEC 60079-1, Sec. 13	Type 1 - Exceeds	NPT thread per AISI/ASME B1.20.1 are accepted to both IEC & UL Explosion test for conduit entry is required by UL and enclosure flameproof test shall be carried out with conduit sealing device per IEC. In addition to conduit entries, IEC also covers cable glands for threaded holes. Conduit sizes and conduit stop throat diameters are specified in UL.
28	Conduit Seals	14.1.2	IEC 60079-1, Annex C	Type 1 - Exceeds	The minimum length of compound in IEC is more than in UL. Both IEC and UL have the test requirements to compounds. IEC covers more types of sealing than UL.
29	Leads	14.1.3	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent section in IEC
30	Grounding	14.1.4	IEC 60079-0, Sec. 15	Type 1 - Exceeds	Minimum cross-sectional area of earthing conductors are specified based on phase conductors in IEC, which are not found in UL.
31	Cord-connected portable equipment	14.2	See Parts/Sections for 10.1-10.6 of UL 1203	See Parts/Sections for 10.1-10.6 of UL 1203	See Parts/Sections for 10.1-10.6 of UL 1203

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
32	Protection Against Corrosion	15	IEC 60079-0, Sec. 15.3 IEC 60079-1, Sec. 5.1	Type 2 - Meets	Similar requirement in IEC & UL
33	Materials applied to joint surfaces	16	IEC 60079-1, Sec. 5.1	Type 2 - Meets	Electroplated joint surface is addressed in IEC, but not mentioned in UL.
34	Devices Having Coated Threaded Joint Surfaces	17	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
35	Porosity in Enclosure Materials	18	IEC 60079-1, Sec. 12.4	Type 3 - Does Not Meet	No detailed requirements to casting in IEC, except cast iron required to follow ISO 185
36	Polymeric Enclosures	19	IEC 60079-0, Sec. 7	Type 2 - Meets	Polymeric enclosure is non-metallic enclosure. UL 746B & UL 746C are referred in both IEC and UL. IEC and UL have the similar requirements.
37	Temperature Test	20	IEC 60079-0, Sec. 26.5	Type 1 - Exceeds	The maximum voltage for the test is equal to the rated value in UL, lower than 110% of the rated voltage required by IEC. Also T-class is determined by maximum surface temperature in IEC. Therefore IEC exceeds UL.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
38	Explosion tests	21	IEC 60079-1, Sec. 15.2.2 Sec. 15.3	Type 2 - Meets	IEC and UL requirements are not exactly consistent, but it appears that only test number (ignition number) "3 or 5" of IIA, IIB & IIC in IEC are less than 10 required per Table 31 in UL. Others are either equivalent or higher in IEC. Flame propagation test gas types, percentages of gas in air, test locations and number of ignitions (tests) are same in IEC & UL. No exception to explosion test and flame propagation test in IEC.
39	Hydrostatic Pressure Test	22	IEC 10079-1, Sec. 15.2.3	Type 2 - Meets	Overpressure test in IEC and hydrotest pressure in UL have the similar approach to set test pressure, i.e. determined by a factor times maximum explosion pressure. Test period is 10 seconds and acceptance criteria are same in both standards. Dynamic test in IEC is not found in UL .
40	Leakage Test on Factory-Installed Conduit Seals	23	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	From the details summarized here, it can be seen that only explosion test number (3 or 5) in IEC is less than 10 required in UL. Others in IEC either meet UL or more stringent.
41	Rust-Resistance Test	24			Class II. Not in scope of the assessment.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
42	Tests for Glass Parts - Thermal-shock test - Impact test	25.1 25.2	IEC 10079-0, Sec. 26.5.2 Sec. 26.4	Type 2 – Meets Type 1 – Exceeds	Shock test included in "Tests for Glass parts" in UL 1203 has same test water temperature with IEC and FM 3600. Also per FM 3600/4.1.3 Note, shock test in FM 3600 is considered equivalent to ISA 60079-0/26.5.2, which is identical with IEC 60079-0/26.5.2. The drop energy for the test derived from the weight and height in UL is less than maximum drop energy for the test of light-transmitting parts in IEC.
43	Secureness of Conduit Hubs Test	26	IEC 60079-1, C.3.3.1	Type 3 - Does Not Meet	The torque specifications for conduit required by IEC 60079-1 is less than UL 844 under the same conduit sizes.
44	Tests on Joint Gaskets	27	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC 60079.
45	Resistance Test	28	IEC 60079-0, Sec. 26.12	Type 1 - Exceeds	Earth continuity test in IEC provides the deatiled requirements including materials, parts, assembly of test sample and test time & temperature, etc.
46	Accelerated-Aging Test on Bushing	29	IEC 60079-0 26.8, 26.9	Type 2 - Meets	required test temperature is the same in IEC & UL
47	Strain-Relief Test	30	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
48	Rough-Usage Test	31	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
49	Drop Test	32	IEC 60079-0, Sec. 26.4.3 26.7.2	Type 2 - Meets	Drop test in UL is required for 10 times more than 4 time in IEC with a little less height.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
50	Non-Metallic Enclosure Material Tests	33	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet	For chemical compatibility test, UL 1203 requires the compatibility to 13 chemicals to be tested on material samples and complete end products, whereas IEC 60079-0has no such detailed requirements.
51	Chemical Resistance Tests on Sealing and Cementing Compounds	34	IEC 60079-1, Annex C.3	Type 3 - Does Not Meet	This test required by UL 1203 is to determine sealing and cementing compound resistance to chemicals and to be tested to 13 chemicals, same as required by chemical test for non-metallic enclosure materials
52	PART II - DUST-IGNITION-PROOF EQUIPMENT	35-57			not in the task scope
53	PART III - MANUFACTURING AND PRODUCTION TESTS	58-59	See Parts/Sections for 58 & 59 of the UL 1203	See Parts/Sections for 58 & 59 of the UL 1203	See Parts/Sections for 58 & 59 of the UL 1203
54	PART IV- MARKINGS	60	IEC 60079-0, Sec. 29	Type 3 - Does Not Meet	In general the marking in both standards are providing similar details as listed here. IEC marking doesn't indicate Zone 0, 1 or 2 whereas UL marking indicates Zone 0, 1 or 2. Ex Symbols and equipment protection level in IEC are not employed by UL.
55	PART V- INDUSTRIAL CONTROL EQUIPMENT General	61	IEC 60079-0/-1/-14	Type 2 - Meets	The related requirements of control devices for service in hazardous area are covered in IEC & UL. Refer to the analysis of sections related.
56	CONSTRUCTION - Holes	62	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
57	No-Load	63	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
58	Markings	64	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
59	PART VI - SWITCHES General	65	IEC 60079-0, Sec. 18 IEC 60079-1, Sec. 17	Type 2 - Meets	Both IEC and UL have specific sections for switches.
60	CONSTRUCTION	66 to 69	IEC 60079-0, Sec. 18 IEC 60079-1, Sec. 17	Type 3 - Does Not Meet	The specific requirements for switch construction in IEC and UL are different.
61	RATINGS	70	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
62	Markings	71	IEC 60079-1, Sec. 17	Type 3 - Does Not Meet	Marking "T"or "L" on a switch for the control of tungsten-filament lamps in UL are not required by IEC.
63	PART VII - CIRCUIT BREAKERS General	72	IEC 60079-0/-1/-14	Type 2 - Meets	The related requirements of circuit breakers for service in hazardous area are covered in IEC & UL. Refer to the analysis of sections related.
64	CONSTRUCTION	73 - 74	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
65	MARKINGS	75	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No detailed markings for circuit breaker are given in IEC.

No.	Section Title / Subject Issue	Baseline Standard UL 1203 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
66	PART VIII - OUTLET BOXES AND FITTINGS General	76	IEC 60079-0, Sec. 16 Appendix A IEC 60079-14, Sec. 10	Type 2 - Meets	Both IEC and UL have the specific sections for cable fittings.
67		77 to 102	IEC 60079-0, Sec. 16 Appendix A IEC 60079-14, Sec. 10	Type 2 - Meets	Both IEC and UL have the detailed requirements on the connection of cables to equipment to ensure the protection level of equipment is not reduced due to external connection.
68	PART IX- RECEPTACLE-PLUG COMBINATIONS	103 to 131	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
69	PART X- ELECTRICALLY OPERATED VALVES	132 to 138	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
70	PART XI - TESTS ON POLYMERIC VALVE ENCLOSURES	139 to 152	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet	Requirements on non-metallic enclosure material test and hydrostatic pressure tests for a valve electrical enclosure without internal volume, etc. in UL & IEC are different.

Appendix F. Analysis of UL 2255 and IEC 60079

Table 40 provides a summary of the comparative assessment between the UL 2255 to IEC 60079.

Table 40: Comparative Assessment Results – UL 2255 to IEC 60079

No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	1.1 to 1.10	IEC 60079-0, Sec. 1 & 4 IEC 60079-1, Sec. 1 IEC 60079-7, Sec. 1 IEC 60079-31, Sec. 1	Type 2 - Meets	Equipment/components and types of protection covered by UL are contained in IEC 60079 series. Note that dust-ignition and dust-tight protection as well as use for underground atmosphere (mines), i.e. Class and Gr, I & III need not to be covered in the gap analysis.
2	Scope (Atmospheric Conditions)	1.11	IEC 60079-0, Sec. 1	Type 3 - Does Not Meet	The normal ambient conditions defined in UL 1203 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -50 °C is specified in UL, which is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, but not specified in UL 2225.
3	Units of Measurement	2	No equivalent requirements in IEC 60079	Type 2 - Meets	Explanation for the use of value in UL standard. No comparison needed.
4	Undated References	3	IEC 60079-0/-1/14, Sec. 2	Type 2 - Meets	The latest edition of the referenced document is required to be applied in UL & IEC.
5	Glossary	4	IEC 60079-0, Sec. 3	Type 2 - Meets	IEC does not have the definitions of specific sealing fittings same as UL. However, it appears that those cable sealing fittings defined in UL could be covered by cable glands and Ex Equipment cable gland per 3.7 of IEC 60079-0.

No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
6	Part I- Cables - Construction - General	5	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
7	Performance - General	6 to 10	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
8	Marking -General	11	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
9	Part II - Explosionproof and Dust-Ignitionproof Cable Sealing Fittings - Construction General	12	IEC 60079-0, Sec. 16.3 IEC 60079-1, Sec. 13.1	Type 3 - Does Not Meet	No detailed requirements in this section. UL 2225 requires that cable sealing fittings shall comply with the applicable construction requirements in UL 514B & UL 1203 which are not referenced in IEC 60079 series. See separate analysis of UL1203 vs. IEC.
10	Materials	13	IEC 60079-0, Annex A.2 IEC 60079-1, Sec. 12.4 & 12.7 IEC 60079-0, Sec. 8.3	Type 3 - Does Not Meet	No requirements for cable sealing fitting materials were found in IEC as detailed as in UL. It appears that material requirements of cable fittings and enclosures in UL 2225 are same. In this regard, if a cable sealing fitting could be considered as a part of enclosures, enclosure materials in IEC were compared with cable fitting materials in UL. UL may be considered more stringent than IEC due to no allowance on zinc alloys as well as magnesium and its alloys in UL. Also max. limit of copper content of alloy in UL is less than in IEC.

No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
11	Bonding Continuity	14	IEC 60079-0, Sec. 15	Type 3 – Does Not Meet	Minimum cross-sectional area of earthing conductor are specified based on phase conductors in IEC, which are not found in UL.
12	Joints	15	IEC 60079-1, Sec. 5.2.1, 5.2.2 & 5.2.3	Type 3 - Does Not Meet	UL requirements in this section and UL 1203 are more conservative. Comparisons show that UL requirements on joint width and/or clearance (gap) are more stringent than IEC, except for enclosure with free internal volume 6 in^3 (100 cm^3) or less for the equivalent gas group. Also width and gap of rabbet joint in UL cannot be satisfied by IEC Table 3; In addition, no minimum thickness of cover thickness at the joint flange is specified in IEC.
13	Supply Connections for Flameproof "d" and Exploslonproof Fittings	16	IEC 60079-1, Sec. 13	Type 2 - Meets	NPT thread per AISI/ASME B1.20.1 are accepted to both IEC & UL
14	Seal	17	IEC 60079-1, Annex C	Type 2 - Meets	The minimum length of compound in IEC is more than in UL. Both IEC and UL have the test requirements to compounds. IEC covers more types of sealing than UL.
15	Protection Against Corrosion	18	IEC 60079-0, Sec. 15.3 IEC 60079-1, Sec. 5.1	Type 2 - Meets	Similar requirement in IEC & UL

No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
16	Materials Applied to Joint Surfaces	19	IEC 60079-1, Sec. 5.1	Type 2 - Meets	Electroplated joint surface is addressed in IEC, but not mentioned in UL.
17	Part II - Explosionproof and Dust-Ignitionproof Cable Sealing Fittings - Performance				
18	General	20	IEC 60079-0, Sec. 1	Type 2 - Meets	The requirements not related to installation in hazardous area are also to be met per IEC & UL.
19	Torque	21	IEC 10079-1, C.3.3.1	Type 3 - Does Not Meet	Torque on the conduit required for the test per IEC 60079-1 is less than UL 674 under the same conduit sizes.
20	Resistance to Impact Test	22	IEC 60079-0, Sec. 26.4.2	Type 2 - Meets	The major requirements on resistance to impact in IEC & UL are same.
21	Explosion Tests	23	IEC 60079-1, Sec. 15.2.2 Sec. 15.3	Type 2 - Meets	IEC and UL requirements are not exactly consistent, but it appears that only test number (ignition number) "3 or 5" of IIA, IIB & IIC in IEC are less than 10 required per Table 31 in UL. Others are either equivalent or higher in IEC. Flame propagation test gas types, percentages of gas in air, test locations and number of ignitions (tests) are same in IEC & UL. No exception to explosion test and flame propagation test in IEC.

No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
22	Hydrostatic Pressure Tests	24	IEC 60079-1, Sec. 15.2.3	Type 2 - Meets	Overpressure test in IEC and hydrotest pressure in UL have the similar approach to set test pressure, i.e. determined by a factor times maximum explosion pressure. Test period is 10 seconds and acceptance criteria are same in both standards. Dynamic test in IEC is not found in UL . Radiator and conduit seal hydrotest are specific to the heater.
23	Dust Penetration Test	25			Not in the task scope
24	Leakage of Sealing Fittings Test	26	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
25	High Humidity Tests	27	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	No equivalent requirements in IEC
26	Non-Metallic Materials Tests	28	IEC 60079-0, Sec. 7 and 26.7	Type 3 - Does Not Meet	Requirements for the tests set by IEC are more than UL, except chemical resistance test. For chemical compatibility test, UL requires the compatibility to 13 chemicals to be tested, IEC requires only oils and grease, hydraulic liquids for mining applications. In this regard, it is considered that IEC does not meet UL.
27	Tests on Epoxy Sealing Compounds	29	IEC 60079-1, Annex C.3	Type 3 - Does Not Meet	Sealing compounds mechanical strength test is required by IEC, in addition to leakage test.

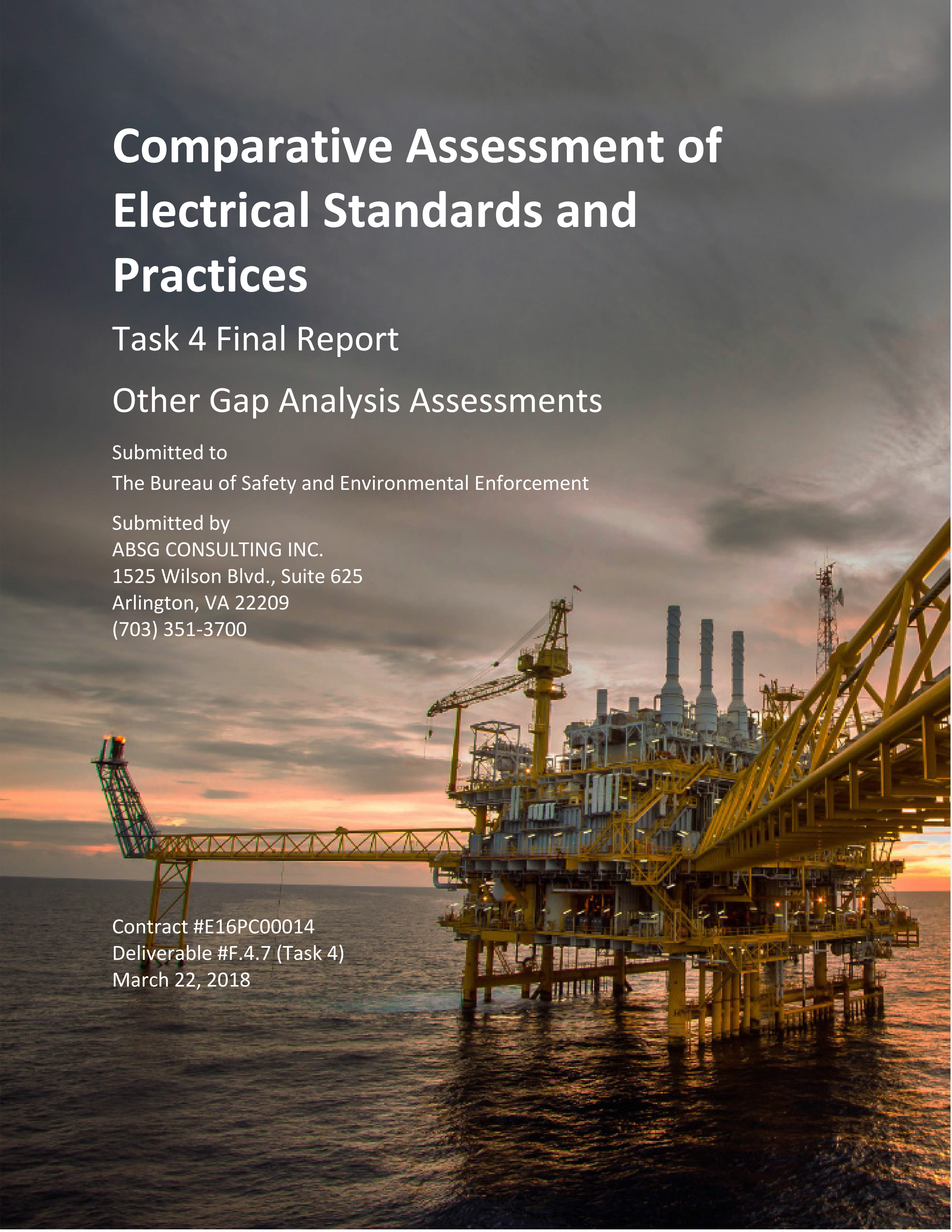
No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
28	Enclosure Types and Degree of Protection	30.1 – 30.3 30.4	No equivalent requirements in 60079 IEC IEC 60079-0, Sec.1	Type 3 - Does Not Meet Type 2- Meets	NEMA ratings are not applicable to IEC. IP ratings are not covered in IEC 60079 series.
29	PART Ill- AEx CABLE FITTINGS AND EXTRA-HARD USAGE CORD CONNECTOR CONSTRUCTION				Similar as Section 12 for explosionproof cable sealing, UL 2225 requires that AEx cable fittings and cord connectors shall comply with the applicable construction requirements in UL 514B Standard for Conduit, Tubing, and Cable Fittings. Where requirements conflict, the requirements in this standard shall apply. Flameproof "d" construction for AEx fittings and connectors are to follow Sections 15, 16, 17 & 19 for explosionproof cable sealing fittings. Metal Increased Safety "e" fittings and connectors shall be NPT or metric threads compliance with Section 16; or in accordance with UL 514B.
29a	**Construction** All AEx Cable Fittings and Cord Connectors	32	See Parts/Sections for 12 & 14 of UL2225	Type 3 - Does Not Meet	
29b	Flameproof "d" Construction	33	See Parts/Sections for 15, 16, 17 & 19 of UL2225	See Parts/Sections for 15, 16, 17 & 19 of UL2225	
29c	Increased Safety "e" Construction	34	See Parts/Sections for 12 & 16 of UL2225	See Parts/Sections for 12 & 16 of UL2225	

No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
30	PART Ill- AEx CABLE FITTINGS AND EXTRA-HARD USAGE CORD CONNECTOR CONSTRUCTION Performance	36			In general, non-metallic fittings and connectors shall comply with the requirements in Non-Metallic Materials Tests, Section 28 in UL 2225. Strain relief tests required in UL are not included in IEC. For mechanical strength test, a torque applied to the fitting in UL is less than in IEC 60079-1. Flameproof fitting or connector performance test for AEx fittings are referred to Sections 21 – 24 & 26 of this standard. Increased safety fitting or connector performance test includes aging test for elastomeric materials, resistance to impact test and test for degree of protection (IP). During aging test, the heat temperature (100 ±5°C) required by UL may be more or less than in IEC, but duration hours (168) in UL are less than IEC; and the cold temperature (- 20 ±2°C) in UL may be more or less than IEC, but duration hours (48) in UL are longer. The resistance to impact test for increased safety fitting can be covered by Section 22. IP rating testing in UL and IEC are to follow the sane IEC standard IEC 60529. Based on the comparison results of sections mentioned above and the assessment results showed in Table 33, it may be considered that IEC meets UL requirements for AEx Cable Fittings and Extra Hard Usage Cord Connectors.
30a	General	36.1	See Parts/Sections for 28 of UL2225	See Parts/Sections for 28 of UL2225	See above.

No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
30b	Unarmored cable fitting strain relief performance	36.2	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	See above.
30c	Strain relief test	36.3	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	See above.
30d	Mechanical strength	36.4	IEC 60079-1, Annex C.3.2	Type 1 – Exceeds	See above.
30e	Armored cable fitting strain relief performance	36.5	No equivalent requirements in IEC 60079	Type 3 - Does Not Meet	See above.
30f	Flameproof fitting or connector	36.6	See Parts/Sections for Sections 21 – 24 & 26 of UL 2225	See Parts/Sections for Sections 21 – 24 & 26 of UL 2225	See above.
30g	Increased safety fitting or connector performance	36.7	IEC 60079-0 Sec. 26.7 & 26.8 See Parts/Sections for Section 22 of UL 2225 IEC 60079-0, Sec. 1	Type 2 – Meets	See above.

No.	Section Title / Subject Issue	Baseline Standard UL 2255 Section #	IEC Standard IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
31	Marking (General)	37.1	IEC 60079-0, Sec. 29 & A.4	Type 2 - Meets	In general, the marking in both standards are providing similar information. IEC 60079-0 marking doesn’t indicate Class & Division and Zone which are required in Sections 37.2 & 37.3 of UL 2225, respectively. Also Ex Symbols are used in IEC 60079-0, whereas AEx Symbols are used in UL 2225.
31a	Marking (Class I, Div. 1 & 2)	37.2	IEC 60079-0, Sec. 29 & A.4	Type 3 - Does Not Meet	See above.
31b	Marking (AEx)	37.3		Type 3 - Does Not Meet	See above.

Appendix E. Task 4 Report: Other Gap Analysis



Comparative Assessment of Electrical Standards and Practices

Task 4 Final Report

Other Gap Analysis Assessments

Submitted to
The Bureau of Safety and Environmental Enforcement

Submitted by
ABSG CONSULTING INC.
1525 Wilson Blvd., Suite 625
Arlington, VA 22209
(703) 351-3700

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Deliverable #F.4.7 (Task 4)
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1. Introduction

On September 16, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) initiated the Comparative Assessment of Electrical Standards and Practices with the issuance of a contract (#E16PC00014) to ABSG Consulting, Inc. (ABSG). BSEE currently incorporates various industry standards into regulation by reference (Title 30 Code of Federal Regulation, 250.198) and conducts inspections of offshore oil and gas facilities to ensure compliance with regulations and incorporated standards. With more facilities and components being manufactured overseas to international standards, determining equivalencies between the domestic standards incorporated into the regulations and international standards has become more challenging, especially in the area of electrical standards. The purpose of this study was to conduct a gap analysis to compare selected domestic electrical standards to selected international electrical standards. As part of this study the following comparative assessments were conducted:

- Task 1 –IEC vs. NEC standards
- Task 2 –IEC vs. API standards
- Task 3 –IEC vs. ANSI/UL standards
- Task 4 –Other gap analysis assessments
- Task 6 –United States vs International Accreditation Practices

Through this comparative gap analysis, BSEE may determine that some of the existing international electrical standards may be easier to follow by the offshore oil and gas industry, more robust, and easier to enforce. BSEE may use the results of this analysis to inform the policies and regulations associated with the electrical-related standards IBR. The ultimate goal of improved regulations is safer operations on the OCS, resulting in better protection of the environment and a reduction in the loss of life and property

This report presents the results of Task 4, other gap analysis assessments which included:

- Section 3 - Comparison of American National Standards Institute (ANSI)/ International Society of Automation (ISA)/ Underwriters Laboratories Inc. (UL) 60079 series vs International Electrotechnical Commission (IEC) 60079 series (SOW 3.1.4.3)
- Section 4 - Comparison of listing, marking and documentation of electrical equipment used in hazardous locations based on U.S. standards (AEx) and IEC 60079 series of standards (EEx) (SOW 3.1.4.1)
- Section 5 - Comparison of Factory Mutual (FM) Approval standards to IEC 60079 series (SOW 3.1.4.4)
- Section 6 - Nationally Recognized Testing Laboratories (NRTLs) vs IEC (SOW 3.1.4.2)
- Section 7 - Comparison of standards used for electrical equipment in hazardous locations by International Regulators' Forum (IRF) member countries to U.S. standards for electrical equipment in hazardous locations. (SOW 3.1.4.5)

2. Methodology

The purpose of the comparative assessment was to determine if the IEC 60079 series of standards meet, exceed or does not meet the requirements in:

- The U.S. nationalized versions of the IEC 60079 series of standards published by ISA/UL
- FM Approval standards 3600, 3610, 3611, 3615, and 3620
- AEx marking requirements for electrical equipment used in hazardous locations.

This report is structured to summarize the results of the comparative assessments in each of the subject areas listed above. Each section includes a brief overview of the subject area, a table highlighting the assessment results and a discussion where there are differences between the baseline and the international standards.

To conduct the analysis, ABSG developed a Standards Analysis Tool to facilitate the comparative assessment. The Standards Analysis Tool was used to map the domestic baseline standards to the comparable section of the international standards. The Standards Analysis Tool incorporated an Impact Type criteria, (Table 1) which allowed for a side-by-side comparison of each section of the domestic baseline standards to the comparable section of the international standards. Lastly, the Standards Analysis Tool included an analysis section for the SME to provide comments on the impact category that was selected. The comments includes a justification of each designation (meets, exceeds, or does not meet) descriptions of similar provisions, additional requirements or shortfalls. Summary versions of the completed analysis templates are provided in Appendices A to this report.

Table 1: Impact Type Criteria

Impact Category	Description
Type 1 - Exceeds	The International Electrotechnical Commission standards exceed the standards currently used by BSEE
Type 2 - Meets	The International Electrotechnical Commission standards meet the standards currently used by BSEE
Type 3 - Does Not Meet	The International Electrotechnical Commission standards does not meet the standards currently used by BSEE

ABSG also conducted research into standards used in the IRF member countries regulations as compared to the standards required by U.S. regulations. Lastly, ABSG conducted an assessment of IEC 60079 requirements as compared to the test standards used by NRTLs for testing of electrical equipment used in hazardous (classified) locations.

3. ANSI/ISA 60079 Series vs IEC 60079 Series of Standards

This section provides the results of the comparative assessment between ANSI/ISA 60079 series of standards and the IEC 60079 series of standards. The ANSI/ISA 60079 series are identical to the IEC 60079 series except for the U.S. National differences. The nationalized versions of the standards have been previously co-published by ISA and UL. The ISA is no longer publishing nationalized versions of new revisions of the IEC 60079 series. Once a new IEC 60079 edition is published, UL will be publishing the standard as a UL only standard with U.S. National Differences

Table 2 provides the list of ISA/UL 60079 standards that were compared to the IEC 60079 standards. The most recent versions of the standards available at the time of the assessment were used for the comparison.

Table 2: ISA/UL 60079 standards compared to IEC 60079 standards

U.S. Standard	Title	IEC Standard
ANSI/ISA-60079-0 (12.00.01) Ed. 6, 2013	*Explosive Atmospheres - Part 0: Equipment - General Requirements*	IEC 60079-0 Ed. 6, 2011-06
UL-60079-1, Ed. 7, September 18, 2015	*Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"*	IEC 60079-1 Ed. 7, 2014-06
UL-60079-2, Ed. 6, June 2, 2017	*Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures "p"*	IEC 60079-2 Ed. 6, 2014-07
ANSI/UL 60079-5, Ed. 4, April 29, 2016	*Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"*	IEC 60079-5 Ed. 4, 2015-02
ANSI/UL 60079-6 Ed. 4, April 29, 2016	*Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"*	IEC 60079-6 Ed. 4, 2015-02
UL-60079-7, Ed. 5, February 24, 2017	*Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"*	IEC 60079-7 Ed. 5, 2015-06
ANSI/ISA-60079-10-1 (12.24.01) Ed. 1, 2014	*Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres*	IEC 60079-10-1 Ed. 2, 2015-09
ANSI/ISA-60079-11 (12.02.01) Ed. 6.2, 2014	*Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"*	IEC 60079-11 Ed. 6, 2011-06
ANSI/ISA-60079-15 (12.12.02) Ed. 4, 2012	*Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"*	IEC 60079-15 Ed. 4, 2010-01
ANSI/UL 60079-18 Ed. 4 December 14, 2015	*Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"*	IEC 60079-18 Ed. 4, 2014-12
ANSI/ISA-60079-25 (12.02.05)-2011	*Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems*	IEC 60079-25 Ed. 2, 2010-02
ANSI/UL 60079-26 Ed. 3, April 21, 2017	*Explosive Atmospheres - Part 26: Electrical Apparatus for Use in Class I, Zone 0 Hazardous (Classified) Locations*	IEC 60079-26 Ed. 3, 2014-10
ANSI/ISA-60079-27 (12.02.04)Ed. 1, 2006	*Explosive Atmospheres – Part 27: Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)*	IEC 60079-27 Ed. 1, 2005-04
ANSI/ISA-60079-29-1 (12.13.01) Ed. 1, 2013	*Explosive Atmospheres - Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases*	IEC 60079-29-1 Ed. 1 2007-08
ANSI/ISA-60079-29-2 (12.13.02)-2012	*Explosive Atmospheres - Part 29-2: Gas Detectors - Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen*	IEC 60079-29-2 Ed. 2, 2015-03

Discussion on National Differences

The ANSI/ISA and ANSI/UL 60079 series of standards adopt the IEC text with differences known as National Differences that may add, delete, or modify the IEC text. There are five categories of National differences that modify the text in the parent IEC standard based on:

- Basic safety principles and requirements
- Safety practices
- Component standards
- Editorial comments or corrections
- National regulatory requirements

The following general modifications are noted in the ANSI/ISA standards when compared with the IEC standards:

- When reference is made to any other IEC 60079 standards, it is required that the requirements in ISA 60079 standard be applied.
- Where references are made to hazardous areas, this is changed to the U.S. terms unclassified locations or hazardous (classified) locations.
- Where requirements call for the application of an "X" appended to the certificate number, this is replaced with a requirement to document this in the manufacturer's instructions.

Each subsection below provides a summary of the analysis and comparative results for each of the standards in the series. Appendices A through O contain the consolidated comparative assessment and results.

3.1 ANSI/ISA 60079-0 vs IEC 60079 Explosive atmospheres – Part 0: Equipment – General Requirements

ANSI/ISA (ISA) 60079-0 is the U.S. Nationalized version of IEC 60079-0 that provides the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres.

Table 3 provides a summary of the comparative assessment of IEC 60079-0 to ISA-60079-0. Subsequent discussions below provide an analysis of the differences between the baseline domestic standard and the associated sections of the international standard.   Overall, the ISA 60079-0 includes the National Differences. As such that the requirements in the IEC 60079-0 do not meet the requirements in ISA 60079-0.

Table 3: ANSI/ISA 60079-0 vs IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General Requirements* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 (12.00.01) Ed. 6, 2013	International Standard IEC 60079-0 Ed. 6, 2011-06	Analysis Results
Define Explosive atmosphere	Scope - First Paragraph	Scope - First Paragraph	Type 2 - Meets
Reference Standards	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet
Standard for special protection "s"	Scope - Note 3	Scope - Note 3	Type 3 - Does Not Meet
Component requirements	Scope	Scope	Type 2 - Meets
Equipment Protection Level	3.26	3.26	Type 3 - Does Not Meet
Ex components	3.28, 3.51, 3.52	3.28, 3.51, 3.52	Type 2 - Meets
Threshold power (addition)	3.46.5	3.46.5	Type 2 - Meets
Cord Connector (addition)	3.6	3.6	Type 2 - Meets
Group II	4.2	4.2	Type 2 - Meets
Temperature Marking Requirement	5.1.1	5.1.1	Type 2 - Meets
Small component temperature for Group I or Group II electrical equipment	5.3.3	5.3.3	Type 3 - Does Not Meet
General requirements	6.1 Note 1, Note 2, Note 5 and Table 3c	6.1 Note 1, Note 2, Note 5 and Table 3c	Type 3 - Does Not Meet
Electromagnetic and ultrasonic energy radiating equipment - Radio frequency sources	6.6.1 Note 5	6.6.1 Note 5	Type 3 - Does Not Meet
Electromagnetic and ultrasonic energy radiating equipment - Lasers or other continuous wave sources	6.6.2	6.6.2	Type 3 - Does Not Meet
Non-metallic enclosure	7.1.1	7.1.1	Type 2 - Meets
Elastomers	7.1.2.3	7.1.2.3	Type 3 - Does Not Meet
Resistance to light	7.3	7.3	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 (12.00.01) Ed. 6, 2013	International Standard IEC 60079-0 Ed. 6, 2011-06	Analysis Results
Avoidance of a build-up of electrostatic charge on Group I or Group II electrical equipment	7.4.2 (e) Note 5	7.4.2 (e) Note 5	Type 2 - Meets
Ex Component Certificate	13.5	13.5	Type 2 - Meets
External Connection for earthing or equipotential bonding	15.1.2 15.3	15.1.2 15.3	Type 2 - Meets
Secureness of electrical connections	15.5	15.5	Type 3 - Does Not Meet
Entries into Enclosures	16.1	16.1	Type 3 - Does Not Meet
Temperature at branching point and entry point	16.6	16.6	Type 3 - Does Not Meet
Disconnectors	18.2	18.2	Type 3 - Does Not Meet
Supplementary requirements for plugs, socket outlets and connectors	20.1	20.1	Type 3 - Does Not Meet
Equipment Protection Level Gc	20.2.1 20.2.2	20.2.1 20.2.2	Type 3 - Does Not Meet
Secondary Cells – Lithium ion batteries	23.3 Table 12	23.3 Table 12	Type 3 - Does Not Meet
Earth Continuity	26.12	26.12	Type 2 - Meets
Manufacturer's Responsibility – Certificate	28.2	28.2	Type 3 - Does Not Meet
Marking	29	29	Type 3 - Does Not Meet
Instructions - General	30.1	30.1	Type 3 - Does Not Meet
Supplementary requirements for cable glands or cord connectors	Annex A.1 General	Annex A.1 General	Type 2 - Meets
Test for degree of protection (IP) of cable glands	Annex A.3.4	Annex A.3.4	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 (12.00.01) Ed. 6, 2013	International Standard IEC 60079-0 Ed. 6, 2011-06	Analysis Results
Common standards – Safety requirements for electrical equipment	Annex G	Annex G	Type 3 - Does Not Meet
Equipment Grounding	Annex H	Annex H	Type 3 - Does Not Meet

3.1.1 Reference Standards

In ISA 60079-0, standards not adopted in the U.S. have been deleted and replaced with applicable U.S. standards. Also, additional U.S. national standards for testing and acceptance of electrical equipment are included in the ISA standard. The following additional standards are included in the ISA standard:

ANSI/IEEE 515: *Standard for Testing, Design, Installation, and Maintenance of Electrical Heat Tracing for Industrial Applications.*
ANSI/NFPA 70*, National Electrical Code*
ANSI/UL 347*, High Voltage Industrial Control Equipment*
ANSI/UL 486E*, Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors*
ANSI/UL 508*, Industrial Control Equipment*
ANSI/ISA-61241-2 (12.10.06), *Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations — Protection by Pressurization "pD"*
ANSI/UL 746B*, Polymeric Materials – Long-Term Property Evaluations*
ANSI/UL 746C*, Polymeric Materials – Used in Electrical Equipment Evaluations*

These additional standards are not included in the IEC. Therefore it can be concluded that the IEC Standard does not meet the ISA standard.

3.1.2 Standard for Special Protection "s"

U.S. standards do not consider special protection type “s” as an option. Hence equipment with special protection "s" rating is not allowed per ISA version of 60079-0. However, the IEC standards allows manufacturer’s to designate equipment with Ex “s” to indicate special protection. A new IEC standard IEC 60079-33 is in development for this type of protection. As the special protection type “s” is not an acceptable option under ISA standard, the IEC standard does not meet the ISA standard.

3.1.3 Equipment Protection Level (EPL)

EPLs in ISA 60079-0 are designated as “G” for gas, “D” for dust, or “M” for mining and are followed by a letter (a, b, or c) to give the user a better understanding as to whether the equipment provides either (a) a “very high,” (b) a “high,” or (c) an “enhanced” level of protection against ignition of an explosive atmosphere. The relationship between zones and EPLs are indicated below, which means that for Zone

0, only EPL of Ga is allowed to install; for Zone 1, only EPLs of Ga or Gb are allowed to install and for Zone 2, EPLs of Ga, Gb or Gc are allowed to install:

- Zone 0 – EPL “Ga”
- Zone 1 – EPL “Ga” or “Gb”
- Zone 1 – EPL “Ga” , “Gb” or “Gc”

IEC 60079-0 allows EPL to be used as part of risk assessment of an installation and reference is made to IEC 60079-14. It is indicated in IEC 60079-14 that as an alternative to the relationship between Zone and EPL as indicated above, EPLs can be determined on the basis of risk by taking into consideration the consequences of an ignition. As a result, under certain circumstances, it may require a higher EPL or permit a lower EPL than that is required for the hazardous zone area. For example, for an area that is classified as Zone 1, as a result of the risk assessment only equipment with an EPL of Ga can be installed, although EPL Ga is normally only be required for Zone 0. Conversely, for a Zone 1 area, equipment with an EPL of Gc is allowed to install instead of Gb.

In ISA standard, the reference to IEC 60079-14 is removed and it is indicated that the NEC does not recognize the concept of employing the concept of equipment protection level in risk assessment as discussed above during classification of an installation. Therefore, it can be concluded that IEC 60079-0 does not meet the ISA 60079-0.

3.1.4 Small component temperature for Group I or Group II electrical equipment

Both IEC and ISA standard states that smaller components require higher surface temperature to cause ignition in an explosive atmosphere. Accordingly, smaller components, with temperatures exceeding the temperature classification limit, are acceptable based on:

1. testing
2. assessment to meets the values provided in Table 3a/3b
3. if the surface area doesn’t exceed 1000 mm2 the T5 temperature class is not to exceed 150^{0}C (normally for T5 Temperature class maximum allowed surface temperature is 100^{0}C) .

ISA 60079-0 includes national differences for smaller components, such as those commonly used in gas detection instruments where the temperature could rise due to internal catalytic or chemical reaction, which requires testing of the components for acceptability. The IEC does not contain the testing requirements for these small components. IEC 60079-0 does not meet ISA 60079-0 in this regard.

3.1.6 General Requirements

ISA 60079-0 and IEC 60079-0 differ in the verification of safety requirements for equipment installation. ISA 60079-0 includes a national difference for the verification of specific safety equipment installed in ordinary (unclassified) locations. This difference requires that equipment listed by a Nationally Recognized Testing laboratory is considered to meet the applicable requirement of the safety standard for the equipment found in other U.S. standards. In IEC 60079-0 standard, there is not a requirement that compliance with industrial standards be verified by an independent testing laboratory. IEC 60079-0 only requires that the equipment be constructed in accordance with applicable safety requirements of the relevant industry standard. Based on these differences IEC 60079-0 does not meet ISA 60779-0 for the verification of safety requirement of electrical equipment in ordinary location.

3.1.7 Electromagnetic and ultrasonic energy radiating equipment

ISA 60079-0 requires that the energy levels of radio frequency sources not exceed the values provided in the Table 4 and 5 of the standard. ISA 60079-0 incudes a national difference that prohibits the use of programmable/software controls in hazardous areas that allow the user to set limits that could exceed the limits in Tables 4 and 5.

For lasers or other continuous wave sources, ISA 60079-0 deletes the text from the IEC standard and refers to ANSI/ISA 60079-28 for requirements.

Based on the additional requirements provided in the ISA 60779-0, it is concluded that IEC 60079-0 does not meet the requirements of ISA 60079-0 for this equipment.

3.1.8 Elastomers

For elastomers, continuous operating temperature is required to be included in the specification by both IEC and ISA standard. In ISA 60079-0, a reference to UL 157 *Standard for Gaskets and Seals* is added as a national difference for determining continuous operating temperature. IEC 60079-0 does not reference this U.S standard nor does it refer any equivalent standard for the determination of continuous operating temperature requirement. Also, IEC 60079-0 does not align with the requirements of UL 157, therefore the IEC standard does not meet the ISA 60079-0 requirement.

3.1.9 Secureness of Electrical Connections

ISA 60079-0 has deleted reference to Clause 26.12 regarding earthing continuity test for non-metallic walled enclosures provided with an internal earth continuity plate. The continuity test in Clause 26.12 has been excluded in ISA standard as part of national difference as this construction is not permitted by U.S. ordinary location standards. The non-metallic walled enclosure construction is not permitted by U.S. standard, however it is allowed by IEC standard. Therefore, it can be concluded that the IEC 60079-0 does not meet ISA 60079-0.

3.1.10 Entries into Enclosures

For entries in enclosure IEC 60079-0 refers to IEC 60079-14 for the installation of conduit or associated fittings. ISA 60079-0 deletes the reference to IEC 60079-14 and replaces the text with reference to NFPA 70, *National Electrical Code (*NEC) Article 505.25(A). It is also noted that ANSI/ISA 60079-10-1 has indicated that IEC 60079-14 has not been adopted for use in the U.S. Therefore, it is concluded that the IEC standard does not meet ISA standard.

3.1.11 Temperature at Branching Point and Entry Point

ISA 60079-0 includes a national difference that requires exterior equipment markings if the temperatures at terminals exceeds 60 °C to align with the NEC. IEC 60079-0 differs in that the temperature requirements triggering marking requirements is set at 70°C. Therefore, ISA 60079-0 has a lower temperature threshold for marking requirements and it is concluded that the IEC 60079-0 requirement does not meet the ISA 60079-0 requirement.

3.1.12 Disconnectors

This section of the standard includes requirements for Switchgear. ISA 60079-0 deletes the reference to IEC 60947-1 *Low-Voltage Switchgear and Controlgear - Part 1: General rules* for the indication of open position for disconnectors and instead refers to:

- ANSI/UL 60947-1 – *Low-Voltage Switchgear and Controlgear - Part 1: General rules*
- ANSI/UL 347 – *Medium-Voltage AC Contactors, Controllers, and Control Centers*
- ANSI/UL 508 – *Standard for Industrial Control Equipment*

The IEC standard does not require adherence to the same U.S. referenced standards contained in the ISA 60079-0, therefore IEC 60079-0 does not meet the ISA 60079-0 requirement.

3.1.13 Supplementary requirements for plugs, socket outlets and connectors

An additional clarifying requirement is included in the ISA 60079-0 for Plugs and Socket installation. This clarification aligns the requirements with NEC wiring methods. IEC 60079-0 does not have reference to this U.S standard or to equivalent wiring methods. Therefore, IEC 60079-0 does not meet ISA 60079-0 for this requirement.

3.1.14 EPL Gc & Gb

ISA 60079-0 includes the additional requirements for EPL Gc to align the standard with the NEC. In Clause 20.1 of both IEC and ISA standard it is indicated that the plugs and socket is to be interlocked mechanically or electrically. However for EPL Gc equipment, ISA standard has included the clarification that it is not necessary for the plugs and socket outlets to comply with interlocking requirements in Clause 20.1, provided the plugs or socket is part of the equipment, can only be separated with the aid of a tool, warning marking is provided, etc. In addition, reference to U.S nationalized standard ISA 60079-1 is made instead of IEC 60079-1 in the ISA standard (see Section 3.2 for analysis of 60079-1). Therefore, it can be concluded that requirement in IEC 60079-0 does not meet requirement of ISA 60079-0.

3.1.15 Secondary Cells – Lithium ion batteries

ISA 60079-0 includes a specific note that the use of spiral-wound Lithium-cobalt-oxide cells, and is not recommended in electrical equipment. This is due to potential thermal runaway hazards resulting from internal short circuits. While the IEC allows the use of lithium batteries, it does not include the special note regarding spiral-wound cells. This is a major national difference when compared with IEC60079-0. Therefore, the IEC standard does not meet ISA 60079-0.

3.1.16 Manufacturer's Responsibility – Certificate

ISA 60079-0 provides clarification that the certificate is to be issued by a NRTL. However, the IEC standard does not require the certificate to be issued by an independent laboratory. Rather, it provides the option that the certificate can be prepared by the manufacturer. Therefore, it can be concluded that requirement in IEC standard does not meet ISA standard.

3.1.17 Marking

Differences in the marking requirements between ISA 60079-0 and IEC 60079-0 is discussed in detail in Section 4 of this report.

3.1.18 Instructions - General

Both ISA and IEC 60079-0 require that the manufacturer prepare documentation which gives full and correct specification of the explosion safety aspects of the electrical equipment. In Clause 30 of the standard, additional guidance is provided that requires specific instructions be included in the documentation. ISA 60079-0 includes additional requirements as indicated below as part of national difference:

- If the marking of the equipment is following Class 1, Division 1 equivalent method, then documentation is to include the requirement for field wiring connection is as per NEC Article 504
- If the marking of the equipment is following Class 1, Division 2 equivalent method, then the details of the sealing required to maintain the specific Type of Protection is to be included in the instructions.

If an equipment marked for Class I, Division1 hazardous locations is used in Class I, Zone 1 or Zone 2 locations for the same gas and with suitable temperature rating, these additional details are to be included in the instructions as per ISA 60079-0. Similar requirements are not included in the IEC standard. Therefore, it can be concluded that requirement in the IEC standard does not meet the ISA standard.

3.1.19 Common Standards– Safety requirements for electrical equipment

ISA 60079-0 has included Normative Annex G which has listed the ordinary location standards commonly applied to hazardous (classified) location electrical equipment. ISA 60079-0 has a national difference in Clause 6.1 which requires that the testing lab verifies the safety requirements in the ordinary location standards for the equipment. IEC 60079-0 also lists applicable industry standards in the body of the standard; however it is not required by the IEC standard to verify compliance with these industry standards. Therefore it can be concluded that IEC 60079-0 does not meet ISA 60079-0 regarding the verification of safety requirement of electrical equipment in ordinary location.

3.1.20 Equipment Grounding

ISA 60079-0 provides additional guidance on typical equipment grounding terminals than the guidance found in IEC 60079-0. Annex H is included in the ISA standard where additional guidance on typical equipment grounding details are provided. As there are additional requirements in the ISA standard that need to be followed when compared with the IEC standard, it can be concluded that IEC 60079-0 does not meet the equipment grounding requirements of ISA 60079-0.

3.1.21 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-0 series meet, or does not meet the requirements of ISA nationalized 60079-0 standard.

IEC 60079-0 standard ***meets*** the requirements outlined in ISA 60079-0 standard, in the following subject areas of:

- Define Explosive atmosphere
- Component requirements
- Ex Components
- Threshold power
- Cord connector
- Group II
- Temperature Marking Requirements
- Non-metallic enclosures
- Resistance to light
- Avoidance of a build-up of electrostatic charges
- Ex Component certificates
- External Connection for earthing or equipotential bonding
- Earth continuity
- Supplementary requirements for cable glands or cord connectors
- Test for degree of protection (IP) of cable glands

IEC 60079-0 standard ***does not meet*** the requirements outlined in ISA 60079-0 standard, in the following subject areas of:

- Reference Standards
- Standard for special protection "s" (Scope)
- Components requirements (Scope)
- Equipment Protection Level Application
- Small component temperature for Group I or Group II electrical equipment

- General requirements – ordinary location standards
- Electromagnetic and ultrasonic energy radiating equipment - Radio frequency sources, Lasers or other continuous wave sources
- Elastomers (Non-metallic enclosures)
- Secureness of electrical connections
- Entries into Enclosures
- Temperature at branching point and entry point
- Disconnectors
- Supplementary requirements for plugs, socket outlets and connectors
- Equipment Protection Level Gc
- Secondary Cells – Lithium ion batteries
- Manufacturer's Responsibility – Certificate
- Marking
- Instructions- General
- Common standards – Safety requirements for electrical equipment
- Equipment Grounding

Nationalized version of IEC 60079-0 is published by ISA with several National Differences. Based on the national differences identified above, it can be concluded that the requirements in IEC 60079-0 do not meet the requirements in ANSI/ISA 60079-0.

3.2 ANSI/UL 60079-1 vs IEC 60079-1 Explosive atmospheres – Part 1: Equipment Protection by Flameproof Enclosures "d"

A comparative assessment of IEC 60079-1 (Ed. 7) and UL 60079-1 (Ed. 7) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. Table 4 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 4: UL 60079-1 vs IEC 60079-1 *Explosive atmospheres – Part 1: Equipment Protection by Flameproof Enclosures "d"* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 60079-1 Ed. 7, 2015	International Standard IEC 60079-1 Ed. 7, 2014-06	Analysis Results
Reference Standards	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet
Definition for MESG	3.7	3.7	Type 2 - Meets
Ex Blanking element definition	3.16	3.16	Type 2 - Meets
Flame proof joints - General Requirements	5.1	5.1	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard UL 60079-1 Ed. 7, 2015	International Standard IEC 60079-1 Ed. 7, 2014-06	Analysis Results
Flame proof joints - Multi-step joints	5.2.9	5.2.9 Multistep joints	Type 2 - Meets
Flame proof joints - Taper threaded joints	5.3, Table 4	5.3, Table 5	Type 3 - Does Not Meet
Fused Glass joints	6.2.1	6.2.1	Type 1 - Exceeds
Ex Component installation instructions for breathing or draining device	10.9.4	10.9.4	Type 2 - Meets
Materials and mechanical strength of enclosures – Materials inside the enclosures	12.4 12.8	12.4 12.8	Type 3 - Does Not Meet
Entries for flameproof enclosures – Threaded Holes	13.2 and Table 16	13.2	Type 3 - Does Not Meet
Entries for flameproof enclosures – Cable Glands, Conduit sealing devices	13.4,13.5 Annex C.1	13.4,13.5 Annex C.1	Type 3 - Does Not Meet
Entries for flameproof enclosures - Plugs and sockets	13.6	13.6	Type 2 - Meets
Entries for flameproof enclosures - Bushings	13.7	13.7	Type 2 - Meets
Entries for flameproof enclosures - blanking elements	13.8	13.8	Type 2 - Meets
Tests of ability of the enclosure to withstand pressure	15.2.1	15.2.1	Type 1 - Exceeds
Determination of explosion pressure (reference pressure)	15.2.2.1	15.2.2.1	Type 1 - Exceeds
Determination of explosion pressure (reference pressure)	15.2.2.2	15.2.2.2	Type 2 - Meets
Overpressure test	15.2.3.1	15.2.3.1	Type 2 - Meets
Marking - Informative markings	20.3	20.3	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard UL 60079-1 Ed. 7, 2015	International Standard IEC 60079-1 Ed. 7, 2014-06	Analysis Results
Marking - Interrupting rating markings	20.4	20.4	Type 3 - Does Not Meet
Instructions	21	21	Type 2 - Meets
Annex B - Additional requirements for elements, with non-measurable paths of breathing and draining devices	B.3	B.3	Type 2 - Meets
Annex C - Additional requirements for flameproof entry devices	C2.1.1 C2.1.2 C2.1.3 C.2.2 C.2.2.1 C2.3.1 C2.3.2 C2.3.3 C.3.1.2 C.3.1.3	C2.1.1 C2.1.2 C2.1.3 C.2.2 C.2.2.1 C2.3.1 C2.3.2 C2.3.3 C.3.1.2 C.3.1.3	Type 2 - Meets
Annex D - Empty flameproof enclosures as Ex components	D.1 D.2 D3.5 D3.7 D3.8 D4.2	D.1 D.2 D3.5 D3.7 D3.8 D4.2	Type 2 - Meets
Annex D - Empty flameproof enclosures as Ex components	D3.10	D3.10	Type 3 - Does Not Meet
Annex E - Cells and batteries used in flameproof “d” enclosures	E4.1.2	E4.1.2	Type 2 - Meets

3.2.1 Reference Standards

In UL 60079-1, standards not adopted in U.S. have been deleted and replaced with applicable U.S. standards. Also, additional U.S. national standards for the equipment are included in the UL standard that are not contained in the IEC 60079-1. Also, additional U.S. national standards for testing and acceptance of electrical equipment are included in the UL standard. The following additional standards are included in the UL standard:

UL 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 2225 Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations

These additional standards are not included in the IEC. The analysis of IEC 60079 series of standards with UL2225 has been conducted and results are included in Task 3 report. Therefore it can be concluded that the IEC standard does not meet the UL standard.

3.2.2 Definition for Maximum Experimental Safe Gap (MESG)

UL 60079-1 refers to IEC 60079-1-1 in the definition of MESG to indicate the test conditions to verify the MESG. IEC refers to the latest edition of the standard IEC 60079-20-1 which replaced IEC 60079-1-1.

UL 60079-1 provides and additional reference to *ANSI/NFPA 497 Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas* for the definition of MESG. The Clause is similar in both the IEC and UL standards with the exception of the added reference in the UL standard.

3.2.3 Flame proof joints - Taper threaded joints

Taper-threaded joint requirements in UL 60079-1 standard is modified to account for the changes required on the equipment to conform to the NEC thread engagement requirements. UL 60079-1 modifies the text in Table 5 of IEC 60079-1 from the requirement that female threads shall gauge at “flush” to “2 turns large” using an L1 plug-gauge to “3 ½ turns”. Requirements added in UL is to include the NEC thread engagement requirement. Equipment certified to IEC Standard is not required to follow NEC thread requirements, and these additional texts are not applicable for such equipment. Although these modification in the UL standard makes IEC standard does not meet UL standard, these changes in UL standard has no major effect on the safety of the equipment.

3.2.4 Fused Glass joints

Fused glass joints are glass-to-metal joints formed by the application of molten glass into a metal frame that results in either a chemical or physical bond between the glass and the metal frame. UL standard has provided consideration that for fused glass joints non-transmission test is not required as they do not have flame path. UL standard also provides clarification that fused ceramic joints are to be considered and evaluated in the same manner as a fused glass joint. IEC 60079-1 does not provide similar exceptions. Based on the differences in the UL standard it can be concluded that IEC 60079-1 exceeds the UL standard for fused glass joints.

3.2.5 Materials and mechanical strength of enclosures – Materials inside the enclosures

Reference to Cast iron enclosure material requirement is not included in UL standard. UL standard is modified and requires that the copper content of the alloy shall be limited to 30% whereas for IEC the cooper content acceptable is 60%. UL has more stringent material requirement than IEC standard. Therefore, it can be concluded that IEC 60079-1 does not meet UL 60079-1 for this requirement.

3.2.6 Entries for flameproof enclosures -Threaded holes

UL 60079-1 has provides additional guidance and requirements regarding National Pipe Thread (NPT) and National Standard Pipe Straight (NPS) threaded entries. It is required by UL standard that NPT threaded entries be between trade sizes ½ and 6; and the inner end of the entry is to be smooth and well-rounded if an integral bushing (conduit stop) is not provided. In the UL standard NPS threaded entries are allowed for enclosures in Group IIA or IIB locations and is to include integral bushings with five full threads of engagement. UL 60079-1 also includes Table 16 which provides dimensions of the integral bushing. Requirements added in UL is to include the NEC requirements. Equipment certified to IEC Standard is not required to follow these NEC requirements, and these additional texts are not applicable for such equipment. Although these modification in the UL standard makes IEC standard does not meet UL standard, these changes in UL standard has no major effect on the safety of the equipment.

3.2.7 Entries for flameproof enclosures – Cable Glands, Conduit sealing devices

As per IEC 60079-1, threaded and non-threaded cable glands that are separate and not part of the equipment could be evaluated separately and such cable glands are not required to be part of the equipment for type testing and routine testing (Clause 15.1 and 16). This consideration is not included in the UL 60079-1. UL standard requires that all cable glands, whether integral or separate must meet the requirement in UL 60079-1 Annex C. The UL 60079-1 Annex C requires that cable glands is to conform to the requirements in UL 2225 *Standard for Safety Cables and Cable Fittings for Use in Hazardous Locations*. It is also stated in UL 60079-1 that the requirements for specific closing devices such as cable glands and conduit sealing devices are to conform to the requirements from the NEC conduit wiring and sealing methods. Based on the differences in the UL standard it can be concluded that IEC 60079-1 does not meet the requirements of UL 60079-1 for cables glands.

3.2.8 Tests of ability of the enclosure to withstand pressure

The UL 60079-1 standard has included the exception that the test of ability of the enclosure to withstand pressure is required only for equipment marked with a name plate circuit breaker interruption rating greater than 10,000 rms symmetrical amperes. However, the IEC 60079-1 standard requires this test be conducted regardless of the circuit breaker rating. It is stated in the UL standard national differences reasoning that the additional energy introduced into an explosion by a fault from a circuit with an available short circuit current of less than 10 000 symmetrical amperes will have a negligible effect on the resulting explosion pressure. Based on the differences in the UL standard it can be concluded that IEC 60079-1 exceeds the requirements of the UL 60079-1 for this requirement.

3.2.9 Determination of explosion pressure (reference pressure)

Reference pressure is the highest value of the maximum smoothed pressure, relative to atmospheric pressure, observed during these tests. Both standards provides test methods for determining the reference pressure for electrical equipment intended for use at an ambient temperature below –20 °C. UL 60079-1 and IEC 60079-1 differ in the application of one of the test methods.

- The UL standard requires that for electrical equipment of Group IIA or IIB where pressure-piling is not considered likely, the reference pressure is determined at normal ambient temperature using the defined test mixture(s). The IEC standard requires that all electrical equipment other than rotating electrical machines (such as electric motors, generators and tachometers) that involve simple internal geometry with enclosure volume not exceeding 3 liters (when empty) where pressure-piling is not considered likely, the reference pressure is determined at normal ambient temperature using the defined test mixture(s). As per UL and IEC standard, the reference pressure for reduced ambient conditions is to be increased based on the test factors provided in Table 7 of the standard. It is noted that for the application of this test method, IEC standard excludes rotating electrical machines and equipment with enclosure volume exceeding 3 liters. However, UL standard does not provide any such details.

IEC standard provides additional test method for electrical equipment other than rotating electrical machines (such as electric motors, generators and tachometers) that involve simple internal geometry with an enclosure volume not exceeding 10 liters (when empty). This additional test method is not included in UL standard.

It is noted that IEC standards provides more detailed test methods. Therefore, it can be concluded that IEC 60079-1 exceeds the requirements of the UL standard for this requirement.

3.2.10 Marking - Interrupting rating markings

Differences in the marking requirements between UL 60079-1 and IEC 60079-1 is discussed in detail in Section 4 of this report.

3.2.11 Annex D - Empty flameproof enclosures as Ex components

UL 60079-1 provides additional installation instructions to be included for empty flameproof enclosures. The instruction states that current interrupting devices with arcing contacts that are intended to interrupt a circuit with an available short circuit current greater than 10,000 rms symmetrical amperes is not to be installed. IEC 60079-1 standard does not provide any such instructions to be considered for installations. Based on the differences in the UL standard it can be concluded that IEC 60079-1 does not meet the requirements of the UL 60079-1 for empty flameproof enclosures.

3.2.12 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-1 series meet, exceed, or does not meet the requirements of UL 60079-1.

IEC 60079-1 ***meets*** the requirements outlined in UL 60079-1, in the following subject areas of:

- Definition for MESG

- Ex Blanking element definition
- Flame proof joints - General Requirements
- Flame proof joints –Multi-step joints
- Ex Component installation instructions for breathing or draining device
- Entries for flameproof enclosures - Plugs and sockets
- Entries for flameproof enclosures – Bushings
- Entries for flameproof enclosures - blanking elements
- Determination of explosion pressure (reference pressure)
- Overpressure test
- Marking - Informative markings
- Instructions
- Annex B - Additional requirements for elements, with non-measurable paths of breathing and draining devices
- Annex C - Additional requirements for flameproof entry devices
- Annex D - Empty flameproof enclosures as Ex components
- Annex E - Cells and batteries used in flameproof “d” enclosures

IEC 60079-1 ***does not meet*** the requirements outlined in UL 60079-1, in the following subject areas of:

- Reference Standards
- Flame proof joints - Taper threaded joints
- Materials and mechanical strength of enclosures – Materials inside the enclosure
- Entries for flameproof enclosures -Threaded holes
- Entries for flameproof enclosures – Cable Glands, Conduit sealing devices
- Marking - Interrupting rating markings
- Annex D - Empty flameproof enclosures as Ex components (D3.10)

IEC 60079-1 ***exceeds*** the requirements outlined in the UL 60079-1, in the following subject areas of:

- Fused Glass joints
- Tests of ability of the enclosure to withstand pressure
- Determination of explosion pressure (reference pressure)

The nationalized version of IEC 60079-1 is published by UL with several National Differences. Based on the national differences identified above, it can be concluded that the requirements in IEC 60079-1 does not meet the requirements in UL 60079-1.

3.3 ANSI/UL 60079-2 vs IEC 60079-2 Explosive Atmospheres Part 2: Equipment Protection by Pressurized Enclosures "p"

A comparative assessment of IEC 60079-2 (Ed. 6) and UL 60079-2 (Ed. 6) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL standard. Table 5 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard. Note that some sections either the baseline and international standards do not contain similar subjects. In these cases no further analysis is needed.

Table 5: UL 60079-2 vs IEC 60079-2 *Explosive Atmospheres Part 2: Equipment Protection by Pressurized Enclosures "p"* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 60079-2 Ed. 6, 2017	International Standard IEC 60079-2 Ed. 6, 2014-06	Analysis Results
Reference Standards	1. Scope 2. References 3. Terms and definitions	1. Scope 2. Normative References	Type 3 - Does Not Meet
Mechanical Strength	5.4	5.4	Type 2 - Meets
Group I and Group II Apertures, partitions, compartments and internal components	5.5	5.5	Type 2 - Meets
Spark and particle barriers	5.9	5.9	Type 2 - Meets
For Level of Protection “pxb” or Level of Protection “pyb”	6.2	6.2	Type 2 - Meets
Suitability of safety devices for hazardous area	7.1	7.1	Type 2 - Meets
Provider of safety devices	7.3	7.3	Type 2 - Meets
Pressurization System evaluated as associated equipment	7.4	7.4	Type 2 - Meets
Safety devices to detect overpressure	7.11	7.11	Type 1 - Exceeds
Release conditions	11.1.2	11.1.2	Type 2 - Meets
Containment system with a limited release	12.3	12.3	Type 2 - Meets
Marking - Supplementary marking	18.3	18.3	Type 2 - Meets
Marking Pressurization systems	18.6	18.6	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard UL 60079-2 Ed. 6, 2017	International Standard IEC 60079-2 Ed. 6, 2014-06	Analysis Results
Annex G – Internal Cells and Batteries for Level of Protection - Protective Components	G.2.2 G.5	G.2.2 G.5	Type 2 - Meets
Annex H - Internal Cells and Batteries for Level of Protection "pzc"	H.2	H.2	Type 2 - Meets

3.3.1 Reference Standards

In UL 60079-2, the IEC 60079 series standards not adopted in U.S. have been deleted and replaced with applicable U.S. 60079 series standards, which have U.S. National Differences applied (e.g. see 60079-0 assessment in Section 3.1). Also, the UL list the following additional standard:

ANSI/NFPA 70 *National Electrical Code*

These differences in the UL standard contain additional requirement that need to be followed for equipment testing and acceptance. Therefore it can be concluded that IEC 60079-2 does not meet the full requirements of UL 60079-2 in this area.

3.3.2 Safety devices to detect overpressure

It is required by both UL 60079-2 and IEC 60079-2 standards that for the pressurized enclosure, automatic safety devices to disconnect power or to sound an alarm or otherwise ensure the safety of the installation be provided when overpressure falls below the specified minimum value. For the equipment level of protection "pzc", both UL and IEC standard lists ten conditions that need to be followed if the enclosure is provided with indicator instead of automatic safety device. One of the conditions in IEC 60079-2 standard is that non-metallic enclosures which have not undergone thermal endurance test, is not allowed to have an indicator instead of automatic safety devices. In UL 60079-2 as part of a national difference, this condition has been removed, which implies that the non-metallic enclosures that have not undergone thermal endurance test is allowed to have indicator instead of automatic safety devices. The requirement in the IEC 60079-2 standard is more stringent than UL 60079-2. Therefore, it is concluded that the requirement in IEC standard exceeds the UL standard.

3.3.3 Marking - Pressurization systems

Differences in the marking requirements between UL 60079-2 and IEC 60079-2 is discussed in detail in Section 4 of this report

3.3.4 . Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-2 series meet, exceed, or does not meet the requirements of UL 60079-2.

The IEC 60079-1 ***meets*** the requirements outlined in the UL 60079-0, in the following subject areas of:

- Mechanical Strength
- Group I and Group II Apertures, partitions, compartments and internal components
- Spark and particle barriers
- For Level of Protection “pxb” or Level of Protection “pyb”
- Suitability of safety devices for hazardous area
- Provider of safety devices
- Pressurization System evaluated as associated equipment
- Release conditions
- Containment system with a limited release
- Marking - Supplementary marking
- Annex G – Internal Cells and Batteries for Level of Protection - Protective Components
- Annex H - Internal Cells and Batteries for Level of Protection “pzc”

The IEC 60079-2 ***does not meet*** the requirements outlined in the UL 60079-2, in the following subject areas of:

- Reference Standards
- Marking Pressurization systems

IEC 60079-2 ***exceeds*** the requirements outlined in the UL 60079-2, in the following subject areas of:

- Safety devices to detect overpressure

The nationalized version of IEC 60079-2 is published by UL with several National Differences. Based on the differences identified above, it can be concluded that the requirements in IEC 60079-2 do not meet the requirements UL 60079-2 in the sections identified above.

3.4 ANSI/UL 60079-5 vs IEC 60079-5 Explosive atmospheres – Part 5: Equipment Protection by Powder Filling "q"

A comparative assessment of IEC 60079-5 (Ed. 4) and UL 60079-5 (Ed. 4) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. Table 6 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 6: UL 60079-5 vs IEC 60079-5 *Explosive atmospheres – Part 5: Equipment Protection by Powder Filling "q"* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/UL-60079-5 (12.00.01)-2013	International Standard IEC 60079-5 Edition 4.0 2015-02	Analysis Results
Reference Standards	1. Scope 2. References 4.1.3 4.4.1	1. Scope 2. References 4.1.3 4.4.1	Type 3 - Does Not Meet
Degree of protection of the container	4.1.3	4.1.3	Type 2 - Meets
Connections - Equipment	4.4.1	4.4.1	Type 3 - Does Not Meet
Fuse	4.8.2 4th paragraph	4.8.2 4th paragraph	Type 3 - Does Not Meet
Fuse - Marking	4.8.2 6th and 7th paragraph	4.8.2 6th and 7th paragraph	Type 2 - Meets
Power supply prospective short-circuit current - Marking	4.8.5	4.8.5	Type 2 - Meets
Marking	6	6	Type 2 - Meets

UL 60079-5 is based on IEC 60079-5. The UL standard is published with U.S. National Differences from the text in the IEC standard.

3.4.1 Reference Standards

In UL 60079-5, standards not adopted in U.S. have been deleted and replaced with applicable U.S. standards. Also, the following additional U.S. national standards for the equipment is included in the UL standard.

UL 2225 *Cables and Cable-Fittings for Use jn Hazardous (Classified) Locations*

Additional standards referenced in the U.S. standards provide for additional requirements that need to be followed for equipment testing and acceptance. The analysis of IEC 60079 series of standards with UL2225 has been conducted and results are included in Task 3 report. Therefore it can be concluded that the IEC 60079-5 does not meet the requirements of the UL standard.

3.4.2 Equipment

Clause 4.4.1 of both IEC and UL 60079-5 include requirements that the cables used for the entry of electrical conductors to powder filled ‘q’ containers must be an integral part of the equipment and must be protected and sealed at the time of manufacture.

UL 60079-5 includes a note in Clause 4.4.1 that clarifies that the type of construction of powder filled containers for electrical equipment is only practical with a factory-installed cable and in most cases a factory-installed cable gland. UL 60079-5 requires that a flameproof "d" cable gland that complies with UL 2225 be provided for the powder filled electrical equipment. The UL standard also states that an increased safety "e" cable gland may not provide adequate pressure sealing of the powder filled "q" enclosure.

This is a national difference included in the UL standard when compared with the IEC standard. Based on these national differences the IEC 60079-5 does not meet the requirement in the UL 60079-5.

3.4.3 Fuse

Both IEC and UL 60079-5 require that the powder filled containers shall not be damaged and that the temperature class shall not be exceeded in the case of malfunctions. The standards also state that malfunctions can be caused by overvoltage or overcurrent and in some cases equipment supply is to be protected by fuses to prevent electrical malfunctions.

The IEC standard indicates that if there are no product standards, the overloads to be considered are those specified by the manufacturer. However, the UL standard has deleted this statement as part of national difference as it is required that overloads are to be tested to applicable U.S. standards. It is concluded that IEC 60079-5 does not meet this requirement of UL 60079-5.

3.4.4 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-5 series meet, or does not meet the requirements of UL 60079-5.

IEC 60079-5 ***meets*** the requirements outlined in the UL 60079-5, in the following subject areas of:

- Degree of protection of the container
- Fuse - Marking
- Power supply prospective short-circuit current - Marking
- Marking

IEC 60079-5 ***does not meet*** the requirements outlined in the UL 60079-5, in the following subject areas of:

- Reference Standards
- Connections - Equipment
- Fuse – overload testing

The nationalized version of the IEC 60079-5 is published by UL with National Differences. It can be concluded that due to these national differences the requirements in IEC 60079-5 do not meet the requirements UL 60079-5.

3.5 ANSI/UL 60079-6 vs IEC 60079-6 Explosive atmospheres – Part 6: Equipment Protection by Oil Immersion "o"

A comparative assessment of IEC 60079-6 (Ed. 4) and UL 60079-6 (Ed. 4) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. Table 7 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 7: UL 60079-6 vs IEC 60079-6 *Explosive atmospheres – Part 6: Equipment Protection by Oil Immersion "o"* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/UL 60079-6 Ed. 4, April 29, 2016	International Standard IEC 60079-6 Ed. 4, 2015-02	Analysis Results
Reference Standards	1. Scope 2. References 4.1	1. Scope 2. References 4.1	Type 3 - Does Not Meet
Requirements for Level of Protection “ob”	4.2.2	4.2.2	Type 3 - Does Not Meet
Remote-indicating protective liquid level indicator	4.7.2	4.7.2	Type 2 - Meets
Safety devices for Level of Protection “ob”	4.7.3	4.7.3	Type 2 - Meets
Marking	7	7	Type 2 - Meets
Selection and erection requirements	Annex A	Annex A	Type 3 - Does Not Meet

UL 60079-6 is based on IEC 60079-6. The UL standard is published with U.S. National Differences from the text in the IEC standard.

3.5.1 Reference Standards

In UL 60079-6, IEC 60079-0 is replaced by UL 60079-0, which includes additional U.S. national standards which have U.S. National Differences applied (e.g. see 60079-0 assessment in Section 3.1). Therefore it can be concluded that the IEC standard does not meet the UL standard.

3.5.2 Requirements for Level of Protection “ob”

In IEC 60079-6, it is required that switching devices protected by liquid immersion Level of Protection “ob” be suitable for a prospective short circuit current of 32 kA, unless marked with a lower value. UL 60079-6 has included a national difference to this requirement by adding a note stating that NEC limits the use of the increased safety termination to 10 kA available short circuit current. As UL 60079-6 has a more stringent requirement, it is concluded that IEC 60079-6 does not meet UL standard.

3.5.3 Selection and erection requirements

With regard to the requirement for selection and erection of equipment with protection type ‘o”, UL 60079-6 refers to the NEC for selection and installation of equipment, whereas IEC 60079-6 refers to IEC 60079-14. It is also to be noted that ISA 60079-10-1 states that IEC 60079-14 has not been adopted in the U.S. Therefore, it is concluded that IEC 60079-6 does not meet the requirements of UL 60079-6 for selection and erection.

3.5.4 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of IEC 60079-6 meet, or does not meet the requirements of UL 60079-6.

IEC 60079-6 ***meets*** the requirements outlined in the UL 60079-6, in the following subject areas of:

- Remote-indicating protective liquid level indicator
- Safety devices for Level of Protection “ob”
- Marking

IEC 60079-6 ***does not meet*** the requirements outlined in the UL 60079-6, in the following subject areas of:

- Reference Standards
- Requirements for Level of Protection “ob”
- Selection and erection requirements

The nationalized version of the IEC 60079-6 is published by UL with National Differences. It can be concluded that due to these national differences the requirements in IEC 60079-6 do not meet the requirements of UL 60079-6.

3.6 ANSI/UL 60079-7 vs IEC 60079-7 Explosive atmospheres – Part 7: Equipment Protection by Increased Safety "e"

A comparative assessment of IEC 60079-7 (Ed. 5) and UL 60079-7 (Ed. 5) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL standard. Table 8 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 8: UL 60079-7 vs IEC 60079-7 *Explosive atmospheres – Part 7: Equipment Protection by Increased Safety "e"* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard UL 60079-7 Ed. 5, 2016	International Standard IEC 60079-7 Ed. 5, 2006-07	Analysis Results
Scope	1. Scope 2. Normative References	1. Scope 2. Normative References	Type 3 - Does Not Meet
Definitions - resistance heating applications	3.13, 3.19, 5.8	3.13, 3.19, 5.8	Type 2 - Meets
Construction Requirements - Level of Protection	4.1	4.1	Type 3 - Does Not Meet
Electrical Connections - Field wiring connection General - Field wiring connections made using terminals conforming to national / international standard - Field wiring connections -Connections designed to be used with cable lugs and similar devices -Factory connections - Permanent connections -Factory connections - Permanent connections, Pluggable connections for Level of Protection “eb” -Factory connections - Permanent connections, Pluggable connections for Level of Protection “ec” - External plug and socket connections for field wiring connection	4.2.1 4.2.2.1 4.2.2.2 4.2.2.4 4.2.3.3 4.2.3.4 4.2.3.5 4.2.4	4.2.1 4.2.2.1 4.2.2.2 4.2.2.4 4.2.3.3 4.2.3.4 4.2.3.5 4.2.4	Type 3 - Does Not Meet Type 3 - Does Not Meet Type 3 - Does Not Meet Type 2 – Meets Type 3 - Does Not Meet Type 3 - Does Not Meet Type 2 – Meets Type 3 - Does Not Meet
Clearances	4.3	4.3	Type 2 - Meets
Creepage distance	4.4.1	4.4.1	Type 2 - Meets
Solid electrical insulating materials	4.6	4.6	Type 2 - Meets
Degrees of protection provided by enclosures	4.10	4.10	Type 2 - Meets
Arcing or sparking contacts	4.11	4.11	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard UL 60079-7 Ed. 5, 2016	International Standard IEC 60079-7 Ed. 5, 2006-07	Analysis Results
Supplementary requirements for specific electrical equipment - Electrical machines - Rotating electrical machines with cage rotors	5.2.7	5.2.7	Type 2 - Meets
Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights	5.3	5.3	Type 2 - Meets
Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights - Light source – Lamps - Luminaires, hand lights, or caplights - Light source - Lamps for rated voltages not greater than 50 V and not greater than 12V - Luminaires, hand lights, or caplights - Electrical spacings - Luminaires for tubular fluorescent bi-pin lamps	5.3.2.2 5.3.2.3 5.3.2.4 5.3.4 5.3.9	5.3.2.2 5.3.2.3 5.3.2.4 5.3.4 5.3.9	Type 3 - Does Not Meet
Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights - Lampholders and lamp caps	5.3.5	5.3.5	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard UL 60079-7 Ed. 5, 2016	International Standard IEC 60079-7 Ed. 5, 2006-07	Analysis Results
Supplementary requirements for - Specific electrical equipment - Analog measuring instruments and instrument transformers - External secondary circuits -Equipment incorporating cells and batteries - Charging of cells and batteries - Equipment - Resistance heating equipment (other than trace heating systems) - Equipment - Resistance heating equipment (other than trace heating systems) - Safety Device	5.4.7 5.6.4 5.8 5.8.11	5.4.7 5.6.4 5.8 5.8.11	Type 2 - Meets
Supplementary Requirement for specific electrical equipment - Other electrical equipment	5.10	5.10	Type 2 - Meets
Type verifications and type tests - Rotating electrical machines - Additional tests for machines - Luminaires - Abnormal operation of luminaires -Verification and tests for cells and batteries of Level of Protection “eb” - Mechanical shock test	6.2.3 6.3.4 6.6.3	6.2.3 6.3.4 6.6.3	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard UL 60079-7 Ed. 5, 2016	International Standard IEC 60079-7 Ed. 5, 2006-07	Analysis Results
Routine verifications and routine tests	7	7	Type 2 - Meets
Ex Component certificates	8	8	Type 2 - Meets
Marking	9.1 9.2	9.1 9.2	Type 3 - Does Not Meet
Temperature determination of electrical machines – Methods of test and of calculation	Annex A (normative)	Annex A (normative)	Type 2 - Meets
Type tests for specific forms of resistance heating devices or resistance heating units (other than trace heater)	Annex B (normative)	Annex B (normative)	Type 2 - Meets
Cage motors – Thermal protection in service	Annex C (Informative)	Annex C (Informative)	Type 2 - Meets
Resistance heating devices and units – Additional electrical protection	Annex D (Informative)	Annex D (Informative)	Type 2 - Meets
Combinations of terminals and conductors for general purpose connection and junction boxes	Annex E (Informative)	Annex E (Informative)	Type 2 - Meets
Dimensions of copper conductors	Annex F (normative)	Annex F (normative)	Type 2 - Meets
Test procedure for T5 (only 8 W), T8, T10 and T12 lamps	Annex G (Informative)	Annex G (Informative)	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard UL 60079-7 Ed. 5, 2016	International Standard IEC 60079-7 Ed. 5, 2006-07	Analysis Results
Alternative separation distances for Level of Protection “ec” equipment under controlled environments	Annex H (normative)	Annex H (normative)	Type 2 - Meets
Application, installation, and testing considerations for Level of Protection “ec” asynchronous machines	Annex I (Informative)	Annex I (Informative)	Type 2 - Meets
Luminaires incorporating LEDs	Annex J (Informative)	Annex J (Informative)	Type 2 - Meets

UL 60079-7 is based on IEC 60079-7. The UL standard is published with U.S. National Differences from the text in the IEC standard.

3.6.1 Reference Standards

In UL 60079-7, standards not adopted in U.S. have been deleted and replaced with applicable U.S. standards. Also, following additional U.S. national standards for the equipment are included in the UL standard.

ANSI C78.1, *Fluorescent Lamps – Rapid Start Types – Dimensional and Electrical Characteristics*
ANSI C81.61, *Electric Lamp Bases*
ANSI C81.62, *Lampholders for Bases*
ANSI /NFPA 70, *National Electrical Code® (NEC®)*
IEC 60034-29, *Rotating electrical machines – Part 29: Equivalent loading and superposition techniques –indirect loading to determine temperature rise*
IEC/IEEE 60079-30-1, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements*
IEC 60081, *Double-Capped Fluorescent Lamps – Performance Specification*
UL 486E *Equipment Wiring Terminal for Use with Aluminum and/or Copper Conductors*
UL 508 *Industrial Control Equipment*
UL 746A *Polymeric Materials – Short Term Property Evaluations*
UL 746B *Polymeric Materials – Long Term Property Evaluations*
UL 840 *Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment*
UL 844 *Luminaires for Use in Hazardous (Classified) Locations*
UL 1059 *Terminal Blocks*
UL 1598 *Luminaires*
UL 2238 *Cable Assemblies and Fittings for Industrial Control and Signal Distribution*

UL 2237 *Multi-Point Interconnection Power Cable Assemblies for Industrial Machinery*
UL 8750 *Light Emitting Diode (LED) Equipment for Use in Lighting Products*
UL 60079-0 *Explosive Atmospheres Part 0: Equipment – General Requirements*
UL 60079-1 *Explosive Atmospheres – Part 1: Equipment Protection by Flameproof Enclosures*
UL 60079-11 *Explosive Atmospheres – Part 11: Equipment Protection by Intrinsic Safety*
UL 60079-15 *Explosive Atmospheres – Part 15: Construction, Test and Marking of Type of Protection Electrical Apparatus*
UL 60947-1 *Low Voltage Switchgear and Controlgear – Part 1: General Rules*
UL 60947-7-1 *Low Voltage Switchgear and Controlgear – Part 7-1: Ancillary Equipment – Terminal Blocks for Copper Conductors*
UL 60947-7-2 *Low Voltage Switchgear and Controlgear – Part 7-2: Ancillary Equipment – Protective Conductors Terminal Blocks for Copper Conductors*
UL 60947-7-4 *Low Voltage Switchgear and Controlgear – Part 7-4: Ancillary Equipment – PCB Terminal Blocks for Copper Conductors*

Additional U.S. standards referenced in the UL standard implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC 60079-7 does not meet the requirements of UL standard.

3.6.2 Construction Requirements - Level of Protection

UL 60079-7 adds a reference allowing equipment evaluated as Level of Protection “ec” include manually operated arcing or sparking components located within an enclosure if it is not accessible in normal operation without a tool and refers to UL 60079-0 for fastener general and documentation requirements. IEC 60079-7 does not provide any such clarification in the standard regarding arcing or sparking components when located within the enclosure. Therefore IEC 60079-7 does not meet UL 60079-7 regarding the requirement for Level of Protection “ec”.

3.6.3 Electrical Connections

Electrical connections can be field or factory wiring. Connections also include permanent or re-connectable types. UL 60079-7 includes a national difference that the electrical connection should be able to provide contact pressure that is not applied through the insulating material. However, IEC 60079-7 allows the contact pressure to be applied through the insulating material if the earth continuity test of IEC 60079-0 is accomplished. UL standards for ordinary locations do not permit the transfer of contact pressure through insulating material.

For screwless electrical connections, IEC 60079-7 requires a method to open the clamping mechanism so that the conductors are not damaged during the installation of the conductor. UL 60079-7 includes a national difference expanding the requirement to include all screwless terminals.

Based on the above differences, it can be concluded that IEC 60079-7 does not meet the requirements of UL 60079-7 for electrical connections.

Field wiring connections General

With regard to the requirements for terminals used for electrical connections, UL 60079-7 includes the national difference indicating that terminals intended for field wiring are to be dimensioned to permit connection of copper conductors. It is noted that IEC 60079-7 does not specify any particular type of conductor in the requirement. The difference is based on NEC requirements. UL 60079-7 also includes a note stating that the terminals are to be identified with the permitted wire sizes as per UL 1059 and UL 486E. Based on the above differences, it can be concluded that IEC 60079-7 does not meet the requirements of UL 60079-7 for field wiring connections.

Field wiring connections using terminals complying with national/international standard

In this section of the UL 60079-7, the U.S. component standards (UL 60947-7-1, -2, UL 1059, UL 486E) are referenced in place of the IEC component standards (IEC 60947-7-1, -2, IEC 60999-1, -2).

UL 60079-7 has additional requirements added to address terminals rated greater than 1500 V. It is required by the UL standard that a terminal greater than 1500 V be subjected to the tests in UL 1059 and UL 486E.

For the temperature rise test as per 60947-7-1 of the corresponding IEC or UL standard, the UL standard indicates that the temperature rise limit is 45K and the IEC standard indicates that the temperature rise limit is 40K. It appears that the IEC standard has a more conservative requirement than the UL standard. However, a caution note is included in the UL standard that temperature rise limit is more restrictive in UL 1059, which is 30K at 100% of the rated current.

Based on the above differences, it can be concluded that IEC 60079-7 does not meet the requirements of UL 60079-7 for field wiring connections.

Factory connections - Permanent Connections

UL 60079-7 requires that terminals with a rated voltage greater than 1500 V be subjected to the tests of UL 1059 and UL 486E except for the dielectric tests. Similar requirements are not included in IEC 60079-7. As part of national differences additional requirements have been added in the UL standard to address terminals rated greater than 1500 V.

For Pluggable connections for Level of Protection “eb”, the UL standard included a note that if an interlock is used and the type of protections selected must be suitable for the application. Based on the above differences, it can be concluded that IEC 60079-7 does not meet the requirements of UL 60079-7 for permanent wiring connections.

External plug and socket connections for field wiring connection

UL 60079-7 modified the IEC text by adding requirements that threaded connections can only be released or removed by use of a tool. It also added requirements that plugs and sockets shall be capable of being connected by wiring methods permitted in NEC. Cable assemblies and associated plugs and sockets shall meet the requirements of UL 2238 and UL 2237, or other relevant standards that include requirements that address voltage and current ratings, and for suitability for field wiring applications. The UL standard also added additional Clause for factory wired connections between enclosures to meet the requirements of the Clause along with strain relief provisions in accordance with the relevant industrial requirements. Based on the above differences, it can be concluded that IEC 60079-7 does not meet the requirements of UL 60079-7 for external plug and socket connections field wiring connections.

3.6.4 Arcing or sparking contacts

UL 600079-7 adds requirements for arcing and sparking contacts. It is required by the UL standard that for level of protection “eb” arcing or sparking contacts are not permitted. And for level of protection “ec”, manually operated arcing or sparking components located within an enclosure that are not accessible in normal operation without the use of a tool need only comply with the separation distances on the external connection points. Based on the above differences, it can be concluded that IEC 60079-7 does not meet the requirements of UL 60079-7 for arcing or sparking contacts.

3.6.5 Supplementary requirements for specific electrical equipment - Luminaires,

UL 60079-7 modified text by replacing IEC 60079-0 with UL 60079-0. It also adds a requirement for a manual switch, per UL 508, rated Category III, per UL 840, as option for the disconnection device. The UL standard also modifies the text of IEC standard by identifying Part 1 of IEC 60598 and adding U.S. standards UL 1598 and UL 8750 for creepage and clearance requirements for luminaries with Level of Protection "ec", except for field wiring terminals. Reference to a U.S. national standard implies that there are additional requirements that need to be followed for the equipment acceptance. Therefore, it can be concluded that IEC 60079-7 does not meet the requirements of UL 60079-7 for luminaries.

3.6.6 Marking requirements

Differences in the marking requirements between ISA 60079-7 and IEC 60079-7 is discussed in detail in Section 4 of this report.

3.6.7 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-7 series meet, exceed, or does not meet the requirements of UL 60079-7.

IEC 60079-7 ***meets*** the requirements outlined in the UL 60079-7, in the following subject areas of:

- Definitions - resistance heating applications
- Electrical Connections
  - Field wiring connections -Connections designed to be used with cable lugs and similar devices
  - Factory connections -Permanent connections - Pluggable connections for Level of Protection “ec”
- Clearances
- Creepage distance

- Solid electrical insulating materials
- Degrees of protection provided by enclosures
- Supplementary requirements for specific electrical equipment
  - Electrical machines - Rotating electrical machines with cage rotors
  - Luminaires, hand lights, or caplights
  - Luminaires, hand lights, or caplights - Lampholders and lamp caps
  - Analog measuring instruments and instrument transformers - External secondary circuits
  - Equipment incorporating cells and batteries - Charging of cells and batteries
  - Resistance heating equipment (other than trace heating systems)
  - Resistance heating equipment (other than trace heating systems) - Safety Device
  - Other electrical equipment
- Type verifications and type tests
  - Rotating electrical machines - Additional tests for machines
  - Luminaires - Abnormal operation of luminaires
  - Verification and tests for cells and batteries of Level of Protection “eb” - Mechanical shock test
- Routine verifications and routine tests
- Ex Component certificates
- Temperature determination of electrical machines – Methods of test and of calculation
- Type tests for specific forms of resistance heating devices or resistance heating units (other than trace heater) (Annex B)
- Cage motors – Thermal protection in service
- Resistance heating devices and units – Additional electrical protection
- Combinations of terminals and conductors for general purpose connection and junction boxes
- Dimensions of copper conductors
- Test procedure for T5 (only 8 W), T8, T10 and T12 lamps
- Alternative separation distances for Level of Protection “ec” equipment under controlled environments
- "Application, installation, and testing considerations for Level of Protection “ec” asynchronous machines"
- Luminaires incorporating LEDs

IEC 60079-7 ***does not meet*** the requirements outlined in the UL 60079-7, in the following subject areas of:

- Scope; Normative References
- Construction Requirements - Level of Protection
- Electrical Connections
  - Field wiring connections – General

- Field wiring connections made using terminals conforming to national/international standard
    - Factory connections -Permanent connections
    - Factory connections -Permanent connections - Pluggable connections for Level of Protection "eb"
    - External plug and socket connections for field wiring connection
- Arcing or sparking contacts
- Supplementary requirements for specific electrical equipment
    - Luminaires, hand lights, or caplights - Light source - Lamps
    - Luminaires, hand lights, or caplights - Light source - Lamps for rated voltages not greater than 50 V and not greater than 12V
    - Luminaires, hand lights, or caplights - Electrical spacings
    - Luminaires, hand lights, or caplights - Luminaires for tubular fluorescent bi-pin lamp
- Marking

The requirements in ISA 60079-7 and IEC 60079-7 are the same except for the U.S. national differences in the UL standard as detailed above. It can be concluded that due to these national differences the requirements in IEC 60079-7 do not meet the requirements in UL 60079-7.

3.7 ANSI/ISA 60079-10-1 vs IEC 60079-10-1 Explosive atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres

A comparative assessment of IEC 60079-10-1 (Ed. 2) and ANSI/UL-60079-10-1 (Ed. 1) was conducted to determine if the IEC standard meets, exceeds or does not meet the ANSI/ISA-standard. Table 9 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard. In some subjects there are no equivalent requirements in either the baseline or the international standards. In these areas, no further analysis is needed.

Table 9: ANSI/ISA 60079-10-1 vs IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 (12.24.01)-2014	International Standard IEC 60079-7 Ed. 4, 2006-07	Analysis Results
Reference Standards	1. Scope 2. References	1. Scope 2. Normative References	Type 3 - Does Not Meet
Scope	Scope	Scope Annex G.11	Type 2 - Meets
Definitions - hazardous area	3.3	3.3.1	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 (12.24.01)-2014	International Standard IEC 60079-7 Ed. 4, 2006-07	Analysis Results
Definitions - non-hazardous area	3.4, 3.30	3.3.2	Type 2 - Meets
Definitions - zones	3.5	3.3.3	Type 2 - Meets
Definitions - Class I, Zone 0	3.6	3.3.4	Type 3 - Does Not Meet
Definitions - Class I, Zone 1	3.7	3.3.5	Type 3 - Does Not Meet
Definitions - Class I, Zone 2	3.8	3.3.6	Type 3 - Does Not Meet
Definition - Continuous grade of release	3.11	3.4.2	Type 2 - Meets
Definition - Secondary grade of release	3.13	3.4.4	Type 2 - Meets
Definition - LEL, UEL	3.17, 3.18	3.6.12, 3.6.13	Type 2 - Meets
Definition - ventilation and dilution	reference not in ISA standard	3.5	Type 1 – Exceeds
Definition - Vapor Pressure	3.26	3.6.10	Type 2 - Meets
Definition - ignition temperature of an explosive gas atmosphere	3.27	3.6.11	Type 2 - Meets
Definition - routine maintenance, rare malfunction	reference not in ISA standard	3.7.2, 3.7.3, 3.7.4	Type 1 – Exceeds
Safety Principles	4.1	4.1	Type 1 - Exceeds
Gas Group	4.2	4.2	Type 2 - Meets
Temperature Class	4.2	4.2	Type 2 - Meets
Area classification objectives - Change Management	4.2	4.2	Type 3 - Does Not Meet
Area classification objectives - Risk assessment	4.2	4.3	Type 3 - Does Not Meet
Competence of Personnel	5.1	4.4	Type 1 - Exceeds
Area Classification Methodology	reference not in ISA standard	5.1	Type 1 – Exceeds
Simplified methods	reference not in ISA standard	5.4	Type 1 – Exceeds

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 (12.24.01)-2014	International Standard IEC 60079-7 Ed. 4, 2006-07	Analysis Results
Combination of methods	reference not in ISA standard	5.5	Type 1 – Exceeds
Use of industry codes and national standards	Scope	5.3	Type 2 - Meets
Sources of Release	5.2	5.2, 6.2 - Sources of Release	Type 1 - Exceeds
Type of Zone	5.3	7 Type of Zone	Type 2 - Meets
Type of Zone	5.3 Annex B	7.2 Influence of grade of the source of release	Type 2 - Meets
Influence of dilution	Annex B	7.3 Influence of dilution	Type 2 - Meets
Influence of availability of ventilation	Annex B	7.4 Influence of availability of ventilation	Type 2 - Meets
Extent of zone	5.4	8 Extent of zone	Type 1 - Exceeds
Forms of Release and Release rate of gas or vapor -Liquefied under pressure -Liquefied by refrigeration -Aerosols -Vapors -Liquid releases -Gaseous Release	5.4.1 5.4.4	Annex B B.7 6.3	Type 1 - Exceeds
Other parameters to be considered	5.4.5	6.4 Ventilation (or air movement) and dilution	Type 1 - Exceeds
Illustrative examples	5.4.6	no reference in IEC	Type 2 - Meets
Ventilation and Degree of ventilation	6.1 6.3 5.4.3 Annex B	6.4 6.5.4 Annex C Annex D	Type 1 - Exceeds
Main Types of Ventilation	6.2 5.4.3 Annex B.2, B.3	6.5.1, 6.5.2, 6.5.3	Type 2 - Meets
Documentation - General	7.1	9.1 Documentation - General	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 (12.24.01)-2014	International Standard IEC 60079-7 Ed. 4, 2006-07	Analysis Results
Documentation - Drawings, Datasheets,	7.2	9.1 Documentation - Drawings, Datasheets	Type 3 - Does Not Meet
Examples of sources of release and release rate	Annex A.1	Annex B B.2 Examples of grade of release	Type 2 - Meets
Assessment of grades of release Summation of releases Hole size and source radius Forms of release	reference not in ISA standard	Annex B B.3 Annex B B.4 Annex B B.4 Annex B B.4	Type 1 – Exceeds
Openings	Annex A.2	Annex B.8	Type 2 - Meets
Release rate	Annex A.3	Annex B.7.2 Estimation of Release rate	Type 2 - Meets
Release rate of liquid	Annex A.3.1	Annex B.7.2.2	Type 3 - Does Not Meet
Release rate of gas	Annex A.3.2	Annex B.7.2.3.1	Type 2 - Meets
Release rate of gas with choked gas velocity	Annex A.3.2.1	B.7.2.3.3 Release rate of gas with choked gas velocity (sonic releases)	Type 2 - Meets
Release rate of gas with non-choked gas velocity	Annex A.3.2.2	B.7.2.3.2 Release rate of gas with non choked gas velocity (subsonic releases)	Type 2 - Meets
Release rate of evaporative pools	reference not in ISA standard	B.7.3 Release rate of evaporative pools	Type 1 – Exceeds
Examples of hazardous area classification	Annex C.7	Annex A	Type 3 - Does Not Meet
Examples of hazardous area classification	Annex C examples	Annex E Examples	Type 1 - Exceeds
Flammable Mist	Annex D	Annex G	Type 2 - Meets
Hydrogen	Annex E	Annex H	Type 2 - Meets
Schematic approach to classification of hazardous areas	reference not in ISA standard	Annex F Schematic approach to classification of hazardous areas	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 (12.24.01)-2014	International Standard IEC 60079-7 Ed. 4, 2006-07	Analysis Results
Hybrid Mixtures	reference not in ISA standard	Annex I Hybrid Mixtures	Type 1 – Exceeds
Useful equations in support to hazardous area classification	reference not in ISA standard	Annex J (informative) Useful equations in support to hazardous area classification	Type 1 – Exceeds
Industry codes and national standards	reference not in ISA standard	Annex K Industry codes and national standards	Type 2 – Meets

ISA 60079-10-1 is harmonized with IEC 60079-10-1, Edition 1; however, the latest edition of the IEC standard is IEC 60079-10-1, Edition 2.0 (2015-09). There are several revisions in the latest edition of the IEC standard including both technical content and design approach to classifying hazardous locations. These major changes in the latest edition of the IEC standard have not yet been incorporated into a newer revision of the ISA or UL standard.

The following general modifications are noted in the ISA standard when compared with the IEC standard:

- Where references are made to other IEC 60079-standards, the referenced requirements found in these standards shall apply as modified by any applicable U.S. National Differences.
- Where references are made to hazardous areas, this is changed to the U.S. terms unclassified locations or classified (hazardous) locations as appropriate.
- Alignment with normal terminology used in U.S. based area classification documents.
- The term Class I was inserted in front of the Zone designation for a specific area.

3.7.1 Reference Standards

In ISA 60079-10-1, standards not adopted in U.S. have been deleted and replaced with applicable U.S. standards. Also, the following additional U.S. national standards for the equipment are included in the ISA standard:

ISA-60079-20-1, *Explosive atmospheres – Part 20-1: Material characteristics for gas and vapor classification - Test methods and data*
ANSI/NFPA 497, *Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*
ANSI/NFPA 70, *National Electrical Code*
29 CFR, *Code of Federal Regulations, Title 29, Labor*

Additional U.S. standards referenced in the ISA standard implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC standard does not meet the requirement of the ISA standard.

3.7.2 Definitions

The following changes are made to the ISA 60079-10-1 standard as part of national differences:

- Definitions of Class 1, Zone 0, 1 and 2 from NEC are used instead of IEC definitions as part of national differences. The definition in IEC Standard for these terms does not meet ISA standard.
- In the latest edition of the IEC standard several new terms and conditions has been introduced such as ventilation and dilution, routine maintenance, rare malfunction. The definition of these terms has been included in the IEC standard. Therefore IEC Standard exceeds the ISA standard as these additional definitions provides guidance to classification of hazardous area.

3.7.3 Safety Principles

In the latest edition of IEC 60079-10-1 it is indicated that the area classification should take into account any routine maintenance. Routine maintenance is defined as the action that needs to be performed during normal operation to maintain the performance of the equipment. In ISA 60079-10-1, the definition of routine maintenance is not included. Also, the definitions in the ISA standard states that 'maintenance' is considered as activities other than normal operation and the area classification is not considered valid during such activities. ISA 60079-10-1 does not have similar requirements as the standard is the nationalized version of the previous edition of IEC 60079-10-1. As such, IEC 60079-10-1 exceeds the ISA standard in this area.

3.7.4 Area classification objectives - change management process

ISA 60079-10-1 includes additional text to clarify the change management process. The ISA standard requires that for any change in the equipment or procedure in an area classification location, a change management procedure is to be used in accordance with 29 CFR 1910.119. IEC 60079-10-1 does not contain a similar requirement. Therefore, the IEC standard does not meet the requirements in ISA 60079-10-1 regarding the change management process.

3.7.5 Area classification objectives – Risk Assessment

IEC 60079-10-1 has requirements in Clause 4.3 regarding risk assessments and how they are to be used to assess whether the consequences of ignition of an explosive atmosphere requires the use of equipment with higher Equipment Protection Level (EPL) or may justify the use of equipment with lower EPL than required. However, as part of national differences, this text is moved to a note in Clause 4.2 of the ISA standard with additional reference made to NEC 505.8(I) or ANSI/ISA-TR12.13.03 for examples of the concept. Although the note in the ISA standard refers to risk assessment for selection of equipment with higher or lower EPL levels, the standard does not recognize the concept of negligible extent of zone be treated as non-hazardous area.

Further, it is noted that IEC 60079-0 describes EPLs and risk assessments, and IEC 60079-14 defines the application of EPLs to an installation. ISA 60079-10-1 states that IEC 60079-14 has not been adopted for use in the U.S. and the NEC does not recognize the concept of employing the concept of equipment protection level in risk assessments during classification of an installation. Therefore, it can be concluded that IEC 60079-10-1 does not meet ISA 60079-10-1 for this requirement.

3.7.6 Competence of Personnel

IEC 60079-10-1 and ISA 60079-10-1 require that the area classification be carried out by personnel who understand the relevance and significance of the properties of flammable substances and are familiar with the process and equipment. IEC 60079-10-1 standard requires that the personnel should also understand the principles of gas/vapor dispersion, and competency must be relevant to the nature of the facility and methodology used. The IEC standard also requires that continuing education and training must be undertaken by the personnel on a regular basis. ISA 60079-10-1 does not contain similar guidance provided in the IEC standard, therefore IEC 60079-10-1 exceeds the requirements in the ISA standard.

3.7.7 Area Classification Methodology

The latest edition of IEC 60079-10-1 provides requirements for alternative methods of area classification. The IEC standard provides a discussion about a detailed approach to area classification and allows that experience or documented evidence may be used to support the classification chosen. The IEC Standard also provides additional guidance on classification by sources of release method, use of industry codes, national standards, simplified methods and combination of methods. ISA 60079-10-1 standard does not have similar requirements. Therefore, the requirement for classification methodology in latest editions of IEC 60079-10-1 exceed that of the requirement in ISA 60079-10-1.

3.7.8 Simplified Methods

IEC 60079-10-1 states that where it is not practicable to perform assessments from individual sources of release, a simplified method could be used. The simplified method identifies sources for each of the zone types, Zone 0, 1 and 2 to allow for potential sources of release without details from individual sources of releases. The details regarding this simplified method is not included in ISA 60079-10-1 , therefore IEC 60079-10-1 exceeds the ISA standard regarding the guidance provided for simplified method.

3.7.9 Combination of methods

IEC 60079-10-1 allows the use of different methods for classification of a facility at various stages of its development or for various parts of the facility. For example, at the initial concept stage simplified method could be used and as the design proceeds, classification is to be updated based on detailed method of assessment. The details regarding this combination of methods is not included in ISA 60079-10-1 standard. IEC 60079-10-1 exceeds the ISA standard regarding the guidance provided for combination of methods.

3.7.10 Source of Releases

The latest edition of IEC 60079-10-1 provides additional guidance regarding the sources of release such as liquid release, gaseous release, release from liquefied gas under pressure/refrigeration, and aerosols. The additional guidance in the IEC standard will assist in determining the possible sources of releases during the classification of a hazardous area. ISA 60079-10-1 does not contain the additional guidance. Therefore IEC 60079-10-1 exceeds the requirements in the ISA standard.

3.7.11 Extent of Zone

The latest edition of IEC 60079-10-1 requires that extent of the zone should consider the level of uncertainty in the assessment by the application of a safety factor. This additional requirement is not included in ISA 60079-10-1. Therefore IEC 60079-10-1 exceeds the requirements in the ISA standard.

3.7.12 Forms of Release and Release Rate of Gas or Vapor

IEC 60079-10-1 provides additional clarification regarding the determination of the characteristic of the release based on the physical state of the release such as gas at elevated temperature or pressure, gas liquefied by application of pressure/refrigeration, liquid with release of vapor, aerosols. The IEC standard clarifies that these physical states and characteristics are to be considered during classification of hazardous area. ISA 60079-10-1 does not have these additional clarifications. It is concluded that the guidance provided in the IEC 60079-10-1 exceeds the ISA standard.

3.7.13 Other Parameters to be Considered

ISA 60079-10-1 requires that other parameters such as climatic conditions and rate of gas or vapor dispersion is to be considered for area classification. IEC 60079-10-1 also provides details regarding parameters to be considered for area classification. The IEC standard requires that the dispersion or diffusion of gas into the atmosphere is a key factor and provides more additional guidance. IEC standard provides additional clarifications compared to the ISA standard. It is concluded that the guidance provided in the IEC 60079-10-1 exceeds the ISA standard.

3.7.14 Ventilation and Degree of Ventilation

Both IEC and ISA 60079-10-1 consider that ventilation will influence the type of zones. In the latest edition of the IEC standard, additional clarification and guidance is provided regarding ventilation and degree ventilation. IEC standard provides additional clarifications compared to the ISA standard. It is concluded that the guidance provided in the IEC 60079-10-1 exceeds the ISA standard.

3.7.15 Documentation - Drawings, data sheets and tables

Both IEC and ISA 60079-10-1 provides details regarding the area classification documentation. The documentation is to include plans and elevations that show the type and extent of the zones, gas group, ignition temperature and temperature class. The documentation should also include relevant information such as location of source of release, and openings in buildings. As part of national difference in ISA 60079-10-1, it is required that documentation should also include identification of the basis that determined the extent of the classified areas including the methodology applied, such as ventilation, pressurization, and vapor tight barriers. Based on this assessment, the requirement in IEC 60079-10-1 does not meet ISA 60079-10-1 for documentation.

3.7.16 Assessment of grades of release, Summation of releases, Hole size and source radius

IEC 60079-10-1 provides additional consideration for the assessment and summation of release grades. The standard also provides additional guidance for determining the hole radius, which is the most significant factor to be estimated in a system as it determines the release rate of the flammable substance and thus eventually the type of zone and the extent of the zone. This additional consideration and guidance is not contained in the ISA 60079-10-1. It is concluded that the guidance provided in the IEC 60079-10-1 exceeds the ISA standard.

3.7.17 Release rate of Liquid

In the latest edition of IEC 60079-10-1, the release rate calculation formula has been revised. The equation uses a factor, coefficient of discharge ($Cd \leq 1$), which is based on the properties of openings and viscosity of the liquid or gas. The value Cd is an empirical value obtained through several experiments for specific cases of release and opening details. The equation provided in ISA 60079-10-1 does not use this factor. It is noted that the calculation using IEC equation could yield a lesser or equal release rate than ISA standard equation. Based on this assessment, it is concluded that IEC standard does not meet the guidance in the ISA standard.

3.7.18 Release rate of evaporative pools

Evaporative pools are the result of liquid spillage or leakage from a process system where a flammable liquid is stored or handled in an open vessel. IEC 60079-10-1 provides a release rate calculation for evaporative pools. ISA 60079-10-1 does not provide release rate calculation for evaporative pools. It is concluded that the guidance provided in the IEC 60079-10-1 exceeds the ISA standard.

3.7.19 Examples of Hazardous Area Classification

In the Annex C of ISA 60079-10-1, several examples for hazardous area classification is included. An additional note has been added to Annex C.7 to add NEC requirements for transition zones with Zone 0 and Zone 1 areas. These details are not included in the IEC 60079-10-1 standard. It is concluded that the IEC standard does not meet the requirements in the ISA standard.

It is also noted that in the latest edition of IEC 60079-10-1 in Annex E, several new examples and guidance for the determination of classification area is presented with more explanation. IEC 60079-10-1 provides detailed methods for classification of hazardous areas considering degree of dilution and hazardous distances. These additional requirements are not included in the ISA standard. The methods provided in IEC Standard would assist in determining more accurate classification of a hazardous area than the ISA standard. As such, the IEC standard exceeds this requirement in the ISA standard.

3.7.20 Hybrid Mixtures

Hybrid mixture is a combined mixture of a flammable gas or vapor with a combustible dust or combustible flyings. IEC 60079-10-1 provides some informative guidance regarding hybrid mixtures. This guidance does not exist in the ISA 60079-10-1. It is concluded that the guidance provided in the IEC 60079-10-1 exceeds the ISA standard.

3.7.21 Useful equations in support to hazardous area classification

Annex J of IEC 60079-10-1 provides equations that could be used to calculate parameters influencing the dispersion and dilution of flammable gas or vapor in air at ambient conditions. These equations are not included in the ISA 60097-10-1. It is concluded that the guidance provided in the IEC 60079-10-1 exceeds the ISA standard.

3.7.22 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-10-1 series meet, exceed, or does not meet the requirements of ISA 60079-10-1.

IEC 60079-10-1 ***meets*** the requirements outlined in the ISA 60079-10-1, in the following subject areas of:

- Scope
- Definitions – hazardous area, non-hazardous area, zones, LEL, UEL, Vapor Pressure
- Definition - Continuous grade of release, Secondary grade of release
- Definition - ignition temperature of an explosive gas atmosphere
- Gas group
- Temperature class
- Use of industry codes and national standards
- Type of zone
- Influence of dilution
- Influence of availability of ventilation
- Illustrative examples
- Main types of ventilation
- Documentation – General

- Examples of sources of release and release rate
- Openings
- Release rate
- Release rate of gas with choked and non-choked gas velocity
- Flammable mist
- Hydrogen
- Schematic approach to classification of hazardous areas
- Industry codes and national standards

IEC 60079-10-1 ***does not meet*** the requirements outlined in the ISA 60079-10-1, in the following subject areas of:

- Reference Standards
- Definitions - Class I, Zone 0; Class I, Zone 1; Class I, Zone 2
- Area classification objectives - Change Management
- Area classification objectives - Risk assessment
- Documentation - Drawings, Datasheets
- Release rate of liquid
- Examples of hazardous area classification (Annex A)

IEC 60079-10-1 ***exceeds*** the requirements outlined in the ISA 60079-10-1, in the following subject areas of:

- Definitions – ventilation and dilution; routine maintenance, rare malfunction
- Safety Principles
- Competence of Personnel
- Area Classification Methodology
    - Classification by sources of release method
    - Simplified methods
    - Combination of methods
- Sources of Release
- Extent of zone
- Forms of Release and Release Rate of Gas or Vapor
    - Liquefied under pressure
    - Liquefied by refrigeration
    - Aerosols
    - Vapors
    - Liquid releases
    - Gaseous Release
- Other parameters to be considered
- Ventilation and Degree of ventilation

- Assessment of grades of release
    - Summation of releases
    - Hole size and source radius
    - Forms of release
- Release rate of evaporative pools
- Examples of hazardous area classification (Annex E)
- Hybrid Mixtures
- Useful equations in support to hazardous area classification

The nationalized version of the IEC 60079-10-1 is published by ISA with National differences and IEC standard does not meet ISA standard in the sections identified above. However the nationalized version of the ISA standard is based on IEC standard Edition 1. The latest IEC standard has since been published with additional requirements. There are significant revisions in the latest edition of the IEC standard from previous editions in both technical content and design approach to classifying hazardous locations. These major changes in the latest edition of IEC 60079-10-1 have not yet been incorporated into the ISA standard.

3.8 ANSI/ISA 60079-11 vs IEC 60079-11 Explosive atmospheres – Part 11: Equipment Protection by Intrinsic Safety "i"

A comparative assessment of IEC 60079-11 (Ed. 6) and ISA 60079-11 (Ed. 6.2) was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. Table 10 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 10: ANSI/ISA 60079-11 vs IEC 60079-11 *Explosive atmospheres – Part 11: Equipment Protection by Intrinsic Safety "i"* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-11 (12.02.01) Ed. 6.2, 2014	International Standard EC 60079-11 Ed. 6.0, 2011-06	Analysis
Reference Standards	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet
Terms and definitions - internal wiring	3.11	3.11	Type 2 - Meets
Grouping and classification of intrinsically safe apparatus and associated apparatus	4	4	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-11 (12.02.01) Ed. 6.2, 2014	International Standard EC 60079-11 Ed. 6.0, 2011-06	Analysis
Voltage between conductive parts - Example of separation of conducting parts	Figure 2	Figure 2	Type 3 - Does Not Meet
Rating of components	7.1	7.1	Type 2 - Meets
Fuses	7.3	7.3	Type 3 - Does Not Meet
Current limiting resistor and its connecting tracks	7.3	7.3	Type 3 - Does Not Meet
Primary and secondary cells and batteries	7.4.1	7.4.1	Type 2 - Meets
Batteries used but not replaced in explosive atmospheres	7.4.8	7.4.8	Type 2 - Meets
Series current limiters	7.5.3	7.5.3	Type 3 - Does Not Meet
Marking	6.3.13 10.7 12.1 Annex F3.1	6.3.13 10.7 12.1 Annex F3.1	Type 2 - Meets

This is the common ANSI/ISA and ANSI/UL 60079-11 standard for *Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"*. ANSI/ISA 60079-11 is based on the sixth edition of IEC 60079-11 including Corrigendum 1. This standard adopts the IEC text with U.S. National Differences:

General – Following general modifications are noted in the ANSI/ISA 60079-11 when compared with the IEC standard:

- Where references are made to other IEC 60079-standards, the referenced requirements found in these standards shall apply as modified by any applicable U.S. National Differences.
- Where references are made to hazardous areas, this is changed to the U.S. terms unclassified locations or hazardous (classified) locations as appropriate.
- Where requirements call for the application of an "X" appended to the certificate number, this is replaced with a requirement to document this in the manufacturer's instructions.

3.8.1 Reference Standards

In ISA 60079-11, standards not adopted in U.S. have been deleted and replaced with applicable U.S. standards. Also, the following additional U.S. national standards for the equipment are included in the ISA standard:

UL746A, *Polymeric Materials B Short Term Property Evaluations, Fifth edition, (Edition Date November 1, 2000)*
IEC 60079-35-1, *Explosive atmospheres Part 35-1: Caplights for use in mines susceptible to firedamp — General requirements — Construction and testing in relation to the risk of explosion*
ANSI/UL 840, Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment
ANSI/UL 248 (all parts)-1, *Low-Voltage Fuses*

Additional references are in UL 60079-11 are to align with U.S. practice and the NEC, and implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC standard does not meet the requirement of the ISA standard.

3.8.2 Voltage between conductive parts

Figure 2 is provided in the standard as an example of separation of conducting parts. This figure has been modified in the ISA 60079-11 standard with national differences. In the IEC 60079-11 standard, it is indicated in the legend key that the dimensions are to be to general industry standards. However, in the ISA standard it indicates that the dimensions are to be in accordance with the details provided in Table 5 (Clearances, creepage distances and separations) or Annex F (Alternative separation distances for assembled printed circuit boards and separation of components) of the standard. It is noted that the requirements in ISA 60079-11 are more stringent than IEC standard, therefore IEC 60079-11 does not meet the requirement in ISA 60079-11.

3.8.3 Fuses

In IEC 60079-11 it is indicated that the Fuses do not have to conform to Table 5 or Annex F, which has requirements regarding clearances, creepage distances and separations. However, in ISA 60079-11 external creepage and clearance distance used for fuses are considered similar to any other creepage and clearance distances. It is noted that the requirements in the ISA standard are more stringent than IEC standard, therefore IEC 60079-11 does not meet the requirement in ISA 60079-11.

3.8.4 Current limiting resistor and its connecting tracks

ISA 60079-11 has a difference from the IEC 60079-11 that the creepage and clearance across the current limiting resistor and its connecting tracks is to comply with the requirements in Clause 6.3, which contains the general requirements for separation distances. It is to be noted that as per ISA 60079-11 the creepage and clearance distance is based on the maximum voltage at one end of the fuse and not the voltage dropped across the fuse. It is noted that the requirements in ISA standard are more stringent than IEC standard, therefore IEC 60079-11 does not meet the requirement in ISA 60079-11.

3.8.5 Series current limiters

In general IEC 60079-11 does not permit the use of semiconductors and controllable semiconductor devices as current-limiting devices for spark ignition limitation for Level of Protection “ia” apparatus. The use of these devices in areas classified as explosive atmosphere could result in ignition caused by the transients in the devices. However, for power limitation purposes, the IEC 60079-11 states that Level of Protection “ia” apparatus may use series current limiters consisting of controllable and non-controllable semiconductor devices. ISA 60079-11 requires additional condition to be met if “ia” apparatus uses series current limiters consisting of controllable and non-controllable semiconductor devices in Division 1. The conditions in the ISA standard that both the input and output circuits are to be intrinsically safe or it is to be demonstrated that the semiconductors or controllable semiconductor devices cannot be subjected to transients from the power supply network. It is noted that the requirements in ISA standard are more stringent than IEC standard, therefore the IEC 60079-11 does not meet the requirement in ISA 60079-11.

3.8.6 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-11 series meet, or does not meet the requirements of ISA 60079-11.

IEC 60079-11 ***meets*** the requirements outlined in the ISA 60079-11, in the following subject areas of:

- Terms and definitions
- Grouping and classification of intrinsically safe apparatus and associated apparatus
- Rating of components
- Primary and secondary cells and batteries
- Batteries used but not replaced in explosive atmospheres
- Marking

IEC 60079-11 ***does not meet*** the requirements outlined in the ISA 60079-11, in the following subject areas of:

- Reference Standards
- Voltage between conductive parts - Example of separation of conducting parts
- Fuses
- Current limiting resistor and its connecting tracks
- Series current limiters

The requirements in the ISA 60079-11 and IEC 60079-11 is the same except for the U.S. national differences in the ISA standard as detailed above. It can be concluded that due to these national differences the requirements in IEC 60079-11 do not meet the requirements in ISA 60079-11.

3.9 ANSI/ISA 60079-15 vs IEC 60079-15 Explosive atmospheres – Part 15: Equipment Protection by Type of Protection "n"

A comparative assessment of IEC 60079-15 (Ed. 4) and ISA 60079-15 (Ed. 4) was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. Table 11 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 11: ANSI/ISA 60079-15 vs IEC 60079-15 *Explosive atmospheres – Part 15: Equipment Protection by Type of Protection "n"* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-15 (12.12.02) Ed. 4, 2012	International Standard IEC 60079-15 Ed. 4, 2010-01	Analysis
Reference Standards	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet
Marking - several sections	6.3.1 6.3.2 8.8.3 13 20.2.7.2	6.3.1 6.3.2 8.8.3 13 20.2.7.2	Type 2 - Meets
Electric strength - Insulation from earth or frame	6.5.1	6.5.1	Type 3 - Does Not Meet
Electrical Connections	7.1	7.1	Type 3 - Does Not Meet
Pluggable connections	7.3.5	7.3.5	Type 2 - Meets
Supplementary requirements for non-sparking electrical rotating machines	8	8	Type 1 - Exceeds
Supplementary requirements for non-sparking electrical rotating machines - General	8.1	8.1	Type 2 - Meets
Alternative type test by calculation	8.10.2.3	8.10.2.3	Type 1 - Exceeds
External Plugs and sockets for external field wiring connections	10.1	10.1	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-15 (12.12.02) Ed. 4, 2012	International Standard IEC 60079-15 Ed. 4, 2010-01	Analysis
Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Cable glands	20.2.2.1	20.2.2.1	Type 3 - Does Not Meet
Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Conduit entries	20.2.2.2	20.2.2.2	Type 3 - Does Not Meet
Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Gasket and seal requirements	20.2.5	20.2.5	Type 3 - Does Not Meet
Luminaires	20.2.7.2.1	20.2.7.2.1	Type 2 - Meets
Tests for enclosed break equipment and non incendive components	22.4	22.4	Type 2 - Meets
Type Test for sealed components– Conditioning	22.5.1	22.5.1	Type 3 - Does Not Meet
Tests for sealed component	22.5	22.5	Type 2 - Meets
Electric strength test	23.2.1	23.2.1	Type 2 - Meets

This is the common ISA and UL standard 60079-15 *Explosive atmospheres – Part 15: Equipment protection by type of protection "n" (nC, nA and nR)*. This ISA standard is based on the fourth edition of IEC 60079-15. This standard adopts the IEC text with U.S. National Differences.

The latest version of the IEC standard 60079-15 (Ed. 5) was published on 8 Dec 2017. IEC 60079-15:2017 (Ed. 5) specifies requirements for the construction, testing and marking for Group II electrical equipment with type of protection "n" which includes; sealed devices "nC", hermetically sealed devices "nC", non-incendive components "nC" and restricted breathing enclosures "nR" intended for use in explosive gas atmospheres. The requirement for "nA" protection have been relocated from IEC 60079-15 to IEC 60079-7 (edition 5.0). Former marking of "nA" has been replaced by marking "ec".

3.9.1 Reference Standards

In ISA 60079-15, standards not adopted in U.S. have been deleted and replaced with applicable U.S. standards. Also, additional U.S. national standards for the equipment are included in the ISA standard. The following additional references are provided in the ISA standard to align with U.S. practice and the NEC:

ANSI/NFPA 70, *National Electrical Code*
ANSI/UL 248-1, Low-Voltage Fuses - Part 1: *General Requirements*
ANSI/UL 486A-486B, *Wire Connectors*
ANSI/UL 486E, *Standard for Safety Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors*
ANSI/UL 746A, *Standard for Polymeric Materials - Short Term Property Evaluations*
ANSI/UL 1598, *Standard for Safety Luminaires*
ANSI/UL 60947-7-1, *Standard for Safety for Low-Voltage Switchgear and Controlgear Part 7-1: Ancillary Equipment Terminal Blocks for Copper Conductors*
ANSI/UL 60947-7-2, *Standard for Safety Low-Voltage Switchgear and Controlgear Part 7-2: Ancillary Equipment Protective Conductor Terminal Blocks for Copper Conductors*
UL 2237, *Multi-Point Interconnection Power Cable Assemblies for Industrial Machinery*
UL 2238, Cable Assemblies and Fittings for Industrial Control and Signal Distribution

Additional references are in ISA 60079-11 are to align with U.S. practice and the NEC, and implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC standard does not meet the requirement of the ISA standard.

3.9.2 Electric strength - Insulation from earth or frame

ISA 60079-15 has included a difference that the normal Dielectric Strength Test voltage is to be based upon the applicable industrial standard for the individual items of electrical equipment where such requirements exists. IEC 60079-15 does not have a similar requirement. It can be concluded that the IEC 60079-15 does not meet the requirements of ISA 60079-15 regarding the verification of requirement of electrical equipment for requirements in the applicable industry standard.

3.9.3 Electrical Connections

Electrical connections can be field or factory wiring and can also be divided into permanent or re-connectable types. ISA 60079-15 has a national difference included in the requirements for electrical connections. ISA 60079-15 requires that the electrical connection should be able to provide contact pressure that is not applied through the insulating material. However, the IEC standard allows the contact pressure to be applied through the insulating material if earth continuity test of IEC 60079-0 is accomplished. The UL standards for ordinary locations do not permit the transfer of contact pressure through insulating material. Therefore, it is concluded that IEC 60079-15 does not meet the requirements of ISA 60079-15 for electrical connections.

3.9.4 Supplementary requirements for non-sparking electrical rotating machines

In Clause 8 of ISA 60079-15, a note is added to indicate that some general purpose induction motors are permitted by Article 505 of the NEC. It is noted that similar statement is not included in the IEC standard. Therefore, it can be concluded that the requirements in IEC 60079-15 exceed the requirements in ISA 60079-15 with regard to non-sparking electrical rotating machines

3.9.5 Alternative type test by calculation - Operation with a frequency convertor or a non-sinusoidal supply

It is required that motors supplied at varying frequency and voltage by a convertor shall be tested with the specified convertor, or with a comparable convertor in reference to the output voltage and current specifications. Both IEC and ISA 60079-15 have provided an alternative to this type test requirement that the temperature class could be determined by calculation. When used to determine the temperature class by calculation, it is stated in the standard that it can be based on the previous representative test data and in accordance with IEC 60034-25.

In Clause 8.10.2.3 of IEC 60079-15 an additional note is included, which states that special attention is to be paid to the rotor temperature for machine operating with a non-sinusoidal supply and is to be considered as a limiting feature of the machine. This is due to the fact that the temperature differential between stator and rotor of a machine operating with a non-sinusoidal supply vary greatly from that of the machine operating with a sinusoidal supply. It is noted that this additional note included in IEC standard is for guidance. It is concluded that IEC 60079-15 exceeds ISA 60079-15 in this regard.

3.9.6 External Plugs and sockets for external field wiring connections

ISA 60079-15 adds several additional requirements in Clause 10.1 regarding plugs and sockets for external field wiring connections in potentially incendive circuits. Additional requirements for protection against unintentional separation plugs and sockets is included in the ISA standard. Also, per ISA 60079-15 plugs and sockets must be capable of being connected to wiring methods such as extra-hard usage cord (NEC Articles 400, 501), instrumentation tray cable (Type ITC) (NEC Article 727), power-limited tray cable (Type PLTC) (NEC Article 725). ISA 60079-15 also requires cable assemblies and the associated separate plugs and sockets shall be in accordance with UL 2238 *Standard for Cable Assemblies and Fittings for Industrial Control and Signal Distribution or* UL 2237*, "Multi-Point Interconnection Power Cable Assemblies for Industrial Machinery"*. These additional requirements are not included in IEC

60079-15. Therefore, it is concluded that IEC 60079-15 does not meet the requirements of ISA 60079-15 regarding external wiring connections.

3.9.7 Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Cable glands

It is required by ISA 60079-15 that only flameproof “d” cable glands are recognized by the NEC and are to be used where cable glands are integral or separate part of the enclosure. However, IEC 60079-15 only requires that the cable gland be tested as part of the enclosure if it is integral with the enclosure; and where the cable glands are separate, it is required to be evaluated to type of protection “nR”. ISA 60079-15 has more stringent requirements for cable glands. It is concluded that IEC 60079-15 does not meet the requirements of ISA 60079-15 regarding requirements for cable glands.

3.9.8 Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Conduit entries

ISA 60079-15 has additional requirements that “installation instructions must specify that all conduit entries used for field wiring connections be sealed with an explosion proof or flameproof conduit seals at the time of the installation”. IEC 60079-15 only requires that the conduit entries be sealed and do not require them to be explosion proof. It is concluded that IEC 60079-15 does not meet the requirements of ISA 60079-15 regarding requirement for conduit entries.

3.9.9 Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Gasket and seal requirements

ISA 60079-15 has an additional requirement that the resilient gasket seals are to comply with gasket retention requirements per ISA-60079-0. The IEC standard does not have such requirement. It is concluded that IEC 60079-15 does not meet the requirements of ISA 60079-15 regarding requirement for gasket seals.

3.9.10 Type Test for sealed components– Conditioning

IEC 60079-15 indicates that three samples of the components be conditioned for testing. However, it is not clearly stated in the IEC standard that all three samples are required to be tested. In ISA 60079-15 additional clarification is added that the three samples must be tested to all the required type tests. It is concluded that IEC 60079-15 does not meet the requirements of ISA 60079-15 regarding type testing.

3.9.11 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-15 series meet, exceed, or does not meet the requirements of ISA 60079-15.

IEC 60079-15 ***meets*** the requirements outlined in the ISA 60079-15, in the following subject areas of:

- Marking

- Pluggable connections
- Supplementary requirements for non-sparking electrical rotating machines – General operating condition
- Luminaires
- Tests for enclosed break equipment and non incendive components
- Tests for sealed component
- Electric strength test

IEC 60079-15 ***does not meet*** the requirements outlined in the ISA 60079-15, in the following subject areas of:

- Reference Standards
- Electric strength - Insulation from earth or frame
- Electrical Connections
- External Plugs and sockets for external field wiring connections
- Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces
  - Cable glands
  - Conduit entries
  - Gasket and seal requirements
- Type Test for sealed components– Conditioning

IEC 60079-15 ***exceeds*** the requirements outlined in the ISA 60079-15, in the following subject areas of:

- Supplementary requirements for non-sparking electrical rotating machines – in Zone 2 location
- Alternative type test by calculation - Operation with a frequency convertor or a non-sinusoidal supply

The requirements in the ISA 60079-15 and IEC 60079-15 is the same except for the U.S. national differences in the ISA standard as detailed above. It can be concluded that due to these national differences the requirements in IEC 60079-15 does not meet the requirements in ISA 60079-15.

3.10 ANSI/UL 60079-18 vs IEC 60079-18 Explosive atmospheres – Part 18: Equipment Protection by Encapsulation "m"

A comparative assessment of IEC 60079-18 (Ed. 4) and UL 60079-18 (Ed. 4) was conducted to determine if the IEC standard meets, exceeds or does not meet the UL-standard. Table 12 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 12: ANSI/ISA 60079-18 vs IEC 60079-18 *Explosive atmospheres – Part 18: Equipment Protection by Encapsulation "m"* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/UL 60079-18 Ed. 4, December 14, 2015	International Standard IEC 60079-18 Ed. 4, 2014-12	Analysis
Reference Standards	1. Scope 2. References 7.1 7.6.2 7.8.5 7.9.3 9.2	1. Scope 2. References 7.1 7.6.2 7.8.5 7.9.3 9.2	Type 2 - Meets
Water absorption	5.3.1	5.3.1	Type 2 - Meets
Marking	10	10	Type 2 - Meets

UL-60079-18 is based on IEC 60079-18 with U.S. National Differences. In UL 60079-18 standard, where references are made to other IEC 60079-standards, the referenced requirements found in these standards is replaced with applicable U.S. standards. Also, the following additional U.S. national standards for the equipment are included in the UL standard.

ASTM-11, *Specification for Wire Cloth and Sleves for Testing Purposes*
UL 60691, *Thermal-links- Requirements and application guide*
UL 60730-2-9, *Automatic electrical controls tor household and similar* use- *Part 2-9: Particular requirements tor temperature sensing controls*

Even though these additional references are included in the UL 60079-18 Standard, there is no impact on the safety of the equipment. As such the requirement in IEC 60079-18 is considered to meet UL 60079-18 for equipment in explosive gas atmosphere.

3.10.1 Summary and Conclusion

Based on the comparative assessments in the above sections, overall, for Group II protection type, there are no major differences between the IEC 60079-18 and UL 60079-18.

3.11 ANSI/ISA 60079-25 vs IEC 60079-25 Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems

A comparative assessment of IEC 60079-25 (Ed. 2) and ISA 60079-25 was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. Table 13 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 13: ANSI/ISA 60079-25 vs IEC 60079-25 Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-25 (12.02.05)-2011	International Standard IEC 60079-25 Ed. 2, 2010-02	Analysis
Reference Standards	1. Scope 2. References Throughout the standard	1. Scope 2. References Throughout the standard	Type 3 - Does Not Meet
Terms and definitions	3.1.3	3.1.3	Type 2 - Meets
Interconnecting wiring / cables used in an intrinsically safe electrical system	8	8	Type 3 - Does Not Meet
Requirements of cables and multi-conductor cables	9.1	9.1	Type 3 - Does Not Meet
Earthing and bonding of intrinsically safe systems	11	11	Type 2 - Meets
Protection against lightning and other electrical surges	12	12	Type 3 - Does Not Meet
Assessment of an intrinsically safe system	13.1	13.1	Type 2 - Meets
Predefined systems	15	15	Type 3 - Does Not Meet
Normative Annex B - Assessment of circuits with more than one source of power	Annex B	Annex B	Type 3 - Does Not Meet
Informative Annex C - Interconnection of non-linear and linear intrinsically safe circuits	Annex C	Annex C	Type 3 - Does Not Meet
Testing of cable electrical parameters	Annex G	Annex G	Type 2 - Meets
Normative Annex I - FISCO systems	Annex I	Annex I	Type 3 - Does Not Meet

ISA-60079-25 is based on the second edition of IEC 60079-25. This standard adopts the IEC text with U.S. National Differences. This standard contains the specific requirements for construction and assessment of intrinsically safe electrical systems, type of protection “i”.

3.11.1 Reference Standards

In ISA 60079-25 standard, where references are made to other IEC 60079-standards, the referenced requirements found is replaced with applicable U.S. standards. Also, the following additional U.S. national standard is included in ISA-60079-25 with additional references to align with U.S. practice and the NEC.

ANSI/NFPA 70:2011*, National Electrical Code*

Additional U.S. standards referenced in the ISA standard implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC standard does not meet the requirement of the ISA standard.

In ISA 60079-25, where references are made to:

- Hazardous areas, this is changed to the U.S. terms unclassified locations or hazardous (classified) locations as appropriate. Where reference is made to term “certified”, this is replaced with to “listed”. Where reference is made to term "core", this is replaced with "conductor".
- Locations in which the use of Group I, II or III apparatus is required, this is changed to Class I, Zone 0, 1, or 2, or Zone 20, 21, or 22 hazardous (classified) locations as defined by the NEC.

For installation requirements, reference to IEC 60079-14 (Electrical installations design, selection and erection) is replaced with the NEC in ISA 60079-25. It is also to be noted that ISA 60079-10-1 has indicated that IEC 60079-14 has not been adopted for use in the U.S.

Therefore, it is concluded that the IEC 60079-25 does not meet the requirements of ISA 60079-25.

3.11.2 Interconnecting wiring / cables used in an intrinsically safe electrical system

ISA-60079-25 references NEC Article 504.10 requirements regarding installation of intrinsically safe wiring. This is a U.S. national difference from the IEC standard which requires following the NEC requirements for intrinsically safe wiring. Therefore, it can be concluded that IEC 60079-25 does not meet the requirement of the ISA standard.

3.11.3 Requirements of cables and multi-conductor cables

Both IEC and ISA 60079-25 standards requires that descriptive system documents be created for all intrinsically safe systems and the documents should provide an adequate analysis of the safety achieved by the system. The minimum requirements for this document is included in Clause 4 of the standards. In Clause 9.1, ISA-60079-25 requires cables information, such as the diameter of individual conductors within hazardous area must be not less than 0.1 mm, be included in the document. The difference in the ISA standard pertains to the cable information that is to be included in the descriptive document. In Clause 9.2, the radial thickness of the insulation of each conductor in a multi conductor cable is changed to 0.25 mm in ISA 60079-25, whereas it is 0.2 mm in IEC 60079-25. The change in ISA standard to 0.25 mm is to align with NEC Article 504 requirements for Intrinsically Safe Circuit Conductors. Therefore, it is concluded that IEC standard does not meet the requirement of the ISA standard. However, this difference does not have major impact on the safety of the system.

3.11.4 Protection against lightning and other electrical surges

With regard to the requirements for surge protection devices, both the IEC and ISA 60079-25 have included several requirements. Both standards require that the surge protection device introduced into an intrinsically safe circuit shall be suitably explosion protected for its intended location. However ISA-60079-25 has a national difference which requires that the device is also to comply the applicable ordinary location standards. It is not a requirement in IEC standard that the device be verified for requirements in ordinary location standards. It can be concluded that the IEC 60079-25 does not meet the requirements of ISA 60079-25 to meet ordinary location standards.

3.11.5 Predefined systems

Clause 15 of both ISA and IEC 60079-25 defines the predefined system, where the system and all individual devices are predefined and previously assessed. For such systems the assessment standards can be simplified. One example of such system is Fieldbus Intrinsically Safe Concept (FISCO) systems. Assessment for FISCO System is included in Annex I of the standard. In ISA-60079-25, reference is made to ANSI/ISA 60079-27 *Fieldbus intrinsically safe concept (FISCO) and Fieldbus non-incendive concept (FNICO)* for requirements for FISCO Power Supplies, Field Devices, and Terminators. Comparative analysis of ISA 60079-27 and IEC 60079-27 is provided in section 3.13 of this report. It is concluded that IEC 60079-25 does not meet the requirement of ISA 60079-25 for predefined systems.

3.11.6 Normative Annex B - Assessment of circuits with more than one source of power Informative Annex C - Interconnection of non-linear and linear intrinsically safe circuits

In ISA-60079-25, the reference to IEC 60079-14 is removed. IEC 60079-25 references IEC 60079-14 and permits assessment in accordance with the IEC 60079-14 as an alternative to assessment requirements in Annex B. IEC 60079-25 Annex C references IEC 60079-14 and indicates that the installation rules in IEC 60079-14 permit the operator to combine several intrinsically safe circuits by interconnection. IEC 60079-14:2013 contains the specific requirements for the design, selection, erection and initial inspection of electrical installations in, or associated with, explosive atmospheres. It is also to be noted that ISA 60079-10-1 has indicated that IEC 60079-14 has not been adopted for use in the U.S. Therefore, it is concluded that the IEC 60079-25 does not meet the requirements of ISA 60079-25.

3.11.7 Normative Annex I - FISCO systems

With regard to the requirement for safety documentation for FISCO system, the IEC standard allows the use of simplified list of the equipment. In ISA-60079-25, this requirement has been deleted as part of the national differences, therefore does not meet the ISA standard. However, the difference does not have any major impact on the safety of the systems.

3.11.8 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-25 series meet, or does not meet the requirements of ISA 60079-25.

IEC 60079-25 ***meets*** the requirements outlined in the ISA 60079-25, in the following subject area of:

- Terms and definitions
- Earthing and bonding of intrinsically safe system
- Assessment of an intrinsically safe system
- Testing of cable electrical parameters

IEC 60079-25 ***does not meet*** the requirements outlined in the ISA 60079-25 standard, in the following subject area of:

- Reference Standards
- Interconnecting wiring / cables used in an intrinsically safe electrical system
- Requirements of cables and multi-conductor cables
- Protection against lightning and other electrical surges
- Predefined systems
- Normative Annex B - Assessment of circuits with more than one source of power
- Informative Annex C - Interconnection of non-linear and linear intrinsically safe circuits
- Normative Annex I - FISCO systems

The requirements in the ISA 60079-25 and IEC 60079-25 is the same except for the U.S. national differences in the ISA standard as detailed above. It can be concluded that due to these national differences the requirements in IEC 60079-25 do not meet the requirements in ISA 60079-25.

3.12 ANSI/UL 60079-26 vs IEC 60079-26 Explosive Atmospheres - Part 26: Electrical Apparatus for Use in Class I, Zone 0 Hazardous (Classified) Locations

A comparative assessment of IEC 60079-26 (Ed. 3) and UL 60079-26 (Ed. 3) was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. Table 14 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 14: ANSI/UL 60079-26 vs IEC 60079-26 *Explosive Atmospheres - Part 26: Electrical Apparatus for Use in Class I, Zone 0 Hazardous (Classified) Locations* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/UL 60079-26 Ed. 3, April 21, 2017	International Standard IEC 60079-26 Ed. 3, 2014-10	Analysis
Scope	1	1	Type 3 - Does Not Meet
Reference Standards	2	2	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard ANSI/UL 60079-26 Ed. 3, April 21, 2017	International Standard IEC 60079-26 Ed. 3, 2014-10	Analysis
Protection measures against ignition hazards of the electrical circuits	4.1.1	4.1.1	Type 2 - Meets
Application of two independent Types of Protection providing EPL Gb	4.1.2	4.1.2	Type 3 - Does Not Meet
Partition walls	4.1.3.2	4.1.3.2	Type 1 - Exceeds
Table 1 – Separation elements	Table 1	Table 1	Type 2 - Meets
Example of a separation element with a cylindrical shaft joint and natural ventilation	Figure 2	Figure 2	Type 2 - Meets
Type Test	5.1	5.1	Type 3 - Does Not Meet
Marking	6.1	6.1	Type 3 - Does Not Meet

UL 60079-26 is based on the third edition of IEC 60079-26 with U.S. National Differences. The following general modifications are noted in the UL standard when compared with the IEC standard:

3.12.1 Reference Standards

In UL 60079-26 standard, where references are made to other IEC 60079-standards, the referenced requirements found is replaced with applicable U.S. standards. Also, following additional U.S. national standards for the equipment are included in the UL 60079-26 with additional references to align with U.S. practice and the NEC.

ANSI/IEC 60529. *Degrees of Protection provided by enclosure IP Code*
NFPA 70, *National Electrical Code*
UL 60079-0 *Explosive atmospheres - Part 0: Equipment - General requirements*
UL 60079-1 *Explosive atmospheres- Part 1: Equipment protection by flameproof enclosures "d"*
UL 60079-11 *Explosive atmospheres- Part 11: Equipment protection by intrinsic safety "f"*
UL 94 *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

Additional U.S. standards referenced in the ISA standard implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC standard does not meet the requirements of the UL standard.

3.12.2 Scope

In both UL and IEC 60079-26 it specifies that the scope covers alternative requirements for construction, test and marking for electrical equipment mounted across a boundary where different equipment protection levels may be required. In addition in the IEC standard, it is noted that the standard also specifies alternative requirements for construction, test and marking for electrical equipment that provide EPL Ga when single standardized type of protection (e.g. “ia”) cannot be applied. This additional scope included in IEC standard is not included in UL standard as it is not allowed in U.S. Therefore, it is concluded that IEC 60079-26 does not meet the requirements of UL 60079-26.

3.12.3 Application of two independent Types of Protection providing EPL Gb

IEC 60079-26 requires that equipment should comply with the requirements of Clauses 4.1.2 or 4.1.3 in the event of failure of one of the equipment means of protection, by the provision of a second means of protection. Clause 4.1.2 describes the application of two independent types of protection providing EPL Gb which is intended to be installed in area requiring EPL Ga. This section requires that the electrical equipment is to comply with requirements of two independent types of protection that provide EPL Gb. If one protection fails, the other type should continue to function. Clause 4.1.3 describes the application of the type of protection providing EPL Gb and a separation element. In the U.S. nationalized standard UL 60079-26, Clause 4.1.2 is not included. The application of two independent types of protection providing EPL Gb in area required by EPL Ga is not allowed as per U.S. standards. Therefore, it is concluded that IEC 60079-26 does not meet the requirements of UL 60079-26.

3.12.4 Partition walls

A partition wall is the mechanical element that separates the different parts of equipment with different Equipment Protection Levels. IEC 60079-26 requires that the partition wall be constructed of corrosion-resistant metals, glass, ceramics or other material with equivalent level of safety. It is also required by the standard that this is to be indicated in the certificate by “X” marking.

In UL 60079-26, the requirement regarding the materials to be used for the partition wall has been removed. The standard still requires the indication of any special conditions of use in the certificate. It is noted that IEC 60079-26 provides more detailed requirements regarding the materials of partition walls, however UL 60079-26 does not appear to have any specific requirement. Therefore the IEC 60079-26 exceeds requirements of the UL 60079-26 for partition walls.

3.12.5 Type Test

IEC 60079-26 has specific requirement for type testing for two independent types of protection providing EPL “Gb” as per Clause 4.1.2. This Clause is not included in UL 60079-26 as this type of protection is not applicable. Therefore, IEC 60079-26 does not meet the type test requirements of UL 60079-26.

3.12.6 Marking

IEC Differences in the marking requirements between UL 60079-26 and IEC 60079-26 is discussed in detail in Section 4 of this report.

3.12.7 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-26 series meet, exceed, or does not meet the requirements of UL 60079-26 standard.

IEC 60079-26 ***meets*** the requirements outlined in the UL 60079-26, in the following subject area of:

- Protection measures against ignition hazards of the electrical circuits
- Table 1 – Separation elements
- Example of a separation element with a cylindrical shaft joint and natural ventilation

IEC 60079-26 ***does not meet*** the requirements outlined in the UL 60079-26 standard, in the following subject area of:

- Scope
- Reference Standards
- Application of two independent Types of Protection providing EPL Gb
- Type Test
- Marking

IEC 60079-26 ***exceeds*** the requirements outlined in the UL 60079-26 standard, in the following subject areas of:

- Partition walls

The requirements in the ISA 60079-26 and IEC 60079-26 are the same except for the U.S. national differences in the UL standard as detailed above. It can be concluded that due to these national differences the requirements in IEC 60079-26 do not meet the requirements in UL 60079-26.

3.13 ANSI/ISA 60079-27 vs IEC 60079-27 Explosive Atmospheres - Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)

A comparative assessment of the first editions of IEC 60079-27 and ISA 60079-27 was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. Table 15 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 15: ANSI/ISA 60079-27 vs IEC 60079-27 *Explosive Atmospheres - Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-27 Ed. 1, (12.02.04)-2006	International Standard IEC 60079-27 Ed. 1, 2005-04	Analysis
Reference Standards	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet
Terms and definitions - control drawing	3.4	NA	Type 3 - Does Not Meet
Power supplies - General	4.1	4.1	Type 2 - Meets
FNICO field devices	5.3 c 7.3	5.3 7.3	Type 2 - Meets
System requirements	7.1. 7.3	7.1. 7.3	Type 3 - Does Not Meet
Marking	8.2	8.2	Type 3 - Does Not Meet

ISA 60079-27 is based on the first edition of IEC 60079-27 and adopts the IEC text with U.S. National Differences. This standard contains the details of apparatus, systems and installation practice for use with the Fieldbus Intrinsically Safe Concept (FISCO) for installation and use in Class I, Zones 0 and 1 and the Fieldbus Non-Incendive Concept (FNICO) for installation and use in Class I, Zone 2.

3.13.1 Reference Standards

In ISA 60079-27, where references are made to other IEC 60079-standards, the referenced standards are replaced with applicable U.S. standards. The following additional U.S. national standards are included in ISA 60079-27 to align with U.S. practice and the NEC.

> ANSI/NFPA 70:2005, *National Electrical Code*
>
> ISA-RP12.02.02, *Recommendations for the Preparation, Content, and Organization of Intrinsic Safety Control Drawings*

In ISA 60079-27 standard, where references are made to hazardous areas, this is changed to the U.S. terms unclassified locations or hazardous (classified) locations as appropriate. Where references are made to FISCO, this is modified to include to (FISCO) for installation and use in Class I, Zones 0 and 1. Where references are made to FNICO, this is modified to include to (FNICO) for installation and use in Class I, Zone 2.

Additional references are included in ISA standard to align with U.S. practice and the NEC, and implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC standard does not meet the requirements of the ISA standard.

3.13.2 Terms and definitions - control drawing and & System Requirements

With regard to the requirement for Safety documentation for FISCO system, IEC 60079-27 allows the use of simplified list of the equipment. In ISA 60079-27 “control drawing” is used to represent the drawing or document provided by the manufacturer that details the allowed interconnections between the intrinsically safe and associated apparatus or between the non incendive field wiring and associated nonincendive field wiring apparatus. As per ISA 60079-27, the control drawing must comply with the applicable requirements of ISA-RP12.02.02. This requirement is not included in IEC 60079-27. Instead of control drawing, IEC 60079-27 refers to apparatus documentation, however, is not required to comply with any national standards. It is concluded that IEC Standard does not meet ISA standard in this regard. However, the differences does not have any major impact on the safety of the systems.

3.13.3 Marking

Differences in the marking requirements between ISA 60079-27 and IEC 60079-27 is discussed in detail in Section 4 of this report.

3.13.4 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-27 series meet, or does not meet the requirements of ISA 60079-27.

IEC 60079-27 ***meets*** the requirements outlined in the ISA 60079-27, in the following subject area of:

- Power supplies – General
- FNICO field devices

The IEC 60079-27 ***does not meet*** the requirements outlined in the ISA 60079-27, in the following subject area of:

- Reference Standards
- Terms and definitions - control drawing
- System requirements
- Marking

The requirements in the ISA 60079-27 and IEC 60079-27 are the same except for the U.S. National Differences in the ISA standard as detailed above. It can be concluded that due to these national differences the requirements in IEC 60079-27 do not meet the requirements in ISA 60079-27.

3.14 ANSI/ISA 60079-29-1 vs IEC 60079-29-1 Explosive atmospheres – Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases

A comparative assessment of the first editions of IEC 60079-29-1 and ISA 60079-29-1 (12.13.01) was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. Table 16 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard.

Table 16: ANSI/ISA 60079-29-1 vs IEC 60079-29-1 *Explosive atmospheres – Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-1 (12.13.01) Ed. 1, 2013	International Standard IEC 60079-29-1 Ed. 1, 2010-01	Analysis
Reference Standards	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet
Scope	1	1	Type 2 - Meets
Ambient Temperature	4.1.2	4.1.2	Type 2 - Meets
Indicating devices	4.2.2.1	4.2.2.1	Type 2 - Meets
Indicating devices – Fault Signals	4.2.4	4.2.4	Type 3 - Does Not Meet
Labelling and marking	4.3	4.3	Type 3 - Does Not Meet
Instruction manual	4.4	4.4	Type 3 - Does Not Meet
Samples and sequence of tests - General	5.2.1.1	5.2.1.1	Type 2 - Meets
IR-sensors using optical filters	5.2.1.1	5.2.1.1	Type 1 - Exceeds
Test Methods – Sample and sequence of tests	5.2.1.2	5.2.1.2	Type 3 - Does Not Meet
Standard test gas	5.3.3	5.3.3	Type 2 - Meets
Test - Pressure	5.3.7	5.3.7	Type 3 - Does Not Meet
Calibration and Adjustment - Calibration curve (accuracy)	5.4.3.2	5.4.3.2	Type 3 - Does Not Meet
Long-term stability (fixed and transportable apparatus – Group II only)	5.4.4.4	5.4.4.4	Type 3 - Does Not Meet
Alarm set point(s) - General	5.4.6	5.4.6	Type 2 - Meets
Humidity	5.4.9	5.4.9	Type 1 - Exceeds
Time of response (not applicable to spot-reading apparatus)	5.4.16	5.4.16	Type 3 - Does Not Meet
High gas concentration operation above the measuring range	5.4.18	5.4.18	Type 3 - Does Not Meet
Short interruption of power supply	5.4.21.2	5.4.21.2	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-1 (12.13.01) Ed. 1, 2013	International Standard IEC 60079-29-1 Ed. 1, 2010-01	Analysis
Voltage transients	5.4.21.3	5.4.21.3	Type 2 - Meets
Electromagnetic immunity	5.4.25	5.4.25	Type 3 - Does Not Meet
Fault signals	5.4.28	No equivalent requirements in IEC 60079-29-2-1	Type 3 - Does Not Meet
Verification of ingress protection claims	5.4.29	No equivalent requirements in IEC 60079-29-2-1	Type 3 - Does Not Meet
Performance requirements	Annex A	Annex A	Type 3 - Does Not Meet

ISA 60079-29-1 is based on the first edition of IEC Publication 60079-29-1. The document is a modification of the IEC standard and includes U.S. National Differences encompassing both additions and deletions of information. This standard provides guidance for the selection, installation, use and maintenance of gas detecting apparatus as set out in ANSI/ISA-60079-29-2*: Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen*.

3.14.1 Reference Standards

In ISA 60079-29-1 where references are made to other IEC 60079-standards, the referenced standards are replaced with applicable U.S. standards. The following additional U.S. national standards for the equipment are included in the ISA 60079-29-1 to align with U.S. practice and the NEC.

> ANSI/NFPA 497: *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installation in Chemical Process Areas*
> ANSI/NFPA 70: *National Electrical Code®*
> ANSI/IEC 60529*: Degrees of protection provided by enclosures (IP)*

Additional references are included in ISA standard to align with U.S. practice and the NEC, and implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC standard does not meet the requirements of the ISA standard.

3.14.2 Indicating devices – Fault Signals

Both ISA and IEC 60079-29-1 require that an indication is provided to show that the gas detection apparatus is energized. ISA 60079-29-1 has further clarified that the indicating devices could be through software annunciation, computer displays, sirens etc. and the indications should be distinguishable between alarms, faults and power failure. ISA 60079-29-1 also requires that for under range values at or below 10%, the indicating devices should indicate a fault condition. IEC 60079-29-1 does not have these additional requirements, therefore does not meet the requirements in ISA 60079-29-1 with regard to the indication of fault signals.

3.14.3 Labelling and marking

Differences in the marking requirements between ISA 60079-29-1 and IEC 60079-29-1 is discussed in detail in Section 4 of this report.

3.14.4 Instruction Manual

ISA 60079-29-1 requires that the details of claimed performance and special features of construction also be included in the instruction manual. IEC 60079-29-1 does not have these additional requirements. Although the IEC standard does not meet ISA 60079-29-1 in this regard, there is no major impact of the safety of the equipment.

3.14.5 IR-sensors using optical filters

ISA 60079-29-1 requirements for IR sensor test using optical filters for response to different gases has been deleted as part of national differences since special filter production by the manufacturer and filter validation by the test laboratory is impractical. This is a national difference in the ISA standard where the requirements is less stringent compared with IEC 60079-29-1. Therefore the requirement in IEC 60079-29-1 exceeds the requirement in ISA 60079-29-1.

3.14.6 Test Methods – Sample and sequence of tests

ISA 60079-29-1 added a national difference that requires all tests be carried out on one apparatus, except for certain tests, and that tests be conducted in a specific sequence. Samples and sequence of tests requirements include drop and vibration tests as pre-conditioning tests along with unpowered storage since these pre-conditioning tests may have an adverse effect on the equipment's ability to pass subsequent test requirements. These additional testing requirements are not included in IEC 6079-29-1, therefore it can be concluded that IEC 60079-29-1 does not meet the testing requirements in ISA 60079-29-1.

3.14.7 Test - Pressure

ISA 60079-29-1 provides additional clarification on the test procedure for ambient pressure to the IEC Clause. It is clarified in ISA 60079-29-1 that the pressure reading must be recorded at the beginning of each short-term test (< 24 hrs); and for long-term tests, the pressure reading must be recorded at the beginning of test and at each time performance data is recorded. These additional details are not included in IEC 60079-29-1. Therefore it can be concluded that IEC 60079-29-1 does not meet the testing requirements in ISA 60079-29-1. It is to be noted that the difference has no major impact on the safety of the equipment.

3.14.8 Calibration and Adjustment - Calibration curve (accuracy)

Calibration curve/accuracy requirements in ISA 60079-29-1 include a 10% measuring range test in order to establish minimum detection accuracy at low range. This additional detail is not included in IEC 60079-29-1. It can be concluded that IEC 60079-29-1 does not meet ISA 60079-29-1 for calibration and adjustment test methods.

3.14.9 Long-term stability (fixed and transportable apparatus – Group II only)

Long-term stability requirements in ISA 60079-29-1 have included the calibration curve/accuracy test in accordance with existing U.S. practice since the standard allows a separate sample to be used for the test which necessitates verification of proper functionality of the apparatus prior and at the conclusion of test**.** This additional detail is not included in IEC 60079-29-1. It can be concluded that IEC 60079-29-1 does not meet ISA 60079-29-1 for long-term stability test methods.

3.14.10 Humidity

Humidity requirements in ISA 60079-29-1 have been restructured for administering the test in accordance with past U.S. practice for ease of administering the test to the minimum level requirements of the standard. The humidity test requirement in IEC 60079-29-1 is more stringent. It can be concluded that IEC 60079-29-1 exceeds the requirements of ISA 60079-29-1 for humidity test methods.

3.14.11 Time of response (not applicable to spot-reading apparatus)

Response time requirements have been modified in ISA 60079-29-1 to include testing with claimed accessories which could directly affect response and recovery time used for proper product selection. This additional detail is not included in IEC 60079-29-1. It can be concluded that IEC 60079-29-1 does not meet ISA 60079-29-1 for time of response test methods.

3.14.12 High gas concentration operation above the measuring range

In ISA 60079-29-1, the test for the high gas concentration operation above the measuring range test is modified. It is required by ISA 60079-29-1 that if the gas detection system is provided with a latching alarm feature, then it must be verified upon application of the high gas concentration operation. A latching alarm means that when an alarm is activated, deliberate action is required to deactivate the alarm. Similar requirement is not included in IEC 60079-29-1 standard. It can be concluded that IEC 60079-29-1 does not meet ISA 60079-29-1 for the test for high gas concentration operation above the measuring range test methods.

3.14.13 Electromagnetic immunity

ISA 60079-29-1 references ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories* regarding electromagnetic compatibility (EMC) testing verification by testing laboratory. It is required that the testing be verified and documented by an ISO/IEC 17025 accredited test laboratory. This additional requirement is not included in IEC 60079-29-1. It can be concluded that IEC 60079-29-1 does not meet ISA 60079-29-1 for electromagnetic immunity test methods.

3.14.14 Fault signals

ISA 60079-29-1 has an additional Clause, as a national difference, for fault signals requirements, such as power failure, open and short-circuit in connections, under range values, and flow failure. IEC 60079-29-1 does not include this Clause, therefore does not meet the requirements of ISA 60079-29-1 with regard to the indication of various fault signals.

3.14.15 Verification of ingress protection claims

ISA 60079-29-1 has an additional Clauses, as a national difference, for dust proof requirements and water proof protection as per ANSI/IEC 60529 *Degrees of Protection Provided by Enclosures (IP Code)*. IEC 60079-29-1 does not include these Clauses, therefore does not meet the requirements of ISA 60079-29-1 with regard to verification of ingress protection claims.

3.14.16 Performance requirements

ISA 60079-29-1 modifies the IEC text in Annex A, Table A.1 – Performance requirements to include the U.S. national differences that include additional requirements in test methods. Major changes include the addition of test requirements for fault signals and environmental exposure (IP testing) tests. IEC 60079-29-1 does not include the additional requirements, therefore does not meet the requirements of ISA 60079-29-1 with regards to performance requirements.

3.14.17 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-29-1 series meet, exceed, or does not meet the requirements of ISA 60079-29-1.

The IEC 60079-29-1 ***meets*** the requirements outlined in the ISA 60079-29-1, in the following subject area of:

- Scope
- Ambient Temperature
- Indicating devices
- Test Methods
  - Samples and sequence of tests – General
  - Standard test gas

  - Alarm set point(s) - General
  - Short interruption of power supply
  - Voltage transients

The IEC 60079-29-1 ***does not meet*** the requirements outlined in the ISA 60079-29-1, in the following subject area of:

- Reference Standards
- Indicating devices – Fault Signals
- Labelling and marking
- Instruction manual
- Test Methods
  - Sample and sequence of tests
  - Test - Pressure
  - Calibration and Adjustment - Calibration curve (accuracy), Long-term stability (fixed and transportable apparatus – Group II only)
  - Long-term stability (fixed and transportable apparatus – Group II only)
  - Time of response
  - High gas concentration operation above the measuring range
  - Electromagnetic immunity
  - Fault signals
  - Verification of ingress protection claims
  - Performance requirements

The IEC 60079-29-1 ***exceeds*** the requirements outlined in the ISA 60079-29-1, in the following subject areas of:

- Test Methods
  - IR-sensors using optical filters – Test for Response to different gases
  - Humidity

The requirements in the ISA 60079-29-1 and IEC 60079-29-1 are the same except for the U.S. national differences in the ISA standard as detailed above. It can be concluded that due to these national differences the requirements in IEC standard 60079-29-1 does not meet ISA standard 60079-29-1.

3.15 ANSI/ISA 60079-29-2 vs IEC 60079-29-2 Explosive Atmospheres - Part 29-2: Gas Detectors - Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen

A comparative assessment of IEC 60079-29-2 (Ed. 2) and ISA 60079-29-2 (12.13.02)-2012 was conducted to determine if the IEC standard meets, exceeds or does not meet the ISA-standard. Table 17 provides a summary of the comparative analysis of the standards. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standard and the associated sections of the international standard. In some subjects there are no equivalent requirements in either the baseline or the international standards. In these areas, no further analysis is needed.

Table 17: ANSI/ISA 60079-29-2 vs IEC 60079-29-2 *Explosive Atmospheres - Part 29-2: Gas Detectors - Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen* Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 (12.13.02)-2012	International Standard IEC 60079-29-2 Ed. 2, 2015-03	Analysis
Reference Standards	Introduction 1. Scope 2. References 3.17, 4,5.1, 5.2.1, 6.1, 10.8, 14, Table 5, 15, 18, 19, Annex C, Annex E	1. Scope 2. Normative References	Type 3 - Does Not Meet
Terms and Definitions group II apparatus	3.23	3.2.9	Type 2 - Meets
Terms and Definitions Span	3.5	3.6.9	Type 2 - Meets
Terms and Definitions - volume fraction	3.57	3.1.19	Type 2 - Meets
Detecting gases and vapors - General	4.1	4.1.1	Type 2 - Meets
Open path gas detection	4.3	4.3.2.2, 4.6, 5.4.2, 5.4.4, 6.2.3.5, 8.2.1, 8.2.4, 8.3.3.2, 8.3.3.4, 8.6, 8.11.2	Type 1 - Exceeds
Propagation and sampling considerations	4.3.3.3	4.3.3.3	Type 2 - Meets
Oxygen deficiency	4.4	4.4.1	Type 3 - Does Not Meet
Dilution of the air by displacement by some other gas or vapor	4.4.3 a 4.4.3 d	4.4.4 a 4.4.3 d	Type 2 - Meets
Specific applications of gas detection		4.5	Type 3 - Does Not Meet
Specific considerations for open path detection	N/A No reference in ISA standard	4.6 Specific consideration s for open path detection	Type 1 - Exceeds
Measuring Principles	5	5.1	Type 3 - Does Not Meet
Catalytic sensors	5.1 5.1.2	5.2 5.2.3	Type 2 - Meets
Interferences	5.1.3	5.2.4	Type 2 - Meets
Poisoning	5.1.4	5.2.5	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 (12.13.02)-2012	International Standard IEC 60079-29-2 Ed. 2, 2015-03	Analysis
Thermal conductivity sensors - Common Applications - Limitations	5.2.1	5.3.2 5.3.4	Type 2 - Meets
Infrared sensors - Common Applications - Interferences	5.3.1 5.3.3	5.4.2 5.4.4	Type 1 - Exceeds
Semiconductor sensors	5.4	5.5.1, 5.5.3	Type 2 - Meets
Limitations	5.5.2	5.6.3	Type 2 - Meets
Selection of apparatus	6	6.1	Type 2 - Meets
Fixed apparatus and fixed systems	6.2.3.1	6.2.3.1	Type 2 - Meets
Fixed apparatus and fixed systems - Point detection equipment - Remote sensors with centralized control equipment - Sample systems with centralized sensor package - Open path equipment	No reference in ISA standard	6.2.3.2 6.2.3.3 6.2.3.4 6.2.3.5	Type 1 – Exceeds
Transportable apparatus	6.2.4.1	6.2.4.3	Type 1 - Exceeds
Intended location(s) of use	6.3.2	6.3.2	Type 2 - Meets
Basic considerations for the installation of fixed systems	8.1	8.2.1	Type 1 - Exceeds
Basic considerations for the installation of fixed systems - - Open path / Line of sight systems	8.1	8.2.4	Type 3 - Does Not Meet
Location of detection points - Adverse weather conditions - Vibration	8.2.2.1 8.2.2.3	8.3.3.2 8.3.3.6	Type 1 - Exceeds
Galvanic corrosion	no reference in ISA standard	8.3.3.6	Type 1 – Exceeds

Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 (12.13.02)-2012	International Standard IEC 60079-29-2 Ed. 2, 2015-03	Analysis
Additional considerations for open path equipment	no reference in ISA standard	8.6	Type 1 – Exceeds
Summary of considerations for the location of sensors or sampling points	8.5	8.7	Type 2 - Meets
Installation of sensors	8.6	8.8	Type 1 - Exceeds
Initial Gas Calibration	8.9.2	8.11.2 Initial Gas Calibration	Type 1 - Exceeds
Electrical safety in hazardous atmospheres	9.3.1	9.3.1	Type 2 – Meets

ISA 60079-29-2 is based on the first edition of IEC 60079-29-2. The document is a modification of the IEC standard and includes U.S. National Differences encompassing both additions and deletions of information. ISA 60079-29-2 gives guidance on, and recommended practice for, the selection, installation, safe use and maintenance of electrically operated group II apparatus intended for use in industrial and commercial safety applications for the detection and measurement of flammable gases complying with the requirements of ISA-60079-29-1 and ANSI/ISA-12.13.04 *Performance Requirements for Open Path Combustible Gas Detectors*. The latest edition of the IEC 60079-29-2 is the second edition. The comparative assessment was performed between ISA 60079-29-2 (first edition) and IEC 60079-29-2 (Edition 2.0).

3.15.1 Reference Standards

In ISA 60079-29-2 where references are made to other IEC 60079-standards, the referenced standards are replaced with applicable U.S. standards. The following additional U.S. national standards for the equipment are included in the ISA 60079-29-2 with additional references to align with U.S. practice and the NEC.

ANSI/NFPA 70, *National Electrical Code*
ANSI/NFPA 497, *Recommended practice for the classification of flammable liquids, gases, or vapors and of hazardous (classified) locations for electrical installations in chemical process areas*
ANSI/ISA-12.13.04, *Performance Requirements for Open Path Combustible Gas Detectors*
ANSI/ISA-92.04.01, *Performance Requirements for Instruments Used to Detect Oxygen-Deficient/Oxygen-Enriched Atmospheres*

Additional references are included in ISA standard to align with U.S. practice and the NEC, and implies that there are additional requirements that need to be followed for equipment testing and acceptance. Therefore it can be concluded that the IEC standard does not meet the requirements of the ISA standard.

3.15.2 Open path gas detection

In the latest edition of IEC 60079-29-2 additional requirements and guidance regarding open path gas detection system is provided. ISA 60079-29-2 has not yet harmonized with this latest edition of the IEC standard. Open path equipment monitors a linear path through the atmosphere. There is a transmitter and a receiver at the end of this path. The IEC standard has outlined several additional requirements for the open path equipment in the standard. As there are additional requirements provided in IEC standard for open path equipment when compared with ISA standard, it is concluded that the IEC 60079-29-2 exceeds ISA 60079-29-2 for open path gas detection system requirements.

3.15.3 Oxygen deficiency

ISA 60079-29-2 has included the national difference that the oxygen detector used should confirm to requirement in ANSI/ISA 92.04.01*, Performance Requirements for Instruments Used To Detect Oxygen-Deficient/Oxygen-Enriched Atmospheres*. Also, typical oxygen deficiency alarm setting is specified in the ISA standard between 19.0 % to 19.5 % v/v; however, in IEC 60079-29-2, the alarm setting is between 17.0 % to 19.5 % v/v. Therefore it can be concluded that IEC 60079-29-2 does not meet the oxygen deficiency requirements of ISA 60079-29-2.

3.15.4 Specific applications of gas detection

The latest edition of IEC 60079-29-2 has Clause 4.5, which provides additional guidance regarding the use of gas detection as means of reducing risk of explosion. The use of gas detection equipment in various combination of operation is used as a means to reduce the probability of an explosion when a non-explosion protected equipment is located in an area that may be exposed to explosive gas atmosphere or by safety action to keep the flammable concentration below 25% LFL (lower flammable limit). With the use of a gas detection system and ventilation the flammable concentration is kept below 25% LFL. This section of the IEC standard also discusses the use of gas detectors when gas free work permit is issued for using portable ignition capable devices or equipment such as arc welding equipment.

ISA 60079-29-2 does not have these additional guidance as the standard is the nationalized version of the previous edition of the IEC standard. Therefore it can be concluded that IEC 60079-29-2 requirement exceeds that of ISA 60079-29-2.

It is noted that similar provisions regarding the use of gas detection as in IEC standard is included in API RP 505 Section 6.8 and NEC Article 505.8 (I).

3.15.5 Measuring Principles

In Clause 5 of the both ISA and IEC standard, measuring principles of various types of sensors (Catalytic sensor, Thermal conductivity sensor, Infrared sensor, Semiconductor sensor, Electrochemical sensor, Flame ionization detector, Flame temperature analyser, Photo ionization detector and Paramagnetic oxygen detector) together with their advantages and typical applications and limitations are provided. An additional paragraph is included in IEC 60079-29-2 Clause 5 states that the IEC allows the use of alternative detection technologies such as ultrasonic detectors, infrared cameras for detecting presence of gas. However, the requirement that allows the use of alternative gas detection technologies is not included in the ISA 60079-29-2. It is also stated in the IEC standard that the use of these alternative technologies is to be assessed with respect to their ability or inability to determine the concentration of gas. As the use of alternative technologies is not allowed as per ISA standard, it is identified as a difference and can be concluded that IEC 60079-29-2 does not meet the requirements of ISA 60079-29-2 for measuring principles. Further, it is to be noted that although the use of alternative technologies for gas detection is allowed in IEC standard, IEC requires that the use of such detection systems be carefully evaluated. Therefore, this difference does not have major impact on the system safety.

3.15.6 Infrared sensors

This section of the IEC 60079-29-2 exceeds the requirement in the ISA 60079-29. See the discussion for Open Path Gas Detection systems in Section 3.15.2.

3.15.7 Fixed apparatus and fixed systems

IEC 60079-29-2 provides additional details with regard to the following fixed gas detection equipment, the principal characteristics of each are listed in the latest edition of the IEC standard:

- Point detection equipment
- Remote sensors with centralized control equipment
- Sample systems with centralized sensor package
- Open path equipment

These additional requirements are not included in ISA 60079-29-2, therefore it can be concluded that IEC 60079-29-2 exceeds the requirements of the ISA standard.

3.15.8 Transportable Apparatus

IEC 60079-29-2 provides additional clarification regarding the effect of sudden change in temperature and pressure on the equipment when moved from area to area. The IEC standard indicates the manufacturer’s advice is to be sought regarding such transient conditions. These additional requirements are not included in ISA 60079-29-2. Therefore it can be concluded that IEC 60079-29-2 exceeds the requirements of ISA 60079-29-2.

3.15.9 Basic considerations for the installation of fixed system

A system consisting of point detection equipment is not included in ISA 60079-29-2. In IEC 60079-29-2, guidance regarding remote sensors and point sensors are provided. It is stated in the IEC standard that sensors must be connected to their associated control and alarm equipment according to the national requirements for installation of electrical equipment, and the sensors and any other parts of the system located in a hazardous area should meet explosion protection technique covered by the IEC 60079 series of standards for the intended Zone of use. As this Clause is not included in ISA 60079-29-2, IEC 60079-29-2 exceeds the requirement in the ISA 60079-29-2.

3.15.10 Basic considerations for the installation of fixed systems Open path / Line of sight systems

ISA 60079-29-2 includes a national difference in the Clause 8.1 that "Open Path or LOS gas detection systems are not recommended for applications where gas detection is used as a protection technique, as permitted in NEC Articles 500.7(K) and 505.8(I)". Similar restrictions are not included in IEC 60079-29-2. Therefore it can be concluded that the IEC 60079-29-2 does not meet the requirement in ISA 60079-29-2.

3.15.11 Location of detection points

Adverse weather conditions

IEC 60079-29-2 has additional requirements and guidance for open path equipment and the possible effects of weather conditions on the equipment itself, such as de-focusing due to water droplets on windows. These additional requirements are not included in ISA standard. IEC 60079-29-2 exceeds the requirement in ISA 60079-29-2. See the discussion for Open Path Gas Detection systems in Section 3.15.2.

Vibration

It is indicated in IEC 60079-29-2 that for open path equipment special anti-vibration mounting is required. Where excessive vibration or buffeting at the measuring points is expected, sampling systems should be considered. These additional requirements are not included in ISA standard. Therefore IEC 60079-29-2 exceeds the requirement in ISA 60079-29. See the discussion for Open Path Gas Detection systems in Section 3.15.2.

3.15.12 Galvanic corrosion

IEC 60079-29-2 provides guidance that suitable precautions are to be taken to protect sensors from galvanic corrosion when in contact with other materials. This requirement regarding galvanic corrosion protection not included in ISA 60079-29-2. Therefore it can be concluded that IEC 60079-29-2 exceeds the requirements of ISA 60079-29-2.

3.15.13 Additional considerations for open path equipment

Additional requirements are included in IEC 60079-29-2 for open path equipment. The requirements in IEC standard includes protection of optical windows from ambient conditions, protection from condensation and sunlight. It is also stated in IEC standard that as open path equipment could be inoperable in dense fogs or intense rain or snow, it is advisable to combine the open path system with other sensors or sample systems. These additional requirements related to open path equipment is not included in ISA 60079-29-2. Therefore it can be concluded that IEC 60079-29-2 exceeds the requirements of ISA 60079-29-2. See the discussion for Open Path Gas Detection systems in Section 3.15.2.

3.15.14 Installation of Sensors

IEC 60079-29-2 provides requirements regarding installation of measuring point and open path equipment. For the proper operation of a fixed gas detection system each sensor, sampling point or component of open path equipment should be placed in a suitable location. It is stated in the IEC standard that adequate drainage and/or heating is to be provided to minimize moisture and condensation in the equipment, detector head and interconnecting cable/conduit system, or sampling tube. Also, requirements regarding the venting of any potential flammable gas introduced into the sampling system is included in IEC standard. These additional requirements are not included in ISA 60079-29-2. Therefore it can be concluded that IEC 60079-29-2 exceeds the requirements of ISA 60079-29-2. See the discussion for Open Path Gas Detection systems in Section 3.15.2.

3.15.15 Initial Gas Calibration

It is required by both ISA and IEC 60079-29-2 standards that after installation each sensor be calibrated to manufacturer's instructions, unless it is factory calibrated. It is also required by the standards that calibration be carried by a suitable trained and competent person. For the sensor system, it is indicted in the IEC standard that the calibration is carried out by application of a zeroing gas and then, by the application of span gas, the sensitivity of the equipment is adjusted. Also, for open path equipment IEC standard has provided additional requirement as the calibration method used for systems with sensors cannot be used for open path equipment. Additional requirements in IEC 60079-29-2 for sensor systems and open path equipment are not included in ISA 60079-29-2. Therefore it can be concluded that IEC 60079-29-2 exceeds the requirements of ISA 60079-29-2. See the discussion for Open Path Gas Detection systems in Section 3.15.2.

3.15.16 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-29-2 series meet, exceed, or does not meet the requirements of ISA 60079-29-2.

IEC 60079-29-2 ***meets*** the requirements outlined in the ISA 60079-29-2, in the following subject area of:

- Terms and Definitions
- Detecting gases and vapors – General
- Propagation and sampling considerations
- Dilution of the air by displacement by some other gas or vapor
- Catalytic sensors
- Interferences
- Poisoning
- Thermal conductivity sensors - Common Applications and Limitations
- Semiconductor sensor
- Limitations
- Selection of apparatus
- Fixed apparatus and fixed systems
- Intended location(s) of use
- Summary of considerations for the location of sensors or sampling points
- Electrical safety in hazardous atmospheres

IEC 60079-29-2 ***does not meet*** the requirements outlined in the ISA 60079-29-2, in the following subject area of:

- Reference Standards
- Oxygen deficiency
- Specific applications of gas detection
- Measuring Principles
- Basic considerations for the installation of fixed systems – open path equipment restriction

The IEC 60079-29-2 ***exceeds*** the requirements outlined in the ISA 60079-29-2, in the following subject areas of:

- Open path gas detection / Specific applications of gas detection
- Specific considerations for open path detection
- Infrared Sensors open path gas detection additional requirement
- Fixed apparatus and fixed systems
    - Point detection equipment
    - Remote sensors with centralized control equipment
    - Sample systems with centralized sensor package
    - Open path equipment
- Transportable apparatus
- Basic considerations for the installation of fixed systems – open path gas detection additional requirement
- Location of detection points - open path gas detection additional requirement
    - Adverse weather conditions

- Vibration
- Galvanic corrosion
- Additional considerations for open path equipment
- Installation of sensors - open path gas detection additional requirement
- Initial gas calibration - open path gas detection additional requirement

The nationalized version of the IEC 60079-29-2 is published by ISA with National differences. The IEC standard does not meet the ISA standard in the sections identified above. However the nationalized version of the ISA standard is based on IEC standard edition 1. The latest IEC standard has since been published with additional requirements. There are several changes in the latest edition of the IEC standard which exceed the requirements in the ISA standard and have not yet been incorporated into ISA 60079-29-2.

4. Listing, Marking and Documentation of Equipment Installed in Hazardous Locations (AEx vs EEx)

This section contains the comparative assessment between standards related to the listing, marking and documentation of equipment installed in hazardous locations. Each subsection provides summary of the analysis and comparative results. Appendix P contains the consolidated comparative assessment and results.

NEC Article 500 covers the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Division 1 and 2 locations where fire or explosion may exist due to flammable gases, flammable liquid-produced vapors and combustible liquid-produced vapors. NEC Article 505 covers the requirements for zone classification system as an alternative to the division classification system covered in Article 505. Article 505 covers the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Zone 0, Zone 1, and Zone 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases, vapors, or liquids.

NEC Article 505.9(I) indicates that equipment identified for Class I, Division 1 or Class I, Division 2 that are marked in accordance with 500.8 (C), are also permitted to be marked with the following:

- Class I Zone 1 or Class 1 Zone 2 (as applicable)
- Gas Classification group as per Table 505.9 (C)(1)(2)
- Temperature Classification as per 505.9(D)(1)

Also, it is to be noted that the equipment marked for Class I, Division1 hazardous locations may be used in Class I, Zone 1 or Zone 2 locations for the same gas and with suitable temperature rating. Further, equipment marked for Class I, Division 2 hazardous locations may be used in Class I, Zone 2 locations for the same gas and with suitable temperature rating. API RP 14 FZ (Edition 1) Section 6.4.1.4 (b) provides guidance on use of Division rated equipment in Zone classified locations.

4.1 National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 vs IEC 61892 and IEC 60079

The IEC defines the symbol EEx which indicates that electrical equipment corresponds to one or more of the types of protection which are the subject of the specific standards, namely the IEC 60079 series of standards. Table 18 provides a summary of the comparison between the marking requirements in NEC and relevant sections of IEC standards. Subsequent discussion provide further analysis of sections of the IEC that do not meet the NEC.

Table 18: Hazardous Location Classification Marking Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard NEC Article 505 and ANSI/ISA 60079	IEC Standard IEC61892 and IEC 60079	Analysis
Listing - of equipment for Zone 0, 1, 2	NEC 505.9 (B)	IEC 61892-1:2015 Clause 4.8 IEC 61892-7: 2014 Clause 8	Type 2 - Meets
Suitability - Documentation	NEC 505.9 (A)	IEC 60079-0: 2011 Clause 28.2 IEC 61892-7: 2014 Clause 27	Type 3 - Does Not Meet
Marking	NEC 505.9 (C) (2)	IEC 60079-0 Clause 29	Type 3 - Does Not Meet
Marking - Group	NEC 505.9 (C) (2) 505.9 (B) (2)	IEC 60079-0 Clause 29.4 (c) and 4.2	Type 2 - Meets
Marking - Temperature Class	NEC 505.9 (C) (2)	IEC 60079-0 Clause 29.4 (d) and 5.3.2.2	Type 2 - Meets
Marking - EPL	NEC 505.9 (C) (2)	IEC 60079-0 Clause 29.4 (e) and 3.26	Type 2 - Meets
Marking for associated apparatus suitable for installation in Class I, Zone 0	NEC 505.9 (C) (2)	IEC 60079-0 Clause 29.4	Type 2 - Meets
Marking for associated apparatus not suitable for installation in hazardous location	NEC 505.9 (C) (2)	IEC 60079-0 Clause 29.4	Type 2 - Meets
Marking - Ambient Temperature	NEC 505.9 (C) (2)	IEC 60079-0 Scope - Note 1 and Clause 29.4 (f) and 5.1.1	Type 2 – Meets

Section Title / Subject Issue	Baseline Standard NEC Article 505 and ANSI/ISA 60079	IEC Standard IEC61892 and IEC 60079	Analysis
Alternative marking of equipment protection levels (EPLs)	NEC Table 505.9 (C)(2)(4)	IEC 60079-0 Clause 29.13	Type 2 - Meets

4.1.1 Suitability – Documentation

NEC Article 505.9 (A) requires that the suitability of the equipment be identified by equipment listing/labeling or evidence of equipment evaluation from a qualified testing laboratory or inspection agency concerned with product evaluation or evidence acceptable to the authority having jurisdiction such as a manufacturer's self-evaluation or an owner's engineering judgment. Based on the requirements in IEC 61892-7, it is to be ensured that the installation complies with relevant equipment certificate and installation details included in the standard. It is also noted that in IEC 60079-0, the manufacturer is to prepare a certificate confirming that the equipment is in conformity with the requirements of the standard. The IEC standard also requires relevant equipment certificate similar to the NEC requirement, however the IEC standards do not specify that the certificate is to be issued by a qualified testing laboratory or inspection agency. Therefore the IEC standards do not meet the requirements in the NEC.

4.1.2 Marking

NEC Article 505.9 (C) (2) and IEC 60079-0 have similar marking requirements except for the following:

- NEC requires AEx marking vs IEC requires symbol EEx.
- NEC requires that Class and Zone of equipment be identified in the marking.
- IEC allows the use of symbol "X" to indicate specific conditions of use. However as per the NEC and ANSI/ISA 60079 standards, identification of specific conditions of use is by specific installation instructions or reference to a specific installation document when if it is necessary to indicate specific conditions of use.
- The protection technique requirement is included in the IEC 60079 series of standards.

Based on the analysis, IEC 60079-0 does not meet the marking requirements in the NEC.

4.2 ANSI/ISA 60079-0 series vs IEC 60079 series Marking Requirements

A comparison between the IEC series of standards and U.S. nationalized 60079 series of standards published by ANSI/ISA or UL for specific marking requirements was performed. The details of the comparative assessment for each of these standards are indicated in the following sections.

Table 19 provides a summary of the comparative assessment of the marking requirements between ANSI/ISA 60079 and IEC 60079 series of standards. The table includes the part and Clause that contained requirements for marking of electrical equipment from each standard. Analysis is provided where the IEC standard does not meet the ISA or UL standards.

Table 19: Hazardous Location Classification Marking ANSI/ISA 60079-0 vs IEC 60079-0 Comparative Assessment Results

Section Title / Subject Issue	Baseline Standard ANSI/ISA 60079 Clause(s)	International Standard IEC 60079 Clause(s)	Analysis
Markings	ISA 60079-0 29.24 ISA 60079-0 29.4 (e)	IEC 60079-0 29.24 IEC 60079-0 29.4 (e)	Type 2 - Meets
General Marking – U or X	ISA 60079-0 29.3 UL 60079-5 4.1.3, 4.8.2, 4.8.5	IEC 60079-0 29.3 IEC 60079-5 4.1.3, 4.8.2, 4.8.5	Type 2 - Meets
Ga equipment using two independent Gb types (or levels) of protection	ISA 60079-0 29.8	IEC 60079-0 29.8	Type 3 - Does Not Meet
Marking - Class and Zone marking	ISA 60079-0 29.4 ISA 60079-0 29.9, 29.10 UL 60079-7 9.2 UL 60079-2 18.6	IEC 60079-0 29.4 IEC 60079-0 29.9, 29.10 IEC 60079-7 9.2 IEC 60079-2 18.6	Type 3 - Does Not Meet
Marking requirements for Division marking	ISA 60079-0 29.18 - 29.24	IEC 60079-0 29.18.4 – 29.24 (Note: IEC standard does not address the Division system)	Type 2 - Meets
Marking - Interrupting rating markings	UL 60079-1 20.4	IEC 60079-1 20.4	Type 3 - Does Not Meet
Marking – Level of Protection of “ec”	UL 60079-7 9.1	IEC 60079-7 9.1	Type 3 - Does Not Meet
Marking	ISA 60079-15 6.3.1, 6.3.2, 8.8.3, 13, 20.2.7.2	IEC 60079-15 6.3.1, 6.3.2, 8.8.3, 13, 20.2.7.2	Type 3 - Does Not Meet
Marking	UL 60079-26 6.1, 6.2	IEC 60079-26 6.1, 6.2	Type 3 - Does Not Meet
Marking - FNICO system or nonincendive field wiring system Marking	ISA 60079-27 8.2	IEC 60079-27 8.2	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard ANSI/ISA 60079 Clause(s)	International Standard IEC 60079 Clause(s)	Analysis
Marking – with type "s"	ISA 60079-29 4.3	IEC 60079-29 4.3	Type 3 - Does Not Meet

IEC 60079 series requires that the certificate number shall include the "X" suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the requirements. However, the marking with U or X are not used for U.S. standards. For U.S. standards, it is required that the equipment be marked in accordance with ISA 60079-0 to indicate that there are special conditions of use. It is to be noted that although the requirement in the standard differs regarding marking for special conditions of use, the intent of the marking in both standards conveys the same information to the user.

4.2.1 Ga equipment protection marking

Under IEC 60079-0 standard, an equipment can get EPL Ga protection level if the same equipment has two independent types of protection, with EPL Gb. In such cases, the equipment is marked with the symbols for the types (or levels) of protection joined with a "+". However, ISA 60079-0 does not allow the marking for Ga equipment using two independent types of protection as this concept is not recognized in the NEC. Based on the analysis, IEC 60079-0 does not meet the requirement in ISA 60079-0.

4.2.2 Marking - Ex Components - Class and Zone marking

ISA 60079-0 requires additional markings of "Class I" and "Zone". Also, as discussed in NEC Article 505.9 requirements, the symbol AEx is to be used for marking the equipment compliant with ISA or UL 60079 series of standards. The added marking in the ISA standard is to designate apparatus conforming to the U.S. requirements and the marking requirements of the NEC.

The marking requirement for Ex components in ISA 60079-0 standard requires that additional details such as Class, Zone and Gas group be indicated so that it complies with the marking requirements of the NEC and conforms to U.S. industry practice. The NEC marking requirements are detailed in the section 4.1 of this report.

For small Ex equipment and components, IEC 60079-0, considering the limitation in the space to indicate all the details, does not require the labeling to indicate the temperature class and gas group. However, ISA 60079-0 requires that Class, Zone, temperature class and gas group be on the smallest unit package to comply with NEC marking requirements.

Examples of marking are shown below:

IEC – Ex db [ia] IIC
–20 °C ≤ *Ta* ≤ +60 °C
Certificate number: XXXX
Serial No.

IEC – Ex pxb IIC T4
–20 °C ≤ *Ta* ≤ +60 °C
Certificate number: XXXX
Serial No.

IEC – Ex ia IIB T3
–20 °C ≤ *Ta* ≤ +60 °C
Certificate number: XXXX
Serial No.

ISA - Class I, Zone 1, AEx db [ia] IIC
–20 °C ≤ *Ta* ≤ +60 °C
Certificate number: XXXX
Serial No.

ISA - Class I, Zone 1, AEx pxb IIC T4
–20 °C ≤ *Ta* ≤ +60 °C
Certificate number: XXXX
Serial No.

ISA - Class I, Zone 1, AEx ia IIB T3
–20 °C ≤ *Ta* ≤ +60 °C
Certificate number: XXXX
Serial No.

Based on the above noted differences, IEC 60079-0 does not meet the marking requirements in ISA 60079-0. Also, the marking requirements specified in ISA 60079-0 is applicable to all other ISA and UL standards in the 60079 series.

4.2.3 UL 60079-1 vs IEC 60079-1 Explosive atmospheres – Part 1: Equipment Protection by Flameproof Enclosures "d" – Marking

UL requires that flameproof enclosures "d" shall be marked in accordance with UL 60079-0 with the additional marking for the type of protection "d" in UL 60079-1. Clause 20.4 in UL 60079-1, has additional requirements that marking for flameproof equipment with high-current interrupting equipment be marked with the interrupting rating in rms symmetrical amperes. IEC 60079-1 has no such requirement. Based on these differences in the UL standard it can be concluded that IEC 60079-1 does not meet the marking requirement of UL 60079-1.

4.2.4 UL 60079-7 vs IEC 60079-7 Explosive atmospheres – Part 7: Equipment protection by increased safety "e"– Marking

UL requires that equipment protection "e" shall be marked in accordance with UL 60079-0 with the additional marking for the type of protection "e" provided in UL 60079-7. UL 60079-7 and IEC 60079-7 have similar marking requirements except for the following.

- As per IEC, the Level of Protection of "eb" or "ec" is to be indicated. Clarification is added in the UL standard that 2017 National Electrical Code®, NFPA 70, does not recognize "ec" as a Type of Protection. The marking "nAc" or "nA" is substituted until this can be rectified.

Based on the differences in the UL standard it can be concluded that IEC 60079-7 does not meet the marking requirements UL 60079-7.

4.2.5 ANSI/ISA 60079-15 vs IEC 60079-15 Explosive atmospheres – Part 15: Equipment protection by type of protection "n" – Marking

With regard to the current version of the IEC standard, it is not be noted that the IEC standard 60079-15 (Ed. 4) is a withdrawn standard. The latest edition of IEC 60079-15 is the fifth edition published on 8 Dec 2017 and specifies requirements for the construction, testing and marking for Group II electrical equipment with type of protection “n” which includes; sealed devices “nC”, hermetically sealed devices “nC”, non-incendive components “nC” and restricted breathing enclosures “nR” intended for use in explosive gas atmospheres. The requirement for “nA” protection have been relocated from IEC 60079-15 to IEC 60079-7 (Ed. 5). Former marking of “nA” has been replaced by marking “ec” in the IEC standard.

Examples of marking:

IEC – Ex nR d IIB T3 Gc
–20 °C ≤ *Ta* ≤ +60 °C
Certificate number: XXXX

ISA - Class I, Zone 2, AEx nR d IIB T3 Gc
–20 °C ≤ *Ta* ≤ +60 °C
Certificate number: XXXX

The marking requirements in both IEC 60079-15 (4th Edition) and ISA 60079-15 (4th Edition) are similar other than the standard that is referred; ISA 60079-15 refers to ISA 60079-0 for general marking requirements and IEC 60079-15 refers to IEC 60079-0 standard. Based on the differences identified in the comparative assessment for ISA 60079-0 vs IEC 60079-0, it can be concluded that IEC 60079-15 does not meet the requirement of UL 60079-15.

4.2.6 ANSI/UL 60079-26 vs IEC 60079-26 Explosive atmospheres – Part 26: Equipment with Equipment Protection Level (EPL) Ga– Marking

IEC 60079-26 requires where more than one type of protection is used as per Clause 4.1.2, the symbols for the type of protection should be joined with a “+”. It is to be noted that the scope of the UL 60079-26 is revised to exclude the application of two independent types of protection providing EPL Gb in locations intended for EPL Ga. The application of two independent type of protection providing EPL Gb in an area required by EPL Ga is not applicable for U.S. standards.

Both the IEC and UL standards require that for equipment installed in the boundary wall between an area requiring EPL Ga and the less hazardous area per Clause 4.1.3, both EPLs are to be marked on the label separated by a slash “/”. However, the marking is different with regard to the symbols used. For example:

- As per IEC –
  - Ex ia/d IIC T6 Ga/Gb

    - Ex d+e/d IIA T4 Ga/Gb (two independent types of protection, d and e providing EPL Ga with flame proof compartment providing EPL Gb)
- As per UL – Class, Zone 0/1 AEx ia/db IIC T6 Ga/Gb

Based on the differences in the identified above, IEC 60079-26 does not meet the marking requirements in UL 60079-26.

4.2.7 ANSI/ISA 60079-27 vs IEC 60079-27 Explosive atmospheres – Part 27: Fieldbus intrinsically safe concept (FISCO) - Marking

ISA 60079-27 requires that marking is to be differentiated between a FNICO system or nonincendive field wiring system. The ISA standard also requires that the control drawing number be included in the marking and the control drawing is to comply with the applicable requirements of ISA-RP12.02.02.

Example of a FNICO marking as per the ISA standard:

FNICO field device
Class 1, Zone 2 AEx nA IIC T4
Company name and address
Type of the product
–20 °C < Ta < +50 °C
Model Serial No.
Control Drawing no.

Example of a FNICO marking as per the IEC standard:

FNICO field device
Ex nL IIC T4
Company name and address
Type of the product
–20 °C < Ta < +50 °C
Lab Certificate No.
Model Serial No.

The IEC standard does not have similar requirement to differentiate the marking between FNICO and nonincendive. Therefore, IEC 60079-27 does not meet the requirements for FNICO systems marking of ISA 60079-27.

4.2.8 ANSI/ISA 60079-29-1 vs IEC 60079-29-1 Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases - Marking

IEC 60079-29-1 requires the marking to be in accordance with IEC 60079-0 and if the equipment is not fully compliant with IEC 60079-0, then where equivalent safety is claimed, it is to be marked "s". The marking type "s" is not in accordance with the NEC, therefore is not included in ISA 60079-29-1.

The ISA standard has included additional marking requirements for portable equipment. It is required by ISA 60079-29-1 where portable equipment uses protective casing, marking on the equipment must be visible; otherwise, the marking must be on the protective casing. Similar requirement is not included in the IEC standard. Based on the differences identified above, it is concluded that IEC 60079-29-1 does not meet the marking requirements in ISA 60079-29-1.

4.3 Summary and Conclusion

Based on the comparative assessments in the above sections, regarding the marking requirements in NEC 505, ANSI/ISA and UL 60079 series of standards and IEC 61892-1, IEC 61892-7 and IEC 60079 series of standards, the summary of the assessment is noted below:

- NEC 505, ISA and UL 60079 requires AEx marking vs IEC 60079 requires symbol EEx.
- NEC 505, ISA and UL 60079 requires that Class and Zone of equipment be identified in the marking.
- IEC allows the use of symbol "X" to indicate specific conditions of use. However as per the NEC, ISA and UL 60079 standards, identification of specific conditions of use is by specific installation instructions or reference to a specific installation document when if it is necessary to indicate specific conditions of use.

5. FM Approval Standards vs IEC 60079 Series of Standards

FM Approvals LLC (FM) is a developer of approval standards for testing and certifying products including electrical equipment for use in explosive atmospheres using the FM 3600 series of standards. This section focuses on the results of a comparative assessment to determine if the IEC 60079 series of standards meet, exceed, or does not meet selected FM standards. Table 20 provides a list of the latest versions of the FM approval standards and IEC 60079 series of standards that were used for the assessment.

Table 20: List of Factory Mutual standards compared to the IEC 60079

Baseline Standard	IEC Standard
FM 3600: *Approval Standard for Electrical Equipment for Use In Hazardous (Classified) Locations - General Requirements* (2001-12)	IEC 60079-0 *Explosive atmospheres – Part 0: Equipment – General Requirements* (Ed. 6, 2011-06)

Baseline Standard	IEC Standard
FM 3610: *Approval Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II & III, Division 1, Hazardous (Classified) Locations* (2015-12)	IEC 60079-11 *Explosive atmospheres – Part 11: Equipment Protection by Intrinsic Safety "i"* (Ed. 6, 2011-06)
FM 3611: *Approval Standard for Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations* (2016-12)	IEC 60079-15 *Explosive atmospheres – Part 15: Equipment Protection by Type of Protection "n"* (Ed. 4, 2010-01)
FM 3615 *Approval Standard for Explosionproof Electrical Equipment General Requirements* (2006-08)	IEC 60079-1 *Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"* (Ed. 7, 2014-06)
FM 3620: *Purged and Pressurized Electrical Equipment for Hazardous (Classified) Location* (2014-12)	IEC 60079-2 *Explosive Atmospheres Part 2: Equipment Protection by Pressurized Enclosures "p"* (Ed. 6, 2014-07)

5.1 FM 3600 vs IEC 60079-0 Explosive Atmospheres - Part 0: Equipment - General Requirements

FM 3600 identifies the basis for approval of electrical equipment installed in hazardous (classified) locations. This standard was compared to IEC 60079-0, which provides general requirements for construction, testing and marking of electrical equipment for use in explosive atmospheres. Table 21 provides a summary of the analysis results. Subsequent discussions below provide a comprehensive analysis of the differences between the two standards. Appendix Q contains the consolidated comparative assessment and results.

Table 21: FM 3600 vs IEC 60079-0 Explosive Atmospheres - Part 0: Equipment - General Requirements

Section Title / Subject Issue	Baseline Standard FM 3600	International Standard IEC 60079-0	Analysis
Introduction			
Scope	1.2	1	Type 2 - Meets
Application	1.2.3	4	Type 2 - Meets
Basis for Approval	1	6.1, 26, 27, 28	Type 3 - Does Not Meet
General Information	2	1	
Normal Atmosphere Conditions	2.1	1	Type 2 - Meets
Mechanisms of Ignition	2.2	2	Type 2 - Meets
Applicability of other standards	2.3	4, 5	Type 3 - Does Not Meet
Classification & Grouping System	2.4		Type 2 - Meets
Marking Requirements	3	29	Type 3 - Does Not Meet

Section Title / Subject Issue	Baseline Standard FM 3600	International Standard IEC 60079-0	Analysis
Performance Requirements	4	6	
Mechanical Strength	4.1	6.2, 26.4, 26.5	Type 1 – Exceeds
Non-Metallic Enclosure materials:			
-- Chemical compatibility	4.2	26.11, 26.3	Type 2 - Meets
– Aging	4.3	26.8, 26.9	Type 1 – Exceeds
Metallic Enclosure materials - Reactance	4.4	8, 9	Type 3 - Does Not Meet
Operation Requirements	9	26, 27, 28	Type 3 - Does Not Meet

5.1.1 Introduction

Scope and Application

Section 1 of FM 3600 defines general information of the standards, including scope, application, references, basis for approval and continued approval as well as effective date of publication, etc. Besides the Division standards defined by NEC, Zone standards are also used by FM for approval, which are based on the U.S. nationalized version of the IEC 60079 series of standards. The scope of FM 3600 indicates that for electrical equipment for Class I, II or III, Division 1 or 2 hazardous locations, FM 3610, FM 3611, FM 3613, FM 3615, FM 3616, FM 3620 and FM 6310/6320 are applicable; and for electrical equipment for Class I, Zones 0, 1 or 2, the requirement in ANS/ISA 60079 series of standards referenced in FM 3600 Clause 1.2.2 Table 2 are applicable. Not all standards of U.S. nationalized version of IEC 60079 series have been included in FM 3600 Table 2.The following nationalized standards have not been listed in FM 3600:

- ANSI/ISA 60079-25 *Explosive atmospheres – Part 25: Intrinsically safe electrical systems*
- ANSI/UL 60079-26 Explosive atmospheres – *Part 26: Equipment with equipment protection level (EPL) Ga*

The scope of IEC 60079-0 standard is defined in Clause 1, which includes general requirements for construction, testing and marking of electrical equipment and Ex components for use in explosive atmosphere. The general requirements are to be supplemented or modified the listed standards concerning specific types of protection.

Basis for Approval

The FM and the IEC differ on their approach to approval and certification. FM is one of OHSA's recognized certifying bodies, providing certification services. The FM's Basis for Approval includes two aspects; (1) verifying products meeting the performance requirements as specified in the standard(s) and (2) evaluating product manufacturers through surveillance audit programs.

IEC is a worldwide organization for establishing standardization for products, i.e. setting up consensus based standards and defining the requirements for products or services. Although the IEC does establish standards for quality systems, testing laboratories, certifying body qualification, it does not provide any attestation of conformity. This standard series defines manufacturers' responsibilities for the products, such as type tests, routine tests, marking and instructions, etc. Manufacturer evaluation is not included in the scope. As such, the IEC standard does not meet the FM standard.

5.1.2 General Information

Normal Atmosphere Conditions

The normal ambient conditions defined in FM 3600 and IEC 60079-0 are similar, except temperature range. Minimum ambient temperature -25 °C as specified in FM 3600, is lower than -20 °C minimum temperature given in IEC 60079-0, and maximum normal temperature in IEC 60079-0 is 60 °C, higher than 40 °C in FM 3600. However, a clarification is made in Note 1 of Clause 1 of IEC 60079-0 that the normal ambient temperature range of -20°C to +40°C for equipment is recognized by IEC.

Applicability of other standards

FM defines that electrical equipment shall also comply with the applicable ANSI requirements for ordinary locations. If no ANSI standard exists for the category of equipment, FM 3810 will be used. In IEC 60079-0, Clause 2 Normative references, more than 50 standards (IEC, ISO and ANSI) that cover the requirements for ordinary locations are listed as indispensable for the application of IEC 60079-0. However, clarifications are given through notes in Clause 6 of IEC 60079-0 that it is not a requirement by the IEC that compliance with these industrial standards be verified. Both FM 3600 and IEC 60079-0 standards require that electrical equipment and components in hazardous (classified) locations shall also comply with applicable safety requirements of the relevant industrial standards for installation in ordinary locations (unclassified). However IEC 60079-0 does not require that the compliance with the industrial standard be verified, whereas FM standards for ordinary locations have requirements on equipment be verified by the testing lab. It can be concluded that IEC 60079-0 does not meet FM 3600 regarding the verification of safety requirement of electrical equipment in ordinary location.

5.1.3 Marking Requirements

In addition to marking information required of ordinary location, the required marking information in FM 3600 for electrical equipment in classified location includes:

- Class, Division, Group rating,
- Maximum operating temperature or temperature class (T-Code)
- Maximum ambient temperature if greater than 40°C
- Minimum ambient temperature if less than -25°C

All FM Approval certification marks may be used only on FM Approval products and related product packaging, in advertising material, catalogs and news release.

IEC 60079-0 required marking information includes:

- The manufacturer name or his trade mark,
- The manufacturer's type identification,
- A serial number
- The name or mark of the certificate issuer and the certificate reference
- Specific condition with the symbol "X" if applicable
- Specific Ex marking to indicate type of protection
- The symbol of the group
- Temperature class for Group II
- Equipment protection level
- The ambient temperature Ta if it is beyond -20 °C < Ta < +40°C.

In general the marking requirements in both standards are providing similar information as listed here. FM 3600 also refers to ISA 60079 series of standards. The marking requirement in ISA 60079 standards are applicable for electrical equipment for Class 1, Zone 0, 1, or 2 hazardous locations. The comparison of marking requirements between IEC and ISA 60079 series of standards are summarized in section 4 of this report. Although it may be considered that IEC 60079-0 does not meet FM 3600 for marking due to the differences between the standards, it should have no material effect on the safety level of equipment operation.

5.1.4 Performance Requirements

The performance requirements considered in FM 3600 include mechanical strength, non-metallic enclosure materials chemical compatibility, non-metallic enclosure materials aging and metallic enclosure reactance. In addition to these items covered by FM 3600, IEC 60079-0 has also specified detailed requirements on Opening Times, Circulating Currents in enclosures, Gasket Retention, Electromagnetic & Ultrasonic energy radiating equipment.

Mechanical Strength

FM 3600 indicates that for electrical equipment for Class I, Zones 0, 1 or 2, the requirement in ANS/ISA 60079 standards referenced in FM 3600 Clause 1.2.2 are to be complied with. It is to be understood that requirements in FM 3600 Clause 4.1 is applicable only for electrical equipment for Class I, Division 1 or 2 hazardous areas. Comparison between the requirements in Clause 4.1 of FM 3600 and IEC 60079-0 is provided below:

FM 3600 and the IEC 60079-0 both include mechanical strength requirements, including:

- Drop Test: The same Drop tests method is used in FM 3600 and IEC 60079-0
- Resistance to Impact: The test parameters in IEC 60079 and FM 3600 are similar except for the drop height. IEC 60079-0 has stringent requirement for various enclosure depending on the risk of mechanical danger.
- Thermal Shock Test: FM 3600 requires that cloth saturated with water at a temperature of (10 ± 5) °C be applied to the enclosure at maximum service temperature. A note in the FM standard

indicates that the thermal shock test per ANSI/ISA 60079-0 is considered equivalent. It is to be noted that the requirements in both IEC and ISA 60079-0 is same. Therefore the thermal shock test in IEC meets FM requirements.

With regard to the testing for mechanical strength, it is to be noted that the Resistance to impact test in IEC 60079-0 exceeds the requirements in FM3600. However, these differences have no major impact. For electrical equipment for Class I, Zones 0, 1 or 2, it is required by FM 3600 that the requirement in ANS/ISA 60079 standards referenced in FM 3600 Clause 1.2.2 be complied with. The ANSI/ISA 60079 series are identical to the IEC 60079 series except for the U.S. National differences. The comparison results of ISA 60079-0 and IEC 60079-0 is included in Section 3.1 of this report.

Non-Metallic Enclosure

FM 3600 indicated that for electrical equipment for Class I, Zones 0, 1 or 2, the requirement in ANSI/ISA 60079 standards referenced in FM 3600 Clause 1.2.2 are to be complied with. It is to be understood that requirements in FM 3600 Clause 4.2 & 4.3 are applicable only for electrical equipment for Class I, Division 1 or 2 hazardous areas. Comparison between the requirements in Clause 4.2 & 4.3 of FM 3600 and IEC 60079-0 is included below:

FM 3600 requires testing of two material properties, chemical compatibility and aging. Whereas IEC 60079-0 standard requires testing of six material properties, resistance to chemical agents, thermal endurance to heat and cold, earth continuity, surface resistance test, measurements of capacitance, and elastomeric O-ring qualification.

- Chemical compatibility: FM 3600 requires the compatibility to six chemicals to be tested, IEC 60079-0 requires only oils and grease, hydraulic liquids for mining applications. However, FM does give exceptions to electrical equipment for Class I, Zones 0, 1, 2, which are equivalent to IEC equipment to Group II gases. This exception makes FM requirements equivalent to the IEC requirements regarding chemical compatibility for Class I by NEC or Group II by IEC only.
- Aging: FM requires rubber/neoprene be tested at 70 ^{0}C, 300 psi for 96 hours and other materials be tested at service temperature plus 20K, not less than 121 C for 14 days. IEC 60079-0 required test temperature is the same as FM 3600, but the test duration is longer than FM (14 to 28 days). In addition, thermal endurance to cold and resistance to light are required by IEC 60079-0, which are not mentioned in FM 3600.
- Earth continuity, surface resistance test and measurement of capacitance are required by IEC 60079-0, but not covered by FM3600.

Based on the assessment above, IEC 60079-0 exceeds FM 3600 requirements for Non-metallic enclosures testing for aging, earth continuity, surface resistance test and measurement of capacitance. However, these differences have no major impact. For electrical equipment for Class I, Zones 0, 1 or 2, it is required by FM 3600 that the requirement in ANS/ISA 60079 standards referenced in FM 3600 Clause 1.2.2 be complied with. The ANSI/ISA 60079 series are identical to the IEC 60079 series except for the U.S. National differences. The comparison results of ISA 60079-0 and IEC 60079-0 is included in section 3.1 of this report.

Metallic Enclosures

FM 3600 specifies provisions for material reactance:

- Copper or copper alloys are not allowed by FM for use in Class I, Group A (equivalent to Group IIC containing acetylene) classified locations unless they are coated with tin, nickel or maximum copper content is less than 30%. FM 3600 does give exception when the limit is exceeded provided production instructions contain sufficient information. IEC 60079-1 Clause 12.8 requires that the copper content of the alloy be limited to 60% for enclosure of equipment in explosive gas atmosphere containing acetylene (Group IIC equivalent to Group A). FM 3600 has a maximum limit of copper content of alloy (30%) less than that is required by IEC (60%) for use in Class I, Group A (equivalent to Group IIC containing acetylene). For the enclosure material requirement for equipment in Group A classified locations, IEC 60079-0 does not meet the requirements in FM 3600.
- Alloys containing more than 7.5% magnesium and titanium are prohibited by FM 3600. IEC 60079-0 also specifies limitations for each Equipment Protection Levels (EPL Ga, Gb, Gc). As per Clause 8.3 of IEC, the materials used in the enclosure of Group II electrical equipment is not to contain by mass more than: 7.5% in total of magnesium, titanium and zirconium for Gb; for Ga, in addition to the restriction listed for Gb, 10 % in total of aluminum, magnesium, titanium and zirconium.

Based on the assessment above, IEC 60079 does not meet FM 3600 requirements for metallic enclosures.

5.1.5 Operations Requirements

The operations requirements in FM 3600 include manufacturers' quality control program and surveillance audit program. The quality control program includes requirements for design quality, conformance to design and performance. Design quality is determined during the examination and tests. Conformance to design is verified by control of quality in the areas of corporate quality control guidelines, incoming inspection, in-process inspection, final inspection and tests, equipment calibration, drawing and change control, packaging and shipping. Quality performance is determined by field performance and re-examination and test. A system of product configuration control and dedicated personnel assignments are required to be established. The surveillance audit program includes inspection of the product manufacturing facility and unannounced follow-up inspections.

IEC 60079-0 defines manufacturers' responsibilities in Clause 28 and type tests and routine tests requirements in Clauses 26 and 27 respectively. The manufacturer is required to carry out the verification tests specified in the standards, prepare or have prepared certificates and make marking per the requirements as specified in Clause 29.

The IEC 60079 series of standards alone do not cover manufacturing quality control, and independent third party verification. Therefore, IEC 60079 series does not meet all aspects of FM 3600 operations requirements.

5.1.6 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-0 meet, exceed, or do not meet the requirements of FM 3600.

IEC 60079-0 ***meets*** the requirements outlined in FM 3600 in the following subject areas:

- Introduction
    - Scope
    - Applications
- General information
    - Normal Atmosphere Conditions
    - Mechanisms of Ignition
    - Classification & Grouping System
- Performance Requirements
    - Non-Metallic Enclosure Materials – Chemical compatibility

IEC 60079-0 ***does not meets*** the requirements outlined in FM 3600 in the following subject areas:

- Introduction
    - Basis for Approval
- General Information
    - Applicability of other Standards
- Marking Requirements
- Performance Requirements
    - Metallic Enclosure Materials - Reactance
- Operation Requirements.

IEC 60079-0 ***exceeds*** the requirements outlined in FM 3600 in the following subject areas. However, these differences have no major impact. For electrical equipment for Class I, Zones 0, 1 or 2, it is required by FM 3600 that the requirement in ANS/ISA 60079 standards referenced in FM 3600 Clause 1.2.2 be complied with. The ANSI/ISA 60079 series are identical to the IEC 60079 series except for the U.S. National differences. The comparison results of ISA 60079-0 and IEC 60079-0 is included in section 3.1 of this report.

- Performance Requirements
    - Mechanical Strength (Resistance to Impact)
    - Non-Metallic Enclosure Materials – Aging

Based on the differences identified, it can be concluded that although IEC 60079-0 exceeds some requirements in FM 3600, the IEC standard does not meet the requirements of FM 3600 in the sections identified above.

5.2 FM 3610 vs IEC 60079-11 - Explosive Atmospheres - Part 11: Equipment protection by intrinsic safe

Table 22 provides a summary of the comparison assessment of the requirements between the FM 3610 and the IEC 60079-11. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the two standards. Appendix R contains the consolidated comparative assessment and results.

Table 22: FM 3610 vs IEC 60079-11 - Explosive Atmospheres - Part 11: Equipment protection by intrinsic safe

Section Title / Subject Issue	Baseline Standard FM 3610	International Standard IEC 60079-11	Analysis Results
Introduction Scope Basis for Approval	1 1.2.1, 2 1.3, 1.4, 1.5	 1 6.1	 Type 2 - Meets Type 3 - Does Not Meet
Apparatus for Class I locations	ANSI 60079-11	IEC 60079-11	(see Section 3.8)
Marking	5	12	Type 3 - Does Not Meet
Operations Requirements	6	IEC 60079-0 28	Type 3 - Does Not Meet

5.2.1 Introduction

Scope

FM 3610 defines the approval criteria for intrinsically safe apparatus intended for use in, and associated apparatus for connection to classified locations.

For intrinsically safe equipment and circuits for used in Class I, Division 1, Group A, B, C and D hazardous locations, FM 3610 refers to U.S. nationalized version of IEC 60079-11 (ANSI/ISA 60079-11, 2014) for Category “ia”, Group IIC, IIB and/or IIA, except equipment marking requirements are modified in Clause 5 of FM 3610. FM 3610 also defines the specific requirements for intrinsically safe equipment and circuits for use in Class II and III.

The scope of IEC 60079-11 includes the construction and testing of intrinsically safe apparatus for use in an explosive atmosphere and for associated apparatus, which is intended for connection to intrinsically safe circuits that enter such atmosphere. The standard is also applicable to electrical equipment or parts located outside the explosive atmosphere or protected by another type of protection where the intrinsic safety of the electrical circuits in the explosive atmosphere may depend upon the design and construction of electrical equipment or parts of electrical equipment. The requirements for intrinsically safe systems are provided in IEC 60079-25.

Basis for Approval

See the discussion in Section 5.1.1 of this report.

5.2.2 Apparatus for Class I Locations

The detailed comparison analysis between ANSI/ISA 60079-11 and IEC 60079-11 is given in Section 3.8 of this report.

5.2.3 Marking

In addition to the general marking requirements specified in FM 3600, specific marking for intrinsically safe apparatus are required:

- FM 3610 marking for intrinsically safe apparatus provides limited information, while IEC 60079-11 marking with ia, ib and ic provide protection level and suitability to Zone classification
- Some parameters are not mentioned in FM 3610, which are required by IEC 60079-11, such as Uo, Um, IP, etc.
- FM 3610 requirements for associated apparatus are more detailed than IEC 60079-11
- FM 3610 provides more warnings examples for repair, maintenance and operational concerns

Based on the assessment above regarding marking it can be concluded that IEC 60079-11 does not meet the requirement in FM 3610.

5.2.4 Operations

Similar to the requirements in FM 3600 (Section 5.1.5), the operations requirements in the FM 3610 include manufacturers' quality assurance program and surveillance audit program. Documentation of quality control program, manual, records, and drawing and change control are also required. Surveillance audit includes continued conformance verification both by re-examining and field performance.

In addition to the manufacturer's responsibilities requirements in IEC 60079-0, documentations for specific information related to intrinsically safe equipment are required in IEC 60079-11, including electrical parameters, special instruction for installation, live maintenance, environmental conditions, etc.

As mentioned below in Clause 6.1.3, the IEC 60079 series alone do not cover manufacturing quality control, independent third party verification. Therefore, the IEC 60079 series does not meet all aspects of FM 3610 operations requirements.

5.2.5 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-11 meet, exceed, or do not meet the requirements of FM 3610.

IEC 60079-11 ***meets*** the requirements outlined in FM 3610 in the following subject areas:

- Introduction
  - Scope
- Apparatus for Class I location (6 items), see Section 3.8 for ISA 60079-11 vs IEC 60079-11 analysis

IEC 60079-11 ***does not meet*** the requirements outlined in FM 3610 in the following subject areas:

- Introduction - Basis for Approval
- Apparatus for Class I location (5 items),see Section 3.8 for ISA 60079-11 vs IEC 60079-11 analysis
- Marking
- Operations Requirements

Based on the differences identified, it can be concluded that the requirements in IEC 60079-11 do not meet the FM 3610 requirements in the sections identified above.

5.3 FM 3611 vs IEC 60079-15 Explosive atmospheres – Part 15: Equipment protection by type of protection "n"

Table 23 provides a summary of the analysis of the requirements for Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations. Subsequent discussions below provide a comprehensive analysis of the differences between the FM 3611 and the associated sections of the international standards IEC 60079-15.

Table 23: FM 3611 vs IEC 60079-15 Explosive atmospheres – Part 15: Equipment protection by type of protection "n"

Section Title / Subject Issue	Baseline Standard FM 3611	International Standard IEC 60079-15	Analysis
Introduction			
Basis for Approval	1.2, 1.3, 1.4	1	Type 3 - Does Not Meet
Applicability of other standards	2.2	2	Type 3 - Does Not Meet
Marking	FM 3611 / 3 ISA 12.12.01 / 9	12	Type 2 – Meets
Operation Requirements	6 FM 3600	13 IEC60079-0 26, 27, 28	Type 3 - Does Not Meet
Comparison of **ISA 12.12.01**	**ISA 12.12.01**		
General Requirements	4	6	Type 2 – Meets
Equipment for Class I, Div. 2			
Enclosure	5.2	6.3	Type 2 – Meets
Fuses	5.3, 5.4	9	Type 3 - Does Not Meet
Circuit Breaker	5.5	17	Type 2 - Meets
Batteries & equipment	5.6	12	Type 1 – Exceeds
Nonincendive Circuits & Field Wiring	7.1	60079-11 10, 6	Type 2 – Meets

Section Title / Subject Issue	Baseline Standard FM 3611	International Standard IEC 60079-15	Analysis
Non-arching Components	8	7, 9,	Type 1 - Exceeds
Surface temperature requirements	10	5	Type 2 – Meets
Spark ignition testing			
Nonincendive Circuit	11	60079-11	Type 1 - Exceeds
Enclosed Break devices	14	17	Type 3 - Does Not Meet
Sealed Devices	13	19	Type 1 - Exceeds
Portable Equipment	16	22.3.1.2	Type 2 – Meets

5.3.1 Introduction

FM 3611 defines approval standard for nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations. Nonincendive equipment includes equipment having electrical / electronic circuitry that is not capable of, under normal operating conditions, causing ignition of a specified gas, vapor mixture due to arcing or thermal means.

IEC 60079-15 standard is applicable to non-sparking electrical equipment and also to electrical equipment with parts or circuits producing arcs or sparks or having hot surfaces which, if not protected in one of the ways specified in this standard, could be capable of igniting a surrounding explosive gas atmosphere. IEC 60079-15 provides the requirements for the construction, testing and marking for Group II electrical equipment with type of protection “n” for use in explosive atmospheres. Type of “n” include “nA” for Non-Sparking, “nC” enclosed-break device/hermetically-sealed device/non-incendive component/sealed device and “nR” Restricted breathing enclosure.

Basis for Approval

See the discussion in Section 5.1.1 of this report.

Applicability of other Standards

FM 3611 adopts the requirements of ISA 12.12.01 *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations* as the basis and adds additional marking and operational requirements. The most updated version of ISA 12.12.01 was published in 17 November 2015, as ANSI/ISA-12.12.01-2015.

In IEC 60079-15, there are 37 standards listed as indispensable normative references. Among these, the requirements (techniques and apparatus) in IEC 60079-11 are often used in IEC 60079-15, which is compared with FM 3610 (section 5.2 of this report). The detailed comparison between ISA 12.12.01 and IEC 60079-15 is provided in Section 5.3.3 of this report.

As stated in Section 5.1.2 of this report, verification of the compliance with the requirements for electrical equipment in ordinary locations is not required in IEC 60079 series; however, is required by the FM standard. Therefore the IEC standard does not meet FM 3611 requirements regarding the verification of safety of electrical equipment in ordinary locations.

5.3.2 Operation Requirements

The Operation Requirements in FM 3611 refer to FM 3600 without specific provisions for non-incendive equipment. The analysis and conclusions discussed in Section 5.1.5 are also applicable for this comparison. Therefore, IEC 60079 series does not meet all aspects of FM 3611 operations requirements.

5.3.3 Comparison Analysis for ISA 12.12.01 vs IEC 60079-15

Equipment for Class I, Division 2

Equipment and its usages considered by ISA 12.12.01 and FM 3611 includes normally nonarching components, nonincendive components, sealed devices, enclosed-break device and their usage in a nonincendive circuit. All these components and applications are also addressed in IEC 60079-15.

Enclosures

ISA 12.12.01 has generic requirements for enclosures to provide a suitable degree of protection against deterioration of the equipment for use in Class I, Division 2 locations. IEC 60079-15 specifies minimum required IP ratings for various application. As such, the requirements in the two standards are equivalent.

Fuses

ISA 12.12.01 requires that fuses used in circuits that are subject to overloading in normal use be housed in an enclosure suitable for Division 1 location, evaluated in accordance with type of protection listed, with operating element immersed in oil or to be a nonindicating, filled, current-limiting type. For replaceable fuses accessible from outside the enclosure without using a tool, ISA 12.12.01 requires a switch suitable for the location to be installed so that power to fuses can be removed before replacement. IEC 60079-15 requires fuses to be non-spark devices and specifies the requirements on temperature class, fuse mounting, interlock for enclosure opening, and replacement identification. The requirement in ISA 12.12.01 is more stringent than the requirements in IEC 6079-15. It is concluded that IEC 60079-15 does not meet ISA 12.12.01 requirement for fuses.

Batteries and battery powered equipment

ISA 12.12.01 requires that the batteries accessible to operator and ignitable to specific gas mixture shall have the current limiting components enclosed, marked with rating and warning, and include battery changing instructions. IEC 60079-15 specifies more comprehensive requirements for three types of batteries (Type 1, Type 2 and Type 3 cells and batteries). IEC has requirement regarding maximum capacity, connections, charging and discharging modes, creepage and clearance, containers, ventilation and seals. ISA standard do not have similar requirements. Based on the assessment, IEC 60079-15 exceeds the requirements in ISA 12.12.01 for batteries and battery powered equipment.

Non-Arching Components

ISA 12.12.01 has included requirements for components that are considered as nonarching in normal operation; such as connectors, plug-in components, plug-in fuses, circuit breakers, lamps and cables assemblies to equipment. IEC 60079-15 has equivalent requirements for most components, but specifies more details for pluggable connection, lamps, etc. For example, ISA 12.12.01 requires that lamps shall be removable only with tools, and also requires a warning be provided. IEC 60079-15 specifies the detailed requirements on constructions, lamp holder, starters, and ballasts, which are not mentioned in the ISA standard. Based on the assessment, IEC 60079-15 exceeds the requirements in ISA 12.12.01 for non-arching components.

Spark Ignition Testing

<u>Nonincendive circuit</u>

ISA 12.12.01 requires that testing be conducted with spark test apparatus complying with ISA 60079-11, which is the same as required by IEC 60079-11, and based on a 1.0 safety factor. IEC60079-11 defines the safety factors for various applications and conditions, with a safety factor of 1.5 is used for several cases, exceeding that of the ISA standard. Based on the assessment, IEC 60079-15 exceeds the requirements in ISA 12.12.01 for nonincendive circuits.

<u>Enclosed Circuit Breaker</u>

Test methods for enclosed break devices defined in ISA 12.12.01 and IEC 60079-11 are the same except for test gas mixture and their concentrations defined in ISA and IEC are different, as shown in Table 35. Therefore the test conditions defined in ISA 12.12.01 are more stringent than in the IEC standard. Based on the assessment, IEC 60079-15 does not meet the requirements in ISA 12.12.01.

Table 24: Test methods for enclosed break devices

ISA required test gas mixture	IEC required Test gas mixture
Group D: (55+/- 0.5)% H2/air at atm. pressure	group IIA: (6.5+/-0.5)% ethylene/air atm. Pressure
Group C: (37+/-0.5)% H2/air at atm. Pressure	group IIB: (27.5+/-1.5)% H2/air atm. Pressure
Group A, B: (40+/-1)% H2, (20+/-1)%O2, atm. or (27.5+/-1.5)% H2 at 1.5 atm. pressure	group IIC: (34+/-2)% H2, (17+/-1)% O2 or (27.5+/-1.5)% H2/air at overpressure 500 mbar.

Sealed Devices

ISA 12.12.01 requires sealing material to have continuous operation temperature (COT) at least equal to maximum and minimum service temperatures. IEC 60079-11 requires gaskets and seals to have a COT at least 10°K higher than the service temperature, and 20°K higher when equipment operating in the most onerous rated service conditions. Minimum temperature is not mentioned. For suitability to environmental conditions, the ISA standard requires consideration of atmosphere contaminations and corrosive compounds, which is not mentioned in IEC 60079-11. The test procedure for Air Leakage Tests is the same in ISA 12.12.01 and IEC 60079-11. IEC 60079-11 required water temperature is higher than the ISA standard (IEC 65°C vs. ISA 50°C). Overall, for sealed devices, IEC 60079 requirements exceed ISA 12.12.01.

5.3.4 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-15 meet, exceed, or do not meet the requirements of FM 3611.

IEC 60079-15 ***meets*** the requirements outlined in FM 3611 in the following subject areas:

- Marking
- General Requirements
- Equipment for Class I, Div. 2
  - Enclosure
  - Circuit Breakers
- Nonincendive Circuits and Field Wiring
- Surface temperature requirements
- Portable Equipment

IEC 60079-15 ***does not meets*** the requirements outlined in FM 3611 in the following subject areas:

- Introduction
  - Basis for Approval
  - Applicability of other Standards
- Operation Requirements
- Equipment for Class I, Div. 2
  - Fuses
- Spark ignition testing
  - Enclosed Break Devices

IEC 60079-15 ***exceeds*** the requirements outlined in FM 3611 in the following subject areas:

- Equipment for Class I, Div. 2
  - Batteries & Equipment
- Non-Aching Components
- Spark ignition testing
  - Nonincendive Circuit
- Sealed Devices

Based on the differences identified, it can be concluded that although IEC 60079-15 exceeds some of the applicable requirements in ISA 12.12.01 as referenced by FM 3611, the IEC standard does not meet the FM 3611 requirements in the sections identified above.

5.4 FM 3615 vs IEC 60079-1 Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "D"

Table 25 provides a summary of the comparison analysis of FM 3615 requirements for Explosion proof electrical equipment and IEC 60079-1 requirements for equipment protection by flameproof enclosures “d”. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the baseline domestic standards FM 3615 and the associated sections of the international standards IEC 60079-1.

Table 25: FM 3615 vs IEC 60079-1 Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "D"

Section Title / Subject Issue	Baseline Standard FM 3615 Section #	IEC Standard IEC 60079-1 Section #	Analysis Results
Introduction	1		
Scope	1.1	Foreword, 1	Type 2 - Meets
Basis for Approval	1.3, 1.4, 1.5, 1.6	1	Type 3 - Does Not Meet
Definitions	2	3	Type 2 - Meets
General Information	3		
Marking	3.1	4.1, 20	Type 3 - Does Not Meet
Documentation	3.2	5 through 11	Type 3 - Does Not Meet
Construction Requirements	3.3	5	
Enclosure mechanical strength	3.3.1	6	Type 2 - Meets
Enclosure Joints	3.3.2	13	Type 2 - Meets
Flame-path Dimension	3.3.3	17	Type 3 - Does Not Meet
Joint Materials	3.3.4	19	Type 1 – Exceeds
Gaskets	3.3.5	21	Type 1 – Exceeds
Cements	3.3.6	6.1	Type 1 – Exceeds
Flexible Cords and Bushings	3.3.7	13	Type 2 - Meets
Material for corrosion Protection	3.3.8	5.1	Type 2 - Meets
Joint Securing Fasteners	3.3.9	11	Type 2 - Meets
Enclosure Outdoor Locations	3.3.10	IEC 60529	Type 3 - Does Not Meet
Energized External Parts	3.3.11	17.2	Type 1 – Exceeds
Performance Tests & Evaluation	4.1	15	
Conduit Opening Torque test	4.2	19	Type 1 – Exceeds
Explosion Pressure tests	4.3	21	Type 2 - Meets
Flame propagation tests	4.4	26	Type 2 - Meets
Hydrostatic Tests	4.5	15	Type 3 - Does Not Meet
Impact Tests	4.6	60079-0/26	Type 1 – Exceeds
Flammability Test	4.7	19	Type 2 - Meets

Section Title / Subject Issue	Baseline Standard FM 3615 Section #	IEC Standard IEC 60079-1 Section #	Analysis Results
Operation Requirements	5	IEC 60079-0 28	Type 3 - Does Not Meet
References	6	2	Type 2 - Meets
Annex			
Group D- Min. widths/Max Gaps	Annex B/C	Table 2	Type 3 - Does Not Meet
Group C- Min. widths/Max Gaps	Annex D/E	Table 2	Type 3 - Does Not Meet
Group B- Min. widths/Max Gaps	Annex F/G	Table 3	Type 3 - Does Not Meet
Group A- Min. widths/Max Gaps	Annex H/I	Table 3	Type 3 - Does Not Meet
Threaded Joint Groups	Annex J	Table 4 & 5	Type 2 – Meets
Shaft/Rod - Sleeve/Bearing Joints	Annex K	Fig. 1 to. 13	Type 2 - Meets

5.4.1 Introduction

Scope

The term "Explosionproof equipment" is used in FM 3615, which is the same definition used by NEC Article 100. FM 3615 contains three aspects – equipment enclosed in a case that is capable of 1) withstanding an internal explosion of a specified gas or vapor-in air atmosphere; 2) preventing the ignition of a specified gas or vapor-in-air surrounding the enclosure due to spark, flashes or internal explosion; 3) operating at temperatures which will not ignite the surrounding atmosphere.

IEC 60079-1 uses the term "flameproof" enclosure containing two aspects: enclosure can 1) withstand the pressure developed during an internal explosion of an explosive mixture; 2) prevent the transmission of the explosion to the explosive gas surrounding the enclosure. Although operating temperature is not mentioned in the definition, it is required to be indicated on the marking for certified equipment. Therefore, the scope of FM 3615 is covered by IEC 60079-1.

Basis for Approval

See the discussion in Section 5.1.1 of this report.

5.4.2 General Information

Marking

In addition to the marking requirements in FM 3600, FM3615 requires three precautionary warning information to be placed on the equipment. FM 3615 and FM 3600 also refers to ISA 60079-1. The marking requirement in ISA 60079-1 is applicable for electrical equipment for Class 1, Zone 0, 1, or 2 hazardous locations. The comparison of marking requirements between IEC and ISA 60079 series of standards are summarized in section 4 of this report. Although it may be considered that IEC 60079-1 does not meet FM 3615 and ISA 60079-1 for marking due to the differences between the standards, it should have no material effect on the safety level of equipment operation.

Documentation for Approval

FM 3615 provides a list of documentation to be submitted for approval procedures. IEC 60079-0 does not provide any attestation of conformity itself, and no submission of documentation is specified in standards. However, information related to construction is contained in various sections of the IEC standard. Independent certification bodies can request documentation for verifying the compliance. Based on the assessment IEC 60079-1 does not meet the requirements in FM 3615 for documentation of approval.

5.4.3 Construction Requirements

FM 3615 specifies the construction requirements in the following aspects for explosion-proof equipment:

- enclosure mechanical strength,
- enclosure joints,
- flame path dimension,
- joint material (non-metallic),
- gaskets,
- cements,
- flexible cords and bushing,
- material applied to joint surface for corrosion protection,
- joint securing fasteners,
- enclosure requirements for outdoor classified location,
- energized parts.

A comparison between these aspects of FM 3615 to IEC 60079-1 corresponding requirements is summarized below.

Flame-path Dimensions

The table in FM 3615 for maximum experimental safe gap (MESG) has been derived from IEC 60079-1. Although IEC 60079-1 has more detailed and comprehensive data than FM 3615, but for the same length, FM 3615 required gaps are smaller than the IEC standard, thus FM 3615 requirements are more stringent than IEC 60079-1 (See also the discussion in the Section 5.4.6 Annex of this report for more information on this same topic). Based on the assessment IEC 60079-1 does not meet the requirements in FM 3615 for flame path dimensions.

Joint Material – Non-Metallic Enclosures

FM 3615 requires chemical compatibility and aging in accordance with FM 3600, in addition, flame resistance tests are required by FM. IEC 60079-1 has similar requirements for chemical compatibility and aging. In addition, IEC 60079-1 requires resistance to tracking and creepage distances on internal surfaces of the enclosure walls, which is not covered by FM 3615. Comparing with FM 3615 flame resistance tests, the tests in the IEC standard are specifically designed for various gas types. In summary, based on the assessment IEC 60079-1 exceeds the requirements in FM 3615 for joint material – non-metallic enclosures.

Gaskets

FM 3615 and IEC 60079-1 have similar requirements; permissible gap and length of the joint shall be maintained with and without gasket; secureness of cover shall not be dependent upon gaskets. For gaskets contributes to explosion, IEC 60079-1 requires the minimum width of cylindrical parts be maintained before and after compression; while the FM standard permits non-metallic gaskets to cushion a lens and requires them to meet non-metallic enclosure requirements. It can be considered that IEC 60079-1 requirements are more stringent than FM 3615. Based on the assessment IEC 60079-1 exceeds the requirements in FM 3615 for gaskets.

Cements (Sealing Adhesive and Poured Seals)

Both standards require that mechanical strength of assembly does not depend upon the cement alone and minimum joint length required are the same. FM 3615 defines softening point of sealing material, which is not mentioned by IEC 60079-1 which requires over-pressure test with water, which is not required by FM 3615. Comparing these two differences, since temperature tests are covered in IEC 60079-0, and over pressure tests is not covered by FM 3615, the IEC 60079-1 requirement is more stringent than FM 3615. Based on the assessment IEC 60079-1 exceeds the requirements in FM 3615 for cements.

Enclosure requirements for outdoor classified locations

FM 3615 requires enclosures to meet ANSI/NEMA 250 and flame path be protected against corrosion. IEC 60079-1 doesn't specify the same. It is understood that ingress protection standard IEC 60529 will be applied. Therefore, the IEC 60079-1 does not meet the requirement in FM 3615.

Energized external parts

FM 3615 requires that any energized part of explosion-proof equipment not protected by the explosion proof enclosure shall be protected using intrinsically safe type protection per FM 3610. IEC 60079-11 has requirements for intrinsically safe protection type. IEC 60079-1 provides requirements for more types of equipment such as switchgear. Therefore, IEC 60079-1 exceeds FM 3615 requirements.

5.4.4 Performance Tests & Evaluation

In Section 4 of FM 3615, sample preparations and test procedures are defined for evaluation of enclosure explosion-proof performance. Comparison analysis of these test procedures with IEC 60079-1 defined tests is summarized as follows:

Conduit Opening Torque Test

Torque test values for NPT thread are same in both FM and IEC standards. IEC 60079-1 also provides metric system value. Additionally, IEC provides values for stopping plugs (higher than thread adapter), which are not included in the FM 3615.

Hydrostatic Tests

Hydrostatic Type Test: FM 3615 requires test pressure to the highest ignition pressure obtained from explosion pressure test multiplied by safety factors given in Table 6 for various moldings and materials. IEC 60079-1 provides various options for overpressure tests: static and dynamic. Static overpressure test in IEC 60079-1 is considered as less stringent than FM 3600; although the IEC standard takes a safety factor of 4, it allows a safety of 1.5 for certain conditions. Dynamic test is to use ignition test to 1.5 times maximum reference pressure, which is treated as equivalent to static test by IEC 600079-1. FM 3615 does not have dynamic test procedure defined. Based on the assessment IEC 60079-1 does not meet FM 3615 for type test requirements.

Impact Tests

IEC 60079-1 provides more details for various groups of enclosures for impact tests as well as more stringent test conditions than FM 3615. Therefore IEC 60079-1 exceeds the FM 3615 for impact tests.

5.4.5 Operation Requirements

Operation requirements in FM 3600 are referred as applicable. As discussed in the analysis for FM 3600 and IEC 60079-0 (Section 5.1), the IEC 60079 series alone does not cover manufacturing quality control or independent third party verification. Therefore, IEC 60079 series does not meet all aspects of FM 3615 operations requirements.

5.4.6 Annex

FM 3615 Annexes provide further detailed information about flame-path dimension in terms of Minimum Widths/Maximum Gaps for Group A, B, C, D. As discussed in Section 5.4.3, in many cases, FM required maximum gaps are smaller than IEC required ones. FM 3615 and other U.S. standards apply additional margin of safety or take more conservative approach in this perspective. Based on the assessment IEC 60079-1 does not meet the requirements in FM 3615 for flame path dimensions.

5.4.7 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-1 meet, exceed, or do not meet the requirements of FM 3615.

IEC 60079-1 ***meets*** the requirements outlined in FM 3615 in the following subject areas:

- Introduction
  - Scope
  - Definitions
- Construction Requirements
  - Enclosure mechanical strength
  - Enclosure joints
  - Flexible cords and bushings
  - Material for corrosion Protection
  - Joint securing fasteners
- Performance Tests and Evaluation
  - Explosion pressure tests
  - Flame propagation tests
  - Flammability test
- References
- Annex
  - Threaded Joint Groups
  - Shaft/Rod - Sleeve/Bearing Joints

IEC 60079-1 ***does not meet*** the requirements outlined in FM 3615 in the following subject areas:

- Introduction
  - Basis for approval
- General information
  - Marking
  - Documentation
- Construction requirements
  - Flame-path dimension
  - Enclosure outdoor locations
- Performance Tests and Evaluation
  - Hydrostatic tests
- Operation Requirements
- Annex
  - Group D- Min. widths/Max Gaps
  - Group C- Min. widths/Max Gaps
  - Group B- Min. widths/Max Gaps
  - Group A- Min. widths/Max Gaps

IEC 60079-1 ***exceeds*** the requirements outlined in FM 3615 in the following subject areas:

- Construction Requirements
  - Joint Materials
  - Gaskets
  - Cements
  - Energized External Parts
- Performance Tests and Evaluation
  - Conduit opening torque tests
  - Impact tests

Based on the differences identified, it can be concluded that although IEC 60079-0 exceeds some requirements in FM 3615, the IEC standard does not meet the requirements FM 3615 in the sections identified above.

5.5 FM 3620 vs IEC 60079-2 Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "P"

Table 26 provides a summary of the analysis of purged and pressurized electrical equipment for classified locations requirements. Subsequent discussions below provide a comprehensive analysis of the differences, as noted, between the two standards.

Table 26: FM 3620 vs IEC 60079-2 Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "P"

Section Title / Subject Issue	Baseline Standard FM 3620	International Standard IEC 60079-2	Analysis Results
Introduction Scope Basis for Approval Definitions	 1.2 1.3, 1.4, 1.5 2	 1 Forward 3	 Type 2 - Meets Type 3 - Does Not Meet Type 2 - Meets
General Information Marking Documentation for Approval	 3.1 3.2	 1 2	 Type 3 - Does Not Meet Type 3 - Does Not Meet
Performance & construction requirements (FM Clarification: NFPA 496 requirements) Enclosure Overpressure Enclosure Windows Compartmentalized Enclosure Air as the Protective Gas Inert Gas as the Protective Gas	 4.1 4.2 NFPA496: 4.3.1.1 NFPA496: 4.3.1 NFPA496:5.4, 5.5.1 NFPA496:5.4, 5.5.1 NFPA496:5.4, 5.5.1	 4 through 17 16 5.2, 5.3 5.5, A.1 16.4.2, A.2 16.4.3, 26.5	 Type 3 - Does Not Meet Type 1 - Exceeds Type 2 - Meets Type 2 - Meets Type 2 - Meets

Section Title / Subject Issue	Baseline Standard FM 3620	International Standard IEC 60079-2	Analysis Results
Operations Requirements	5	IEC 60079-0 28	Type 3 - Does Not Meet
References	6	2	Type 2 - Meets
Comparison analysis between NFPA 496 and IEC 60079-2			
General Requirements for Pressurized Enclosures Enclosures (modified by FM 3620) Pressurizing Systems Protective Gas System Determination of temperature marking Type Z Pressurizing Type Y Pressurizing Type X Pressuring	**NFPA 496** 4 4.3 4.3.1 to 4.3.4 4.5 4.6 to 4.8 4.9 4.104.11 4.12	 5.1 5.2 to 5.5, 5.8 7.11 to 7.15, 19 7, 8, 9, D3 5.2, 6 7.4.1, 7.11 7.4.2, 7.10. 7.4.3, 7.15	 Type 3 - Does Not Meet Type 1 - Exceeds Type 2 - Meets Type 2 – Meets Type 1 - Exceeds Type 2 – Meets Type 2 - Meets
Marking	**NFPA 496** 4.12.1 4.12.2 4.12.3 4.12.4 4.12.5 4.12.6	18	Type 3 - Does Not Meet
Pressurizing Enclosures for Class I General Requirements Marking Additional requirements: Y / Z This section is modified by FM 3620 Additional requirements: X type This section is modified by FM 3620	**NFPA 496** 5.1 5.2, 5.2.6 5.3 5.4 5.5.1	5, 7, 8 7.8 c), 7.12 18 7.5, 7.7, 5.3.3	 Type 2 – Meets Type 3 - Does Not Meet Type 1 - Exceeds Type 2 - Meets
Pressurized enclosures w/ internal source flammable gas General requirements Specific Requirements	**NFPA 496** 8.1 8.2 8.3	 10 4, 11 to 15 5, 7, 8, 13 to 17 Annex F	 Type 2 - Meets Type 1 - Exceeds

5.5.1 Introduction

Scope:

The scope covered in FM 3620 includes purged and pressurized electrical equipment (not including purged and pressurized control rooms) and purged and pressurized electrical equipment having an internal source of gas or vapor.

The Scope of IEC 60079-2 includes the same topics, and specifies the exclusions of enclosures having containment system releasing oxygen content greater than 21%, pressurized enclosures where explosive dusts, hybrid mixtures, etc. are present.

Basis for Approval:

See the discussion in Section 5.1.1 of this report.

Definitions:

FM 3620 defines three types of pressurizing X, Y, Z and allows to reduce the classification within the protected enclosure, such as Division 1 to unclassified (X), to Division 2 (Y), from Division 2 to unclassified (Z).

IEC 60079-2 uses level of protection “pxb”, “pyb”, “pzc” selected based upon the Equipment Protection Level required (MB, GB, Db, Gc or Dc), whether there is the potential for an internal release and whether the equipment within the pressurized enclosure is ignition-capable, as listed in IEC 60079-2 Table 1. Protection level in the IEC standard focuses on the hazards the equipment may face and the techniques to address the concern. No general statements for reducing hazardous classification are given in NEC. But the final results are the same, proper protection measures or techniques are to be used to ensure the equipment is capable of operating safely in the environmental conditions anticipated. IEC 60079-2 and FM 3620 use different terms for describing the same subject.

FM 3620 uses ANSI/NFPA 496-2013 *Standard for Purged and Pressurized Enclosures for Electrical Equipment* as the basis for approval. Some modified requirements are specified in FM 3620. This standard is used in conjunction with FM 3600.

IEC 60079-2 is a part of IEC 60079 series, all other related parts in this series, such as part 0, 11, 15, as well as other IEC standards for electrical equipment in ordinary conditions are listed as indispensable references.

5.5.2 General Information

Marking

Comparison of marking requirements between IEC 60079-2 and NFPA 496 is included Section 5.5.6 below.

Documentation for Approval Examinations:

FM 3620 provides a list of documentation to be submitted for approval procedures. IEC 60079-2 does not provide any attestation of conformity itself, and no submission of documentation is specified its standards. However, information related to construction is contained in requirements in various Clauses of the IEC standard. Independent certification bodies can request documentation for verifying the compliance. Based on the assessment IEC 60079-2 does not meet the requirements in FM 3620 for documentation of approval.

5.5.3 Performance and Construction Requirements (Clarification of ANSI/NFPA 496 Requirements)

FM 3620 uses ANSI/NFPA 496-2013 as the basis for approval for purged and pressurized electrical equipment. Some clarifications on the requirements are made by FM 3620 as listed following sections.

NFPA 496: 4.3.1.1 – Enclosure over-pressure

FM 3620 requires that enclosures can sustain an overpressure at greater of 300% of pressure relieving setting or of the maximum enclosure operating pressure. Compliance verification tests are required to be conducted for 1 minute. In addition, FM 3620 requires pressure relieving device in pressure supply line if a pressure reducing valve is in the supply line.

IEC 60079-2 requires the manufacturer to define the maximum overpressure rating for the enclosure, and overpressure tests are to be conducted at 1.5 times the maximum overpressure rating or 200 Pa, whichever is the greater for 2 minutes. Based on the assessment IEC 60079-2 does not meet the requirements in FM 3620 for enclosure over pressure.

NFPA 496: 4.3.1 – Enclosure Windows

As per Clause 4.2 of the FM 3620 standard, the requirements for mechanical strength resistance to impact (referenced in FM 3600 Clause 4.1) is considered not applicable to purged and pressurized equipment as the required interlocks and alarms would provide fail-safe conditions. In Table 2 of IEC 60079-2, it is indicated that the resistance of enclosure to impact is required for pressurized enclosures. It is also noted that IEC 60079-2 does not provide any exemption similar to FM 3620 for enclosure windows. Based on the assessment it is concluded that IEC 60079-2 exceeds the requirements in FM 3620 for enclosure windows.

5.5.4 Operation Requirements

The operation requirements in FM 3620 Clause 5.0 refer to FM 3600 Clause 5.0. In addition to the general requirements specified in IEC 60079-0, the IEC standard requires that the instructions to be provided to the users regarding the protective gas and any alternative permitted. Recommendations with respect to pressurization are provided in Annex D of IEC 60079-2.

The detailed analysis for other respects of operation is given in Section 5.1.5 of this report. Therefore, IEC 60079 series does not meet all aspects of FM 3620 operations requirements.

5.5.5 General Requirements for Pressurized Enclosures

Enclosure

Enclosure outlet for protective gas

NFPA 496 requires normal discharge of the protective gas from the enclosure outlet to be to unclassified locations, or Division 1 or 2 if the outlet is design to prevent the discharge of ignition-capable particles. IEC 60079-2 requires that spark and particle barriers are to be provided for the protective gas, unless make/break contacts operate at less than 10A, 275 VAC or 60 VDC. NFPA 496 makes distinction between divisions; IEC 60079-2 focuses on operating conditions of electrical equipment. Same hazard is addressed by both standards in different ways. They can be considered as equivalent.

Conduit to pressurized enclosure

NFPA 496 requires an explosion-proof conduit seal for Division 1 location if the conduit is not pressurized as a part of the approved protection system. IEC 60079-2 requires that all cable and conduit connections to a pressurized enclosure shall be sealed to maintain the IP rating of the enclosure or be considered as part of the enclosure. NFPA's Explosion-proof conduit seal requirement are more stringent than IEC's IP rating requirement. Based on the assessment IEC 60079-2 does not meet the requirements in NFPA 496 for conduit to pressurized enclosures.

Pressurizing Systems

NFPA 496 requires that the enclosure shall be maintained at a pressure of 25 pa above the surrounding atmosphere during operation, while IEC 60079-2 requires an overpressure 50 Pa for "pxb" and "pyb", 25 Pa for "pzc". i.e. IEC 60079-2 has more stringent requirements than NFPA 496 in this aspect.

NFPA 496 also requires that failure of protective gas supply shall be alarmed for Type Y and Type Z protection. IEC 60079-2 requires safety device to detect loss of minimum overpressure for all levels of protection with more detailed requirements for sensor and alarm locations, piping connections, etc.

For Type Y protection, NFPA 496 requires that equipment within the protected enclosure is approved for Division 2 or Zone 2; and for Type X, all circuits and equipment within the enclosure that are not suitable for Division 1 or Zone 1 be de-energized upon failure of the protective gas supply. NFPA 496 requires that for Type Z protection, all components energized in absence of protective gas be identified. IEC 60079-2 requires equipment that may remain energized when level of protection "pxb" or "pyb" is not in operation be protected by EPL Ga or Gb for Gas Group II and the equipment that remain energized when level of protection "pzc" is not in operation be protected by EPL Ga, Gb, or Gc. Similar requirements are also specified for Group I and Group III gas in the IEC standard. The protections techniques in IEC 60079-2 are more stringent than NFPA 496.

Based on the assessment IEC 60079-2 exceeds the requirements in NFPA 496.

Type Z, Y, X Pressurizing

Type Z

NFPA 496 requires that detection, alarm and indicator are provided to indicate failure to maintain positive pressure in an enclosure. Also, requirements for valve, detector, alarm and indicator arrangement and location are specified in the standard. NFPA 496 requires that for Type Z protection, all components energized in absence of protective gas be identified; while IEC 60079-2 requires equipment that may remain energized when level of protection “pzc” is not in operation be protected by EPL Ga, Gb, or Gc. The protections techniques in IEC 60079-2 for “pzc” are more stringent than NFPA 496 Type Z. Based on the assessment, IEC 60079-2 exceeds NFPA 496 for Type Z requirements.

Type Y

NFPA 496 requirements for type Z are applicable, in addition, equipment within a protected enclosure shall be approved for Division 2 or Zone 2, electrical alarm actuators shall be identified for Division 1, ventilated equipment shall be automatically de-energized when the protective gas stop flow. IEC 60079-2 has similar requirements to “pyb” protection with their terminology, such as EPL Ga, Gb, Gc, automatic safety devices, etc. Overall from safety perspectives, IEC “pyb” protection can be considered as equivalent to Type Y in NFPA.

Type X

NFPA 496 requires automatic de-energizing all equipment inside enclosure upon failure of protective gas supply, actuated by flow or pressure sensor in protected enclosure; temperature sensor for equipment subject to overloading. Most of those requirements are covered in various Clauses of IEC 60079-2 for “pxb” protection, such as automatic safety devices, sensors for pressure flow. Temperature sensor and shutdown for overloading are not mentioned in the IEC standard, but flow control regulator, equipment with complex geometries, rotating machines, interlock for door and covers, etc. required by the IEC standard are not mentioned in NFPA. Overall from safety perspective, IEC “pxb” protection can be considered as equivalent to Type X in NFPA.

5.5.6 Marking

FM 3620 requires marking for purged and pressurized equipment in accordance with FM 3600 and NPFA 496. NFPA requires the following information:

- Warning for pressurized enclosure
- external area classification
- pressurization type
- Temperature code
- Warning for exceptions.

For pressurized enclosures in Class I location, start-up conditions are required, including protective gas flow rate and purging time.

In addition to the general marking information required in IEC 60079-0, IEC 60079-2 requires the following marking information:

- identifying as pressurized enclosure
- level of protection “pxb”, pyb or pzc or minimum quantity of protective gas (flow rate, purging duration)

- type of protective gas if other than air
- minimum and maximum overpressure
- minimum flow rate of protective gas
- minimum and maximum supply pressure to the pressurization system
- the maximum leakage rate from the pressurized enclosure
- temperature range for the protective gas at the inlet to the pressurized enclosure
- the point or points at which the pressure is to be monitored unless this is indicated in the relevant documentation.

FM standard requires Class and Division marking which is not required by IEC standard. FM 3620 and FM 3600 also refers to ISA 60079-2. The marking requirement in ISA 60079-2 are applicable for electrical equipment for Class 1, Zone 0, 1, or 2 hazardous locations. The comparison of marking requirements between IEC and ISA 60079 series of standards are summarized in section 4 of this report. Although it may be considered that IEC 60079-2 does not meet FM 3620 and ISA 60079-2 for marking due to the differences between the standards, it should have no material effect on the safety level of equipment operation.

5.5.7 Pressurized Enclosures for Class I

Additional Requirements for Type Y or Type Z Pressurizing

NFPA 496 requires that equipment shall not be energized until four enclosure volumes of the protective gas (ten volumes for rotating machinery) have passed through the enclosure. The internal pressure to be maintained at 25 Pa; IEC 60079-2 requests manufacturer to specify the minimum purge flow rate and time to satisfy test requirements with quantified gas concentration value, and IEC 60079-2 requires a minimum overpressure if 50 Pa for “pyb”, which is higher than required for Type Y in NFPA 496. Based on the assessment IEC 60079-2 exceeds the requirements in NFPA 496.

5.5.8 Pressurized Enclosures having an Internal Source of Flammable Gas or Vapor

NFPA 496 Chapter 8 specifies requirements for instruments such as chromatographs, gas analyzers, and other enclosures that contain an internal source of flammable gas or vapor. IEC 60079-2 Clauses 10 to 15 provide the release conditions, containment system design requirements, the pressurization techniques and the restrictions on ignition-capable equipment and internal hot surfaces. NFPA 496 has requirements for gas/vapor release, whereas the IEC standard has requirements for both gas and liquid releases. As such, IEC 60079-2 exceeds the requirements in NFPA 496.

5.5.9 Summary and Conclusion

Based on the comparative assessments in the above sections, various sections of the IEC 60079-2 meet, exceed, or do not meet the requirements of FM 3620.

IEC 60079-2 ***meets*** the requirements outlined in FM 3620 in the following subject areas:

- Introduction
  - Scope
  - Definitions
- Performance and Construction Requirements
  - Compartmentalized Enclosure
  - Air as the Protective Gas
  - Inert Gas as the Protective Gas
- References
- General Requirements for pressurized enclosures
  - Protective gas system
  - Determination of temperature marking
  - Type Y Pressurizing
  - Type X pressurizing
- Pressurizing Enclosures for Class I
  - General requirements
  - Additional Requirements: X type
- Pressurized enclosures with internal source flammable gas
  - General requirements

IEC 60079-2 ***does not meet*** the requirements outlined in FM 3620 in the following subject areas:

- Introduction
  - Basis for approval
- General Information
  - Marking
  - Documentation for approval
- Performance and construction requirements
  - Enclosure Overpressure
- Operations Requirements
- General requirements for pressurized enclosures
  - Enclosures (modified by FM 3620)

IEC 60079-2 ***exceeds*** the requirements outlined in FM 3620 in the following subject areas:

- Performance and construction requirements
  - Enclosure windows
- General requirements for pressurized enclosures
  - Pressuring system
  - Type Z Pressurizing
- Pressuring enclosures for Class I
  - Marking
  - Additional requirements : Y / Z
- Pressurized enclosures with internal source flammable gas
  - Specific requirements

Based on the differences identified, it can be concluded that although IEC 60079-2 exceeds some of the applicable requirements in NFPA 496 as referenced by FM 3620, the IEC standard does not meet the FM 3620 requirements in the sections identified above.

6. Test Standards in NRTLs vs IEC

This section provides a comparative analysis for the test standards in the Nationally Recognized Testing Laboratories (NRTLs) and the IEC standards for the electrical equipment for use in classified locations. U.S. test standards in the NRTLs are developed by the OSHA recognized organizations such as the ANSI, UL, ISA and FM. The electrical equipment for use in Hazardous (classified) locations requires NRTL approval as per OSHA 29 CFR 1910.307. A list of OSHA recognized standards for electrical equipment for use in classified locations and the NRTLs recognized for certifying to those standard is contained in Appendix V.

IEC 60079 series of standards is developed by IEC which provides general requirements and explosion protection techniques for electrical equipment in explosive atmospheres.

The comparative assessment of UL, ISA, FM standards for electrical equipment for use in hazardous area with IEC 60079 series of standards were performed and results are given in Task 3 report and Sections 3 through 5 of this report. One major difference identified from the assessment is regarding the requirement for verification of equipment for ordinary location standard.

6.1 Requirements for functional testing of equipment for ordinary location standards

In the IEC 60079 series of standards ordinary location requirements are referenced so that the equipment is constructed in accordance with the applicable safety requirements in these industry standards. However, a clarification is given that it is not a requirement in IEC 60079 series that the compliance with these industrial standard be verified.

In the U.S. standards, manufacturers must comply with the applicable requirements for similar equipment for use in ordinary (unclassified) locations in addition to the hazardous area requirements. U.S. standard ISA 60079-0 state that the equipment listed by NRTLs is considered to meet the applicable requirements found in the ordinary location standards.

U.S. standards for classified (hazardous) locations assessed in this project reference the requirements for electrical equipment to meet ordinary (unclassified) location standards. The references for these standards are listed in Table 27. IEC requirements are contained in IEC 60079-0 Clause 6.1, which has a guidelines to the manufacturer that the equipment be constructed in accordance with applicable safety requirement of the relevant industrial standard. The foot note in this section of the standard indicates that it is not a requirement of this standard to verify compliance with the industrial standard.

Table 27: US Requirements for Ordinary Location Standards

Baseline Standard
ISA 60079-0, Clause 6.1, Annex G The ISA standard is the nationalized version of the IEC standard. The Clause 6.1 of the standard is modified to include requirements for safety of electrical equipment in ordinary (unclassified) locations. Annex G is also included which list the commonly applied standards.
UL 913, Appendix B Appendix B lists the standards for equipment for ordinary locations
UL 674. Annex A and B. Motors and generators used in hazardous locations must comply with the standards listed Annex A for the appropriate country (U.S., Canada, or Mexico). Annex B lists the standards that components must comply with.
UL 823 Clause 2.1c Electric heater for use in hazardous locations shall also comply with the applicable requirements for similar product for use in ordinary locations
UL 844 Clause 2.1 Luminaires for use in hazardous locations shall also comply with the applicable requirements for similar product for use in ordinary (unclassified) locations
UL 1203, Clause 1.7 Equipment covered in the standard UL1203 for use in hazardous locations shall also comply with the applicable requirements for similar equipment for use in ordinary (unclassified) locations
FM 3600 Clause 2.3 Electrical equipment shall comply with applicable ANSI requirements for ordinary locations FM 3610, FM 3611 standard refers to FM 3600 Clause 2.3 for ordinary location requirements Other FM standards FM 3615 and FM 3620 refers to FM 3600 to be used in conjunction with the standard for application of requirements.

The IEC has developed various separate standards for electrical equipment for use in ordinary locations for regulatory bodies or independent testing laboratories to use. Appendix W provides a list of some of the OSHA and IEC standards for electrical equipment for use in both ordinary locations and in classified location.

Specific testing requirements for various electrical components depends on the type of certification that the manufacturer desires and are contained in the various standards. Manufacturer can certify equipment to one or more of the standards.

7. Hazardous Location Standards in IRF Member Countries

The International Regulators' Forum (IRF) is made up of 9 country members which include Australia, Brazil, Canada, Denmark, Mexico, The Netherlands, New Zealand, Norway, United Kingdom and United States. This forum provides international leadership on safety and safety-related regulatory matters for offshore installations. It provides a platform for sharing of regulatory practice and experience among the member countries. This section provides information on the electrical standards used by the offshore regulators in these countries.

7.1 Australia and New Zealand

In Australia, the National Offshore Petroleum Safety/Environmental Management Authority (NOPSEMA) established in 2012 is the national regulator for health/safety, well integrity & environmental management for oil and gas operations. In New Zealand, WorkSafe NZ is the agency that regulates the offshore industry. There is Australian/New Zealand standard AS/NZS 3000 (Electrical Installations – The Australian and New Zealand Wiring Rules) which contains the requirements for the electrical installations in hazardous areas. AS/NZS 3000 is the national electrical code which is similar to National Electrical Code in US. AS/NZS 3000 is aligned with IEC 60364-1 Low-voltage electrical installations.

IEC 60079 series standards are adopted with national variations, which are known as AS/NZS 60079 series standards. Australia is the one of the founding member country of the international IECEx schemes and recognizes IECEx scheme for hazardous area equipment. There is ANZEx Scheme (Australia/New Zealand Certification Scheme) which is similar to IECEx scheme and mutually accepts IECEx certificates. Safety cases are to be produced by the operator of an installation and assessed by NOPSEMA. It should be noted that safety cases for electrical equipment are based on IECEx schemes of certification

7.2 Brazil

The National Agency of Petroleum, Natural Gas and Biofuels is the federal agency that regulates the offshore industry. ABNT (Brazilian Association for Technical standards) sets the hazardous area standards. Brazil adopts international standards, including the IEC, without any national difference. IEC 60079 standards are translated to Portuguese as ABNT NBR IEC 60079. Brazilian Ex NBR IEC standards are fully harmonized with IEC 60079 Series. INMETRO, National Institute of Metrology, Quality and Technology plans and executes the activities of accreditation of calibration laboratories and testing, inspection and training. It develops the infrastructure of technological services in the country. It develops the conformity assessment programs in the areas of products involving the adoption of regulations. The other standards such as NEC and API are not officially allowed unless they are harmonized standards with IEC Ex scheme.

7.3 Canada

The Canada-Newfound and Labrador Offshore Petroleum Board manages the petroleum resources in the Newfoundland and Labrador offshore area on behalf of the governments of Canada, Newfoundland and Labrador. There are two other boards, Canada – Nova Scotia Offshore Petroleum Board and National Energy Board that oversee the offshore activities on behalf of the governments of Canada.

Regulations for oil and gas installations in Canada under the Canada Oil and Gas Operations Act are known as the Canada Oil and Gas Installations Regulations (SOR/96-118). SOR/96-118 refers to *API RP 500* for the classification of hazardous areas with respect to hazards caused by combustible gases on offshore platforms.

For hazardous areas, Class/Zone system are mandatory for new constructions since 1998. Class/Division system are permitted for existing facilities. The regulations also require that all equipment at or near a well, a process vessel, an oil storage tank or other source of ignitable vapor shall be constructed in accordance with Part I of the Canadian Electrical Code and the Oil and Gas Occupational Health and Safety Regulations. Under the Canadian Electrical Code, it refers to IEC standard 60092-3 and IEC standard 60092-332-3 for electrical wiring. For fire detection systems, it refers to National Fire Prevention Association, 72E. For portable gas detection, it refers to API RP 14C and API RP 14F.

7.4 Denmark and The Netherlands

Danish Working Environmental Authority (DWEA) is the government agency that oversees the offshore installations. In the Netherlands, State Supervision of Mines is the regulatory agency that oversees the offshore installations. Both regulatory agencies allow the use of IEC and ATEX standards for fixed offshore installations. Safety case is required for offshore facilities operating in Danish Continental Shelf in the North Sea. Use of the industry standards such as API 14F, API 14FZ, API 500 and API 505 is not allowed. Also, North American standards such as ANSI/UL and NEC are also not allowed. However, the regulations allow performance based requirements rather than prescriptive requirements.

7.5 Mexico

Mexico has a national agency ASEA (Agency for Industrial Safety and Environmental Protection of the Hydrocarbons Sector), which regulates and supervises the industrial, operational safety and environmental protection of the facilities and activities related to hydrocarbon sector. Mexico adopted the NEC 2011 in November 2012 with the effective date of May 30, 2013. Hence, for hazardous locations (special environments), NEC articles 500, 501, 504 and 505 should be applicable.

In Mexico, there are two main categories of regulations for energy known as Norma Official Mexicana (NOM) and Norma Mexicana (NM). IEC standards are adopted as Normas Mexicanas (NM). However, IECEx scheme is not accepted yet since there are no laboratories equipped for managing experiments for explosive atmosphere. The agency allows the use of ANSI/UL harmonized standards through the Harmonization of Electro technical Standards Council of the Americas (CANENA).

7.6 Norway

PSA is an independent government regulator that oversees the Norwegian petroleum industry. It conducts audits for offshore facilities and land based plants. Regulation of offshore facilities, they are called the Facilities Regulations which fall under the Framework Regulations. These regulations consists largely of risk and performance-based requirements.

PSA accepts the industry standards developed by the Norwegian petroleum industry. The authorities allow the use of various industry standards such as NORSOK, API or other normative documents with supplementary addendums provided in the guidelines. NORSOK standard is developed by the Norwegian petroleum industry. NORSOK Standard E-001 for electrical system is mainly based on the IEC 61892. A detailed analysis of IEC 61892 compared to API 14F and API 14FZ is provided in task 2 report. In areas where industry standards are not published or these are not found satisfactory, the authorities will describe solutions in the guidelines to fulfil the regulatory requirements.

7.7 United Kingdom

In United Kingdom, the agencies that oversee the offshore installation is the Health and Safety Executives (HSE) along with the Offshore Petroleum Regulator for Environment and Decommissioning. The Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996 are performance based regulations rather than prescriptive requirements.

Safety cases are required in accordance with the Offshore Installations (Offshore Safety Directive) Regulations 2015 (SCR 2015) under Directive 2013/30/EU of The European Parliament and of the Council of 12 June 2013 on Safety of offshore oil and gas operations. Within this Offshore Safety Directive, it refers to SOLAS, MARPOL and MODU Code.

For electrical equipment in hazardous areas, internationally recognized standards such as IEC, IECEx, NEC, API 14/14FZ/500/505 and the ANSI/UL are accepted. There is also Hazardous Installations Directorate which addresses specific topics such as source terms, ignition, fire/gas detection, dispersion and ventilation and so on.

8. Recommendations

The following recommendations are offered for BSEE's considerations;

1) BSEE should consider an interim approach of using an audit protocol to determining compliance with standards included in the comparative assessment. This approach would enable BSEE inspectors and engineers to determine compliance with standards not incorporated into BSEE regulations. Development of an audit protocol will be conducted during Task 5 of this project.
2) BSEE should provide training to inspectors and engineers on the ANSI/ISA 60079, the FM, and the IEC 60079 standards included in this report so that they are familiar with the various provisions in these standards.

3) BSEE should provide inspectors and engineers with a copy of this report so they can become familiar with the differences among the standards.
4) BSEE should obtain copies of the ANSI/ISA, the FM and the IEC standards referenced in this report for use by engineers and inspectors.
5) BSEE incorporates standards into federal regulation by reference in Title 30, Code of Federal Regulations Part 250.198. Since these regulations represent minimum requirements, BSEE may want to consider incorporating Clauses in the IEC 60079 that exceed the comparable Clauses in the ANSI/ISA 60079 into regulation by reference. Likewise, BSEE should consider incorporating Clauses of the ANSI/ISA 60079 that exceed the comparable Clauses of the IEC 60079 into regulations by reference.
6) BSEE may also want to consider incorporating Clauses in the IEC 60079 that exceed the comparable clauses of the FM standards into regulation by reference. Likewise, BSEE should consider incorporating Clauses in the FM standards that exceed the comparable Clauses of the IEC 60079 into regulation by reference.

9. Appendix A. ANSI/ISA 60079 vs IEC 60079 - Part 0: Equipment – General Requirements

Table 28 provides a summary of the comparative assessment between the ANSI/ISA 60079-0 and the IEC 60079-0. This appendix contains the analysis for general requirements.

Table 28: Comparative Assessment Results - ANSI/ISA 60079-0 and the IEC 60079-0.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Define Explosive atmosphere	Scope - First Paragraph	Scope - First Paragraph	Type 2 - Meets	DR Modification This section in the ISA Standard is added to provide definition of the term Explosive Atmosphere. This variation has no effect on the equipment standard as the classification of area is to be based on the regulatory requirement.
2	Reference Standards	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet	DC Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
3	Reference Standards - Add	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet	DR Modification The additional standards that are included in the ISA Standard are U.S. national standards for the equipment. These standards are not included in the IEC Standard.
4	Standard for special protection "s"	Scope - Note 3	Scope - Note 3	Type 3 - Does Not Meet	DR Modification U.S. standards do not consider this as an option. Hence equipment with special protection "s" rating is not possible
5	Components requirements	Scope	Scope	Type 2 - Meets	DR Modification Additional requirement in ISA Standard regarding evaluation of components. These requirements are not included in the IEC standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
6	Equipment Protection Level	3.26	3.26	Type 3 - Does Not Meet	D1 Modification Basic safety principles and requirements, elimination of which would compromise safety ANSI/ISA standard do not recognize EPL levels as part of risk assessment of an installation. IEC 60079-0 refers to risk assessment as per IEC 60079-14. IEC 60079-14 has not been adopted for use in the U.S..
7	Ex component	3.28, 3.52, 3.53	3.28, 3.52, 3.53	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards.
8	Threshold power (addition)	3.46.5	3.46.5	Type 2 - Meets	DR Modification Additional definition included
9	Cord Connector (addition)	3.6	3.6	Type 2 - Meets	DR Modification Additional definition included
10	Group II	4.2	4.2	Type 2 - Meets	DR Modification
11	Temperature Marking	5.1.1	5.1.1	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Text referring to ambient temperatures has been aligned with that of the NEC where extensions outside the standard range are permitted, but not inside the standard range.
12	Small component temperature for Group I or Group II electrical equipment	5.3.3	5.3.3	Type 3 - Does Not Meet	These small components will produce temperature rise more than what is specified in IEC Standard

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
13	General requirements	6.1 Note 1, Note 2, Note 5 and Table 3c	6.1 Note 1, Note 2, Note 5 and Table 3c	Type 3 - Does Not Meet	Relationship between EPL and NEC Zone classification shown as a hard link by Table 3c This standard also requires conformance to the applicable requirements for similar apparatus for use in unclassified locations. Text has been added to conform to U.S. practice for hazardous locations, electrical apparatus.
14	Electromagnetic and ultrasonic energy radiating equipment - Radio frequency sources	6.6.1 Note 5	6.6.1 Note 5	Type 3 - Does Not Meet	The energy levels of radio frequency sources are not to exceed the values provided in the Table 4 and 5 of the standard. ISA standard has included the national difference that the programmable/software control that can be set by the used if exceeding the limit in the Tables are not permitted for installation in hazardous area.
15	Electromagnetic and ultrasonic energy radiating equipment - Lasers or other continuous wave sources	6.6.2	6.6.2	Type 3 - Does Not Meet	DR Modification Specify the U.S. requirements for laser and other continuous wave sources can be found in ANSI/ISA 60079-28. Alignment with U.S. requirements.
16	Non-metallic enclosure	7.1.1	7.1.1	Type 2 - Meets	DR Modification
17	Elastomers	7.1.2.3	7.1.2.3	Type 3 - Does Not Meet	DC modification
18	Resistance to light	7.3	7.3	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
19	Avoidance of a build-up of electrostatic charge on Group I or Group II electrical equipment	7.4.2 (e) Note 5	7.4.2 (e) Note 5	Type 2 - Meets	DR Modification Additional guidance provided. No change to requirements
20	Non-metallic enclosure	7.1.1	7.1.1	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Added note regarding the use do copper or copper alloys for enclosure
21	Ex Component Certificate	13.5	13.5	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. For ANSI Standard, the provision of special conditions is deleted as the equipment should be safe to use without any special considerations

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
22	External Connection for earthing or equipotential bonding	15.1.2	15.1.2	Type 2 - Meets	D2 Modification NEC not include mandatory requirements for the connection of an external bonding terminal. Providing such a terminal has not been prohibited, hence it is optional. For a U.S. manufactured product to comply with this, redesigning and retesting is required to meet this IEC requirement Mandatory external bonding terminal has been deleted. U.S. term of "equipment grounding" is considered equivalent to "earthing." Sizing requirements are also referred to the NEC. NEC does not include requirements for the connection of an external bonding terminal. It should be noted that providing such a terminal has not been prohibited. Term "equipment grounding" was added to align with NEC.
23	Earthing or equipotential bonding	15.3	15.3	Type 2 - Meets	DR Modification Additional Reference to U.S. standard provided.
24	Secureness of electrical connections	15.5	15.5	Type 3 - Does Not Meet	ISA standard has deleted reference to section 26.12 of the standard regarding earthing continuity test for non-metallic walled enclosures provided with an internal earth continuity plate.
25	Entries into enclosures	16.1	16.1	Type 3 - Does Not Meet	DR Modification Additional Reference to U.S. standard provided.
26	Temperature at branching point and entry point	16.6	16.6	Type 3 - Does Not Meet	DR Modification This change is to align with NEC

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
27	Disconnectors	18.2	18.2	Type 3 - Does Not Meet	DC Modification ISA Standard refers to disconnectors meeting U.S. standard, whereas IEC standard refers to IEC 60947-1.
28	Supplementary requirements for plugs, socket outlets and connectors	20.1	20.1	Type 3 - Does Not Meet	Added additional requirements to be considered for Plugs and Socket installation Clarification added for application and wiring methods Alignment with NEC
29	EPL Gc	20.2.1	20.2.1	Type 3 - Does Not Meet	Added additional requirements to be considered for Plugs and Socket installation Specific requirements added for EPL Gc to align with the NEC and the U.S. adoption of 60079-15.
30	EPL Gb	20.2.2	20.2.2	Type 3 - Does Not Meet	Reference made of U.S. nationalized standard
31	Secondary Cells	23.3 Table 12	23.3 Table 12	Type 3 - Does Not Meet	Added requirements for Lithium batteries
32	Earth Continuity	26.12	26.12	Type 2 - Meets	Earthing continuity test is deleted in ISA standard as this construction is not permitted by the U.S. ordinary location standards.
33	Manufacturer's Responsibility - Certificate	28.2	28.2	Type 3 - Does Not Meet	DR Modification ANSI requires certificate issued by NRTL. However, IEC standard does not require certificate issued by NRTL, certificate can be prepared by manufacturer

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
34	Marking - General	29.3	29.3	Type 3 - Does Not Meet	DR Modification The requirement for a Certificate has been revised to include only the name or mark of the Certificate issuer. The name or mark is consistent with U.S. NRTL Listing practice. IEC required "X" mark after Certificate reference ISA standard requires installation instructions or reference to specific installation instructions. Reference with installation instructions or reference to specific installation instructions is consistent with current U.S. industry practice.
35	Marking - Ex marking for explosive gas atmosphere	29.4	29.4	Type 3 - Does Not Meet	DR Modification ANSI required Zone marking also An "A" prefix has been added to "Ex." Added marking is to designate apparatus conforming to these U.S. requirements and the marking requirements of the NEC. Additional markings of "Class I" and "Zone" have been added.
36	Marking - Ex marking for explosive gas atmosphere	29.4 (b)	29.4 (b)	Type 2 - Meets	DR Modification ISA Standard added markings for optical radiation to align with U.S. adoption of 60079-28
37	Marking - Ex marking for explosive gas atmosphere	29.4 (e)	29.4 (e)	Type 2 - Meets	DR Modification ISA Standard make EPL marking optional. This is not an NEC required marking

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
38	Ga equipment using two independent Gb types (or levels) of protection	29.8	29.8	Type 3 - Does Not Meet	Delete marking for Ga equipment using two independent types of protection Concept not recognized in the NEC or the adoption of 60079-26
39	Marking - Ex Components	29.9	29.9	Type 3 - Does Not Meet	DR Modification The marking of Ex components has been revised to accommodate the marking required by the NEC Added marking complies with the marking requirements of the NEC and conforms to U.S. industry practice.
40	Small equipment and small Ex Components	29.10.	29.10.	Type 3 - Does Not Meet	DR Modification The marking of Ex components and small components has been revised to accommodate the marking required by the NEC and to allow for marking of the smallest unit package. Added marking complies with the marking requirements of the NEC and conforms to U.S. industry practice.
41	External grounding or bonding terminal	29.17	29.17	Type 3 - Does Not Meet	DR Modification Requirements for identification of supplemental external grounding or bonding terminal has been added along with instruction requirements to show that it is a “supplemental” terminal. Added marking and instruction to align with the NEC.
42	Class I, Division 1, Group D	28.18.1	28.18.1	Type 2 - Meets	DR Modification Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC
43	Class I, Division 1, Group C	29.18.2	29.18.2	Type 2 - Meets	DR Modification Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
44	Class I, Division 1, Group B	29.18.3	29.18.3	Type 2 - Meets	DR Modification Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC
45	Class I, Division 1, Group A	29.18.4	29.18.4	Type 2 - Meets	DR Modification Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC
46	29.19 Class I, Division 2, Equivalency Marking	29.19	29.19	Type 2 - Meets	DR Modification Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC
47	Abbreviated Markings	29.24	29.24	Type 2 - Meets	DR Modification Added marking complies with the alternate marking requirements of the NEC
48	Instructions - General	30.1	30.1	Type 3 - Does Not Meet	DR Modification Added instruction requirements related to the use of alternate “Division” marking Align with NEC requirements for installation.
49	Supplementary requirements for cable glands or cord connectors	Annex A.1 General	Annex A.1 General	Type 2 - Meets	DR Modification Align with U.S. component standards and NEC installation. The changes in ISA is applicable only to Group II or III.
50	Test for degree of protection (IP) of cable glands	Annex A.3.4	Annex A.3.4	Type 2 - Meets	DR Modification Align with U.S. component standards and NEC installation. IEC standard also refers to Group II and III

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-0 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
51	Common standards – Safety requirements for electrical equipment	Annex G	Annex G	Type 3 - Does Not Meet	DC Modification Added ordinary location standards commonly applied to hazardous (classified) location electrical equipment.
52	Equipment Grounding	Annex H	Annex H	Type 3 - Does Not Meet	D1 Modification

10. Appendix B. ANSI/ISA 60079 vs IEC 60079 - Part 1: Equipment Protection by Flameproof Enclosures

Table 29 provides a summary of the comparative assessment between the ANSI/ISA 60079-1 and the IEC 60079-1. This appendix contains the analysis for equipment protection by flameproof enclosures.

Table 29: Comparative Assessment Results - ANSI/ISA 60079-1 and the IEC 60079-1.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in US has been deleted and replaced with US standards
2	Reference Standards - Add	2. References	2. References	Type 3 - Does Not Meet	DR Modification ISA standards includes additional US standards in the reference.
3	Definition for MESG	3.7	3.7	Type 2 - Meets	DE Modification Added Note under definition for MESG. Note is not included in IEC document
4	Ex Blanking element definition	3.16		Type 2 - Meets	DR modification
6	Flame proof joints - General Requirements	5.1	5.1	Type 2 - Meets	DR Modification Marking with X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions. However the intent of the marking in both standards conveys the same information to the user.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
7	Flame proof joints - General Requirements	5.1 last paragraph	5.1 last paragraph	Type 2 - Meets	ISA Standard has additional notes added in this section: Anodizing of aluminum enclosure is not considered as plating. Thread locking compound is permitted as sealant on threaded joints that are note intended to be opened after assembly.
10	Flame proof joints - Multi-step joints	5.2.9	5.2.9 Multistep joints	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions.
12	Taper threaded joints	Table 5	Table 5	Type 3 - Does Not Meet	DR Modification. Dimension of thread in ANSI/ISA standard is differs from the requirement in IEC Standard
14	Fused Glass joints	6.2.1	6.2.1	Type 1 - Exceeds	Latest edition of IEC Standard has requirements for Fused Glass joints. ISA Standard has provided consideration that the fused glass joints are not needed to be subjected to non-transmission test as they do not have flame path. ISA standard also provides clarification that Fused ceramic joints are to be considered and evaluated in the same manner as a fused glass joint.
16	Ex Component installation instructions for breathing or draining device	10.9.4	10.9.4	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
20	Materials and mechanical strength of enclosures – Materials inside the enclosures	12.4	12.4	Type 3 - Does Not Meet	D1 Modification Reference to Cast iron enclosure material requirement is not included in ISA standard.
22	Materials and mechanical strength of enclosures – Materials inside the enclosures	12.8	12.8	Type 3 - Does Not Meet	ISA standard is modified and requires that the copper content of the alloy shall be limited to 30%
23	Entries for flameproof enclosures - Threaded holes	13.2 Addition of Table 16DV.1 Table 16DV.1 – Number of non-transmission tests for level of protection “da”	13.2	Type 3 - Does Not Meet	DR Modification ISA standard has provided additional guidance regarding NPT threaded entries. The standard also has a new Table 16 with dimensions of integral bushings.
26	Entries for flameproof enclosures - Cable glands	13.4	13.4	Type 3 - Does Not Meet	DR Modification Special consideration provided in IEC Standard for cable glands that are separate has been removed in the ISA Standard.
27	Entries for flameproof enclosures - Conduit sealing devices	13.5	13.5	Type 3 - Does Not Meet	DR Modification Changes were made to this Clause in ISA Standard to align with the NEC conduit wiring method.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
28	Entries for flameproof enclosures - Conduit sealing devices	13.5.2	13.5.2	Type 3 - Does Not Meet	DR Modification Changes were made to align with the NEC requirements concerning the sealing provisions for the conduit wiring method.
29	Entries for flameproof enclosures - Plugs and sockets	13.6	13.6	Type 2 - Meets	DR Modification
30	Entries for flameproof enclosures - Bushings	13.7	13.7	Type 2 - Meets	DR Modification
19	Entries for flameproof enclosures - blanking elements	13.8	13.8	Type 2 - Meets	D2 Modification
31	Tests of ability of the enclosure to withstand pressure 15.1.1 General	15.2.1	15.2.1	Type 1 - Exceeds	D2 Modification Routine testing is not the U.S. practice for welded enclosures. Based on North American experience with circuit breaker testing, it has been demonstrated that the additional energy introduced into an explosion by a fault from a circuit with an available short circuit current of less than 10 000 symmetrical amperes will have a negligible effect on the resulting explosion pressure. Above this level, additional testing is required to confirm that the energy introduced into the explosion does not have a detrimental effect on the enclosure and enclosed safety components.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
32	Determination of explosion pressure (reference pressure)	15.2.2.1	15.2.2.1	Type 1 - Exceeds	D2 Modification IEC Standard and ISA standard varies in the method used for determining the reference pressure. IEC has additional testing requirements
33	Determination of explosion pressure (reference pressure)	15.2.2.2	15.2.2.2	Type 2 - Meets	DR Modification
34	Overpressure test	15.2.3.1	15.2.3.1	Type 2 - Meets	DR Modification
	Marking - Informative markings	20.3		Type 2 - Meets	DR Modification IEC Table 15 references both metric and NPT. Ul deletes reference to NPT.
	Marking - Interrrupting rating markings	20.4		Type 3 - Does Not Meet	DR Modification UL standards has an additional Clause on marking.
	Instructions	21	21	Type 2 - Meets	
	Annex B - Additional requirements for elements, with non-measurable paths of breathing and draining devices	B.3	B.3	Type 2 - Meets	DR Modification
51	Additional requirements for flameproof entry devices	Annex C.1	Annex C.1	Type 2 - Meets	DR Modification

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
52	Additional requirements for flameproof entry devices	C2.1	C2.1.1	Type 2 - Meets	DR Modification Additional details provided in IEC Standard
53	Additional requirements for flameproof entry devices	C.2.1.3	C.2.1.3	Type 2 - Meets	DR Modification
52	Annex C - Additional requirements for flameproof entry devices	C2.1.1 C2.1.2 C2.1.3	C2.1.1 C2.1.2 C2.1.3	Type 2 - Meets	DR Modification
	Annex C - Additional requirements for flameproof entry devices - Threaded joints	C.2.2 C.2.2.1	C.2.2 C.2.2.1	Type 2 - Meets	DR Modification
	Annex C - Additional requirements for flameproof entry devices - Constructional requirements for Ex blanking elements	C2.3.1	C2.3.1	Type 2 - Meets	DR Modification

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
	Annex C - Additional requirements for flameproof entry devices - Constructional requirements for Ex blanking elements	C2.3.2	C2.3.2	Type 2 - Meets	DR Modification
	Annex C - Additional requirements for flameproof entry devices - Constructional requirements for Ex blanking elements	C2.3.3	C2.3.3	Type 2 - Meets	DR Modification
	Annex C - Additional requirements for flameproof entry devices -Type Tests	C.3.1.2 C.3.1.3	C.3.1.2 C.3.1.3	Type 2 - Meets	DR Modification
	Annex C - Additional requirements for flameproof entry devices -Type Tests	C3.3.1		Type 2 - Meets	DR Modification UL standard deleted reference to Figure C.1c. See 3.2.1 analysis
	Annex D - Empty flameproof enclosures as Ex components	D.1	D.1	Type 2 - Meets	DR Modification UL standard deletes reference to certificate and replaces with evaluation.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
	Annex D - Empty flameproof enclosures as Ex components	D.2	D.2	Type 2 - Meets	DR Modification UL standard deletes reference to certificate and replaces with evaluation. Also deletes manufacturer responsibility for ensuring equipment meets requirements.
	Annex D - Empty flameproof enclosures as Ex components	D3.5	D3.5	Type 2 - Meets	DR Modification UL standard deletes reference to certificate and replaces with evaluation.
	Annex D - Empty flameproof enclosures as Ex components	D3.7	D3.7	Type 2 - Meets	DR Modification UL standard changes requirement of Ex component enclosures of welded construction to meet requirements of Section 16.3 Enclosures incorporating a welded construction
	Annex D - Empty flameproof enclosures as Ex components	D3.8	D3.8	Type 2 - Meets	DR Modification UL standard changes reference to UL 60079-0 and changes certificate to evaluation.
	Annex D - Empty flameproof enclosures as Ex components	D3.10	D3.10	Type 3 - Does Not Meet	DR Modification UL standard changes certificate to installation instructions, deleted Clause d) on manufacturer is holder of related equipment certificates and adds language on current interrupting devices.
	Annex D - Empty flameproof enclosures as Ex components	D.4.1	D.4.1	Type 2 - Meets	DR Modification UL standard deletes reference to certificate and replaces with evaluation. It also deletes schedule of limitations and replaces with instructions
	Annex D - Empty flameproof enclosures as Ex components	D.4.2	D.4.2	Type 2 - Meets	DR Modification UL standard deletes schedule of limitations and replaces with instructions

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-1 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
	Annex E - Cells and batteries used in flameproof “d” enclosures	E.4.1.2	E.4.1.2	Type 2 - Meets	DR Modification UL standard replaces IEC 60079-11 with UL 60079-11 and adds UL 248 for fuse requirements
60	Empty flameproof enclosures as Ex components	Annex D	Annex D	Type 2 - Meets	DR Modification
61		Annex D.2	Annex D.2	Type 2 - Meets	DR Modification

11. Appendix C. ANSI/ISA 60079 vs IEC 60079 - Part 2: Equipment Protection by Pressurized Enclosures

Table 30 provides a summary of the comparative assessment between the ANSI/ISA 60079-2 and the IEC 60079-2. This appendix contains the analysis for equipment protection by pressurized enclosures.

Table 30: Comparative Assessment Results - ANSI/ISA 60079-2 and the IEC 60079-2.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-2 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References 3. Terms and definitions	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in US has been deleted and replaced with US standards. UL standard references UL 60079-0, 11, and 15 Instead of IEC standards
2	Mechanical Strength	5.4	5.4	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions.
3	Group I and Group II Apertures, partitions, compartments and internal components	5.5	5.5	Type 2 - Meets	D2 Modification UL adds statement about other geometries and arrangements may meet the basic requirements as in the IEC standard.
4	Spark and particle barriers	5.9	5.9	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-2 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
5	For Level of Protection “pxb” or Level of Protection “pyb”	6.2	6.2	Type 2 - Meets	DR Modification References to IEC 60079-0 changed to UL 60079-0 and changed the text on how the requirements may be achieved, and added note with examples of "appropriate measures" on design and construction of joints of pressurized enclosures
6	Suitability of safety devices for hazardous area	7.1	7.1	Type 2 - Meets	DE Modification UL standard added the following words: “the likelihood of" to the IEC text.
7	Provider of safety devices	7.3	7.3	Type 2 - Meets	DE Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions.
8	Pressurization System evaluated as associated equipment	7.4	7.4	Type 2 - Meets	DE Modification UL standard adds reference to Table 2.
9	Safety devices to detect overpressure	7.11	7.11	Type 1 - Exceeds	DE Modification UL standard deleted item on exclusion of non-metallic enclosures and parts
10	Release conditions	11.1.2	11.1.2	Type 2 - Meets	DE Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-2 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
11	Containment system with a limited release	12.3	12.3	Type 2 - Meets	DE Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions.
12	Marking - Supplementary marking	18.3	18.3	Type 2 - Meets	DE Modification of Clause 18.3, item a) to include permissible substitute marking for the level of protection marking for Group III with the following:
13	Marking Pressurization systems	18.6	18.6	Type 3 – Does Not Meet	DE Modification Modifies IEC 60079-0 to UL 60079-0 and adds additional note of markings “[p]” and “[Ex p]” do not appear in NEC 2017 or earlier
14	Annex G – Internal Cells and Batteries for Level of Protection - Protective Components	G.2.2	G.2.2	Type 2 - Meets	DE Modification Added reference to UL 248 series of standards in addition to IEC 60127
15	Annex G – Internal Cells and Batteries for Level of Protection	G.5	G.5	Type 2 - Meets	DE Modification Replaced IEC 60079-11 with UL 60079-11 and added text " with a safety factor of x1"
16	Annex H - Internal Cells and Batteries for Level of Protection “pzc”	H.2	H.2	Type 2 - Meets	DR Modification Replace IEC text referencing IEC 60079-11, 60079-15 for Level of Protection "ic” with "a minimum Equipment Protection Level of Gc or Dc, as applicable."

12.Appendix D. ANSI/ISA 60079 vs IEC 60079 - Part 5: Equipment protection by Powder Filling

Table 31 provides a summary of the comparative assessment between the ANSI/ISA 60079-5 and the IEC 60079-5. This appendix contains the analysis for equipment protection by powder filling.

Table 31: Comparative Assessment Results - ANSI/ISA 60079-5 and the IEC 60079-5

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-5 Section #	IEC Standard IEC 60079-5 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References 4.1.3 4.4.1	1. Scope 2. References 4.1.3 4.4.1	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
2	Marking - Degree of protection of the container	4.1.3	4.1.3	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with reference to specific Conditions of Use
3	Equipment	4.4.1	4.4.1	Type 3 - Does Not Meet	UL standard clarifies that a flameproof "d" cable gland in accordance with UL 2225 may be required as the Increased safety "e" cable gland may not provide adequate pressure sealing
4	Fuse	4.8.2 4th paragraph	4.8.2 4th paragraph	Type 3 - Does Not Meet	D1 Modification Overloads are to be tested to applicable U.S. standard
5	Marking - Fuse	4.8.2 6th and 7th paragraph	4.8.2 6th and 7th paragraph	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with reference to specific Conditions of Use

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-5 Section #	IEC Standard IEC 60079-5 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
6	Marking - Power supply prospective short-circuit current	4.8.5	4.8.5	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with reference to specific Conditions of Use
7	Marking	6	6	Type 2 - Meets	Marking is to be in accordance with corresponding IEC and UL 60079-0 standard

13. Appendix E. ANSI/ISA 60079 vs IEC 60079 - Part 6: Equipment Protection by Liquid Immersion

Table 32 provides a summary of the comparative assessment between the ANSI/ISA 60079-6 and the IEC 60079-6. This appendix contains the analysis for equipment protection by liquid immersion.

Table 32: Comparative Assessment Results - ANSI/ISA 60079-6 and the IEC 60079-6

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-6 Section #	IEC Standard IEC 60079-6 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References 4.1	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
2	Requirements for Level of Protection "ob"	4.2.2	4.2.2	Type 3 - Does Not Meet	DR Modification UL Standard has added clarification regarding using of increased terminations
3	Remote-indicating protective liquid level indicator	4.7.2	4.7.2	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with reference to specific Conditions of Use
4	Safety devices for Level of Protection "ob"	4.7.3	4.7.3	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with reference to specific Conditions of Use
5	Marking	7	7	Type 2 - Meets	
6	Selection and erection requirements	Annex A	Annex A	Type 3 - Does Not Meet	DR Modification UL standard refers to NEC for selection and installation of equipment, whereas IEC refers to 60079-14. Installation requirement is different in UL and IEC Standard

14. Appendix F. ANSI/ISA 60079 vs IEC 60079 - Part 7: Equipment Protection by Increased Safety

Table 33 provides a summary of the comparative assessment between the ANSI/ISA 60079-7 and the IEC 60079-7. This appendix contains the analysis for equipment protection by increased safety.

Table 33: Comparative Assessment Results - ANSI/ISA 60079-7 and the IEC 60079-7

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	1	1	Type 3 - Does Not Meet	DR Modification / Addition UL standard deleted references to IEC 60079-0 and replaced with UL 60079-0. The standard also added text where references to other IEC 60079 standards are made, the referenced requirements are modified by U.S. National Differences.
2	Normative References	2	2	Type 3 - Does Not Meet	DR Modification UL standard deleted references to IEC 60079-0, 1, 11, and 30-1; IEC 60947-1, 2, and 4; IEC 60999-1 and 2; and referenced U.S. Standards which are more stringent.
3	Definitions - resistance heating applications	3.13, 3.19, 5.8	3.13, 3.19, 5.8	Type 2 - Meets	DR Modification Definitions using “device” have been changed to “equipment”, where applicable, to align with the use of the terms in the National Electrical Code, ANSI/NFPA 70. IEC60079-30-1 and IEC/IEEE60079-30-1 are the same standard with the correct title being IEC/IEEE 60079-30-1.
4	Construction Requirements - Level of Protection	4.1	4.1	Type 3 - Does Not Meet	DR Modification UL standard adds reference allowing equipment evaluated as Level of Protection “ec” include manually operated arcing or sparking components located within an enclosure if it is not accessible in normal operation without a tool and referrers to UL 60079-0 for fastener general and documentation requirements.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
5	- Electrical Connections	4.2.1	4.2.1	Type 3 - Does Not Meet	DR Modification UL standard deletes the references to IEC 60079-0 and 60228 and the class of fine-stranded conductors, making the requirement for all screwless connections. In the ISA standard: (f) As the ordinary location standards do not permit contact pressure to be transferred using an insulating material, such a construction has been removed for type of protection “e”. (j)The requirement for screwless terminals, intended for fine-stranded conductors, to include a means of opening the clamping mechanism, has been expanded to include all screwless terminals.
6	- Field wiring connections - General	4.2.2.1	4.2.2.1	Type 3 - Does Not Meet	DR Modification UL standard deletes the references to IEC 60079-0 and replaces with UL 60079-0 and adds note referencing UL 1059 and UL 486E requirements that terminals to be identified with the wire sizes.
7	- Field wiring connections made using terminals conforming toh national/international standard	4.2.2.2	4.2.2.2	Type 3 - Does Not Meet	DR Modification UL standard deletes the references to IEC 60947-7-1, IEC 60947-7-2, IEC 60947-7-4, IEC 60999-1, or IEC 60999-2, replacing them with UL 60947-7-1, UL 60947-7-2, UL 1059, or UL 486E. Additional requirements have been added to address terminals rated greater than 1500 V. UL 60947-7-1 replaced IEC 60947-7-1 and UL486E is added as an acceptable test method for temperature rise test for Level of Protection "eb". A note has been added to draw attention to the more restrictive temperature rise permitted by ANSI/UL 1059.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
8	- Field wiring connections - Connections designed to be used with cable lugs and similar devices	4.2.2.4	4.2.2.4	Type 2 - Meets	DR Modification UL standard modified text of IEC by deleting reference to "X" suffix and IEC 60079-0 and replacing with UL 60079-0 requirement.
9	-Factory connections - Permanent connections	4.2.3.3	4.2.3.3	Type 3 - Does Not Meet	DR Modification UL added additional requirements to address terminals rated greater than 1500 V.
10	-Factory connections - Permanent connections - Pluggable connections for Level of Protection “eb”	4.2.3.4	4.2.3.4	Type 3 - Does Not Meet	DR Modification UL elevated Note 2 to regular text and adds new Note 3 referencing UL 60079-0 requirements for interlocks and the type of protections selected must be suitable for the application.
11	-Factory connections - Permanent connections - Pluggable connections for Level of Protection “ec”	4.2.3.5	4.2.3.5	Type 2 - Meets	DR Modification UL elevated Note 2 providing typical examples of pluggable connectors to regular text.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
12	External plug and socket connections for field wiring connection	4.2.4	4.2.4	Type 3 - Does Not Meet	DR Modification UL standard modified the IEC text by adding requirement that the threaded connection can only be released or removed by use of a tool. It also added requirements that plugs and sockets shall be capable of being connected by wiring methods permitted in NEC. Cable assemblies and associated plugs and sockets shall meet the requirements of UL 2238 and UL 2237 or other relevant standards that include requirements that address voltage and current ratings, and for suitability for field wiring applications. The UL standard also added additional Clause for factory wired connections between enclosures to meet the requirements of the Clause along with strain relief provisions in accordance with the relevant industrial requirements.
13	Clearances	4.3	4.3	Type 2 - Meets	DC Addition UL standard clarifies the intention of the terms main circuits, isolated circuits, and PWB mounted components and the applicability of Table 2 Minimum Creepage distances, clearances and separations in the standard.
14	Creepage distance	4.4.1	4.4.1	Type 2 - Meets	DC Modification / Addition UL standard allows use of U.S. standards in addition to IEC standards. It also clarifies the intention of the terms main circuits, isolated circuits, and PWB mounted components and the applicability of Table 2 Minimum Creepage distances, clearances and separations, in the standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
15	Solid electrical insulating materials	4.6	4.6	Type 2 - Meets	UL standard modified text of d), e), and f) in Clause 4.6.1 of the IEC standard to delete "ANSI", add UL 746A and added text in f) which added "strength or RTI - mechanical impact" to "RTI - mechanical" in the parenthesis' of the last sentence of the paragraph.
16	Degrees of protection provided by enclosures	4.10	4.10	Type 2 - Meets	DR Modification UL standard modified text of IEC by adding additional text modifying the test requirements for Level of Protection "ec" to remove the 80 °C minimum test temperature, and deleting reference to "X" suffix and IEC 60079-0 and replacing with UL 60079-0.
17	Arcing or sparking contacts	4.11		Type 3 - Does Not Meet	DR Addition
18	Supplementary requirements for specific electrical equipment - Electrical machines - Rotating electrical machines with cage rotors	5.2.7	5.2.7	Type 2 - Meets	DR Modification UL standard modified text of IEC by adding additional text deleting reference to "X" suffix and IEC 60079-0 and replacing with UL 60079-0.
19	Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights	5.3		Type 2 - Meets	UL standard modified text of IEC by adding additional text referencing UL 1598 and UL 844 in addition to IEC 60598-1.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
20	Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights - Light source - Lamps	5.3.2.2	5.3.2.2	Type 3 - Does Not Meet	DC Modification UL standard modified text of IEC by deleting references to IEC standards and replacing with ANSI standards
21	Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights - Light source - Lamps for rated voltages not greater than 50 V and not greater than 12V	5.3.2.3 5.3.2.4	5.3.2.3 5.3.2.4	Type 3 - Does Not Meet	DC Modification UL standard modified text of IEC by deleting references to IEC standards and replacing with ANSI standards
22	Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights - Electrical spacings	5.3.4	5.3.4	Type 3 - Does Not Meet	DR Modification UL standard modified text of IEC by identifying Part 1 of IEC 60598 and adding U.S. standards UL 1598 and UL 8750 for creepage and clearance requirements for luminaries with Level of Protection "ec" except for field wiring terminals
23	Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights - Lampholders and lamp caps	5.3.5	5.3.5	Type 2 - Meets	DC Modification UL standard modified text of IEC by deleting references to IEC standards and replacing with U.S. standards

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
24	Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights - Lampholders and lamp caps	5.3.5	5.3.5	Type 2 - Meets	DE Modification
25	Supplementary requirements for specific electrical equipment - Luminaires, hand lights, or caplights - Luminaires for tubular fluorescent bi-pin lamps	5.3.9	5.3.9	Type 3 - Does Not Meet	DR Modification UL standard modified text by replacing IEC 60079-0 with UL 60079-0, adds requirement for a manual switch per UL 508 rated Category III per UL 840 as option for the disconnection device.
26	Supplementary requirements for specific electrical equipment - Analog measuring instruments and instrument transformers - External secondary circuits	5.4.7	5.4.7	Type 2 - Meets	DR Modification UL standard modified text of IEC by deleting reference to "X" suffix and IEC 60079-0 and replacing with UL 60079-0 requirement.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
27	Supplementary requirements for equipment incorporating cells and batteries - Charging of cells and batteries	5.6.4		Type 2 - Meets	DR Modification UL standard modified text of IEC by deleting reference to "X" suffix and IEC 60079-0 and replacing with UL 60079-0 requirement.
28	Supplementary Requirement for specific electrical equipment - Resistance heating equipment (other than trace heating systems)	5.8	5.8	Type 2 - Meets	DC Modification
29	Supplementary Requirement for specific electrical equipment - Resistance heating equipment (other than trace heating systems) - Safety Device	5.8.11	5.8.11	Type 2 - Meets	DR Modification UL standard modified text of IEC by deleting reference to "X" suffix and IEC 60079-0 and replacing with UL 60079-0 requirement.
30	Supplementary Requirement for specific electrical equipment - Other electrical equipment	5.10	5.10	Type 2 - Meets	DR Modification UL standard modified text of IEC by deleting reference to "X" suffix and IEC 60079-0 and replacing with UL 60079-0. It also added note to Note @ the Special protection "s" is not intended to be adopted in the U.S.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
31	Type verifications and type tests - Rotating electrical machines - Additional tests for machines	6.2.3	6.2.3	Type 2 - Meets	DE Modification
32	Type verifications and type tests - Luminaires - Abnormal operation of luminaires	6.3.4	6.3.4	Type 2 - Meets	DR Modification UL standard modified text of IEC by adding U.S. standards UL 1598 and UL 8750 and replacing IEC 60079-0 with UL 60079-0
33	Type verifications and type tests - Verification and tests for cells and batteries of Level of Protection “eb” - Mechanical shock test	6.6.3	6.6.3	Type 2 - Meets	DR Modification UL standard modified text of IEC by deleting reference to "X" suffix and IEC 60079-0 and replacing with UL 60079-0 requirement.
34	Routine verifications and routine tests	7	7	Type 2 - Meets	UL and IEC standard contain the same text.
35	Ex Component certificates	8	8	Type 2 - Meets	UL and IEC standard contain the same text.
36	Marking	9.1	9.1	Type 3 - Does Not Meet	DR Modification UL standard modified the IEC text in by deleting IEC 60079-0 and replacing them with UL 60079-0. It also added not about NEC not recognizing “ec” as a Type of Protection and using the substituted marking “nAc” or “nA” is until this can be rectified.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
37	Marking	9.2	9.2	Type 3 - Does Not Meet	DR Modification UL standard modified the IEC text in by deleting IEC 60079-0 and replacing them with UL 60079-0. It also added Class 1, Zone 1 and replaced "Ex" with "AEx"
38	Temperature determination of electrical machines – Methods of test and of calculation	Annex A (normative)	Annex A (normative)	Type 2 - Meets	UL and IEC standard contain the same text.
39	Type tests for specific forms of resistance heating devices or resistance heating units (other than trace heater)	Annex B (normative)	Annex B (normative)	Type 2 - Meets	DR Modification UL standard modified the IEC text in B.1 by deleting IEC 60079-0 and IEC 60079-30-1 and replacing them with UL 60079-0 and IEEE60079-30-1 standards, respectively. UL 60079-0 replaced IEC 60079-0 in B.3 also. IEEE 60079-30-1 is a harmonized standard based on IEC 60079-3-0-1
40	Cage motors – Thermal protection in service	Annex C (Informative)	Annex C (Informative)	Type 2 - Meets	UL and IEC standard contain the same text.
41	Resistance heating devices and units – Additional electrical protection	Annex D (Informative)	Annex D (Informative)	Type 2 - Meets	UL and IEC standard contain the same text.
42	Combinations of terminals and conductors for general purpose connection and junction boxes	Annex E (Informative)	Annex E (Informative)	Type 2 - Meets	UL and IEC standard contain the same text.
43	Dimensions of copper conductors	Annex F (normative)	Annex F (normative)	Type 2 - Meets	UL and IEC standard contain the same text.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-7 Section #	IEC Standard IEC 60079-7 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
44	Test procedure for T5 (only 8 W), T8, T10 and T12 lamps	Annex G (Informative)	Annex G (Informative)	Type 2 - Meets	UL and IEC standard contain the same text.
45	Alternative separation distances for Level of Protection “ec” equipment under controlled environments	Annex H (normative)	Annex H (normative)	Type 2 - Meets	DR Modification UL standard modified the IEC text in H.1 by adding note about achievement of separation distances and references IEC 60664-1 and UL 840 standards.
46	Alternative separation distances for Level of Protection “ec” equipment under controlled environments	Annex H (normative)	Annex H (normative)	Type 2 - Meets	DR Modification UL standard modified the IEC text in H.2 deleting the reference to the "X" suffix which is not included in UL 60079-0 and by replacing IEC 60079-0 with UL 60079-0.
47	Application, installation, and testing considerations for Level of Protection “ec” asynchronous machines	Annex I (Informative)	Annex I (Informative)	Type 2 - Meets	UL and IEC standard contain the same text.
48	Luminaires incorporating LEDs	Annex J (Informative)	Annex J (Informative)	Type 2 - Meets	UL and IEC standard contain the same text.

15. Appendix G. ANSI/ISA 60079 vs IEC 60079 - Part 10-1: Classification of areas – Explosive Gas Atmospheres

Table 34 provides a summary of the comparative assessment between the ANSI/ISA 60079-10-1 and the IEC 60079-10-1. This appendix contains the analysis for classification of areas with explosive gas atmospheres.

Table 34: Comparative Assessment Results - ANSI/ISA 60079-10-1 and the IEC 60079-10-1

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
2	Reference Standards - Add	2. References	2. References	Type 3 - Does Not Meet	DR Modification Additional references in ISA Standard to align with U.S. practice and the National Electrical Code:
3	Scope	Scope	Scope Annex G.11	Type 2 - Meets	IEC 60079-14 has not been adopted in the U.S.
4	Definitions - hazardous area	3.3	3.3.1	Type 2 - Meets	Definitions in ISA Standard is updated with the specific definitions in Article 505 of NFPA 70. Added note in IEC standard provides additional clarification to hazardous area interior of process equipment
5	Definitions - non-hazardous area	3.4, 3.30	3.3.2	Type 2 - Meets	The term non-hazardous area is not in defined in NEC. Hence the term unclassified is used instead
6	Definitions - zones	3.5	3.3.3	Type 2 - Meets	ISA definition covers adjacent to areas that are classified
7	Definitions - Class I, Zone 0	3.6	3.3.4	Type 3 - Does Not Meet	For ISA Standard: Definition for Class I, Zone 0, 1 and 2 provided from NEC to replace IEC definition. Alignment with the NEC designation for Zones.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
8	Definitions - Class I, Zone 1	3.7	3.3.5	Type 3 - Does Not Meet	For ISA Standard: Definition for Class I, Zone 0, 1 and 2 provided from NEC to replace IEC definition. Alignment with the NEC designation for Zones.
9	Definitions - Class I, Zone 2	3.8	3.3.6	Type 3 - Does Not Meet	For ISA Standard: Definition for Class I, Zone 0, 1 and 2 provided from NEC to replace IEC definition. Alignment with the NEC designation for Zones.
10	Definition - Continuous grade of release	3.11	3.4.2	Type 2 - Meets	The term "frequently" is removed in the ISA standard.
11	Definition - Secondary grade of release	3.13	3.4.4	Type 2 - Meets	The term infrequently was removed from the definition of secondary grade of release
12	Definition LEL, UEL	3.17, 3.18	3.6.12, 3.6.13	Type 2 - Meets	Notes added to definition of LEL and UEL in ISA Standard which describe alternate use of LFL and UFL.
13	Definition - ventilation and dilution	reference not in ISA Standard	3.5	Type 1 - Exceeds	Definition of Ventilation and dilution added to the latest edition of the IEC Standard
14	Definition - Vapor Pressure	3.26	3.6.10	Type 2 - Meets	
15	ignition temperature of an explosive gas atmosphere	3.27	3.6.11	Type 2 - Meets	ISA Standard: Note added to definition of ignition temperature that states it is understood to be the same as autoignition.
16	Definition - routine maintenance, rare malfunction	reference not in ISA Standard	3.7.2, 3.7.3, 3.7.4	Type 1 - Exceeds	Definition added in the latest edition of the standard
17	Safety Principles	4.1	4.1	Type 1 - Exceeds	Latest edition of IEC refers only to nonroutine maintenance. Whereas ISA do not differentiate between routine or nonroutine maintenance. Also, IEC requires that the classification of area should take in to account any routine maintenance.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
18	Gas Group	4.2	4.2	Type 2 - Meets	Both standards have similar requirements
19	Temperature Class	4.2	4.2	Type 2 - Meets	Both standards have similar requirements
20	Area classification objectives - Risk assessment	4.2	4.3	Type 3 - Does Not Meet	D1 Modification Basic safety principles and requirements, elimination of which would compromise safety Note 3 in ISA Standard refers to risk assessment for selection of equipment with higher or lower EPL levels. However, ISA standard do not recognize the concept of negligible extent of zone be treated as non-hazardous area.
21	Area classification objectives - Change Management	4.2	4.2	Type 3 - Does Not Meet	Added text in ISA standard to clarify the change management process. Requires change management. ISA Standard requires that for any change in the equipment or procedure in an area classification location. change management procedure is to be used in accordance with 29CFR 1910.119
22	Competence of Personnel	5.1	4.4	Type 1 - Exceeds	Requirement for competence of personnel in IEC standard exceed that of the requirement in ISA standard

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
23	Area Classification Methodology	reference not in ISA Standard	5.1	Type 1 - Exceeds	Latest edition of IEC introduces clauses for alternative methods of area classification ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
24	Simplified methods	reference not in ISA Standard	5.4	Type 1 - Exceeds	Latest edition of IEC introduces clauses for simplified methods of area classification ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
24	Combination of methods	reference not in ISA Standard	5.5	Type 1 - Exceeds	Latest edition of IEC introduces clauses for alternative methods of area classification
27	Use of industry codes and national standards	Scope	5.3	Type 2 - Meets	
28	Sources of Release	5.2	5.2, 6.2 - Sources of Release	Type 1 - Exceeds	Latest edition of IEC standard has additional requirement to consider for determining sources of releases ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
29	Type of Zone	5.3	7 Type of Zone	Type 2 - Meets	The term Class I was inserted in front of the Zone designation for a specific area. Definition for Class I, Zone 0, 1 and 2 provided from NEC to replace IEC definition. Alignment with the NEC designation for Zones.
30	Type of Zone	5.3 Annex B	7.2 Influence of grade of the source of release	Type 2 - Meets	IEC latest edition provides additional clarification regarding consideration to the degree of dilution and availability of ventilation is classifying an area more or less severe ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
31	Influence of dilution	Annex B	7.3 Influence of dilution	Type 2 - Meets	IEC latest edition provides additional clarification regarding consideration to the degree of dilution and availability of ventilation is classifying an area more or less severe ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
32	Influence of availability of ventilation	Annex B	7.4 Influence of availability of ventilation	Type 2 - Meets	IEC latest edition provides additional clarification regarding to the degree of dilution and availability of ventilation is classifying an area more or less severe. ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
33	Extent of zone	5.4	8 Extent of zone	Type 1 - Exceeds	IEC latest edition requires that extent of the zone should consider the level of uncertainty in the assessment by the application of safety factor. Additional requirement in IEC standard. ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
34	Forms of Release and Release rate of gas or vapor -Liquefied under pressure -Liquefied by refrigeration -Aerosols -Vapors -Liquid releases -Gaseous Release	5.4.1	Annex B B.7 6.3.3 6.3.4 6.3.5 6.3.6 6.3.7 6.3.2	Type 1 - Exceeds	Additional clarification regarding flashpoints provided in IEC standard. ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
36	Relative density of the gas or vapor when it is released	5.4.4	6.3 Forms of Release	Type 1 - Exceeds	Latest edition of IEC provides guidance regarding various sources of Release ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
37	Other parameters to be considered	5.4.5	6.4 Ventilation (or air movement) and dilution	Type 1 - Exceeds	Latest edition of IEC provides guidance regarding Ventilation. ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
38	Illustrative examples	5.4.6	no reference in IEC	Type 2 - Meets	See the comparison provided for Annex C below
39	Ventilation and Degree of ventilation	6.1 6.3 5.4.3 Annex B	6.4 6.5.4 Annex C Annex D	Type 1 - Exceeds	Latest edition of IEC provides guidance regarding Ventilation. ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
46	Main Types of Ventilation	6.2 5.4.3 Annex B.2, B.3	6.5.1, 6.5.2, 6.5.3	Type 2 - Meets	
48	Documentation - General	7.1	9.1 Documentation - General	Type 2 - Meets	
49	Documentation - Drawings, Datasheets,	7.2	9.1 Documentation - Drawings, Datasheets	Type 3 - Does Not Meet	ISA Standard has additional features to be included on area classification documents
50	Examples of sources of release and release rate	Annex A.1	Annex B B.2 Examples of grade of release	Type 2 - Meets	

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
51	Assessment of grades of release Summation of releases Hole size and source radius Forms of release	reference not in ISA Standard	Annex B B.3 Annex B B.4 Annex B B.4 Annex B B.4	Type 1 - Exceeds	IEC latest edition provides additional consideration for Assessment of release grades. IEC latest edition provides additional consideration for Assessment and summation of release grades. IEC latest edition provides additional guidance for determining the hole radius. Latest edition of IEC provides guidance regarding various forms of Release ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
55	Openings	Annex A.2	Annex B.8	Type 2 - Meets	
56	Release rate	Annex A.3	Annex B.7.2 Estimation of Release rate	Type 2 - Meets	
57	Release rate of liquid	Annex A.3.1	Annex B.7.2.2	Type 3 - Does Not Meet	With the calculation using IEC equation will yield a lesser release rate than ISA standard equation
58	Release rate of gas	Annex A.3.2	Annex B.7.2.3.1	Type 2 - Meets	
59	Release rate of gas with choked gas velocity	Annex A.3.2.1	B.7.2.3.3 Release rate of gas with choked gas velocity (sonic releases)	Type 2 - Meets	
60	Release rate of gas with non-choked gas velocity	Annex A.3.2.2	B.7.2.3.2 Release rate of gas with non choked gas velocity (subsonic releases)	Type 2 - Meets	

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
61	Release rate of evaporative pools	reference not in ISA Standard	B.7.3 Release rate of evaporative pools	Type 1 - Exceeds	IEC standard provides release rate calculation for Evaporative pools. ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
63	Examples of hazardous area classification	Annex C.7	Annex A	Type 3 - Does Not Meet	Added notes to C.7 in Annex C to add NEC requirement for transition zones with Zone 0 and Zone 1 areas
64	Examples of hazardous area classification	Annex C examples	Annex E Examples	Type 1 - Exceeds	Determination of classification area is presented in latest edition of IEC standard with more explanation and the resulting classification appears to be more conservative than ISA standard
65	Flammable Mist	Annex D	Annex G	Type 2 - Meets	
66	Hydrogen	Annex E	Annex H	Type 2 - Meets	In general, the informative section in ISA and IEC is discussing the features or Hydrogen gas.
67	Schematic approach to classification of hazardous areas	reference not in ISA Standard	Annex F Schematic approach to classification of hazardous areas	Type 2 - Meets	Additional guidance in IEC standard ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
68	Hybrid Mixtures	reference not in ISA Standard	Annex I Hybrid Mixtures	Type 1 - Exceeds	IEC Standard provides some informative guidance regarding hybrid mixtures. ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-10-1 Section #	IEC Standard IEC 60079-7-10-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
69	Useful equations in support to hazardous area classification	reference not in ISA Standard	Annex J (informative) Useful equations in support to hazardous area classification	Type 1 - Exceeds	IEC Standard provides some additional guidance for hazardous area classification. ISA standard was harmonized with previous edition of IEC standard. This analysis has been conducted between ISA standard and latest edition of IEC standard.
70	Industry codes and national standards	reference not in ISA Standard	Annex K Industry codes and national standards	Type 2 - Meets	IEC Standard allows use of any Industry standards. For U.S. acceptable standard is API, NFPA standards

16. Appendix H. ANSI/ISA 60079 vs IEC 60079 - Part 11: Equipment protection by Intrinsic Safety (Edition 6.2)

Table 35 provides a summary of the comparative assessment between the ANSI/ISA 60079-11 and the IEC 60079-11. This appendix contains the analysis for equipment protection by intrinsic safety.

Table 35: Comparative Assessment Results - ANSI/ISA 60079-11 and the IEC 60079-11

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-11 Section #	IEC Standard IEC 60079-11 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References	1. Scope 2. References	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards in the ISA standard
2	Reference Standards - Add	2. References	2. References	Type 3 - Does Not Meet	DR Modification Additional references in ISA Standard to align with U.S. practice and the National Electrical Code:
3	Reference Standards - Add	2. References	2. References	Type 3 - Does Not Meet	DR Modification Additional of missing reference to ISA Standard. This reference added in ISA standard is applicable for Mines
4	Terms and definitions - internal wiring	3.11	3.11	Type 2 - Meets	Additional note in ISA standard to provide clarification
5	Grouping and classification of intrinsically safe apparatus and associated apparatus	4	4	Type 2 - Meets	Modified text in ISA standard to provide clarification;
6	Voltage between conductive parts - Example of separation of conducting parts	Figure 2	Figure 2	Type 3 - Does Not Meet	ISA Standard Figure 2 modified to align with U.S. differences and is also applicable to Annex F

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-11 Section #	IEC Standard IEC 60079-11 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
7	Rating of components	7.1	7.1	Type 2 - Meets	Paragraph reworded in ISA standard for clarity
8	Fuses	7.3	7.3	Type 3 - Does Not Meet	In ISA standard, external creepage and clearance distance used for fuses are considered no different to any other creepage and clearance distances.
9	current limiting resistor and its connecting tracks	7.3	7.3	Type 3 - Does Not Meet	ISA Standard clarified as the creepage and clearance is based on the maximum voltage at one end of the fuse and not the voltage dropped across the fuse.
10	Primary and secondary cells and batteries	7.4.1	7.4.1	Type 2 - Meets	IEC standard Note 1 contained a requirement. ISA standard Paragraph written to incorporate this requirement.
11	Batteries used but not replaced in explosive atmospheres	7.4.8	7.4.8	Type 2 - Meets	ISA Standard text modified to align with the difference taken in the adoption of IEC 60079-0
12	Series current limiters	7.5.3	7.5.3	Type 3 - Does Not Meet	ISA standard Section rewritten to permit active limitation in Division 1.
13	Marking	6.3.13 10.7 12.1 Annex F3.1	6.3.13 10.7 12.1 Annex F3.1	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions I ISA Standard

17. Appendix I. ANSI/ISA 60079 vs IEC 60079 - Part 15: Equipment Protection by Type of Protection (Edition 4)

Table 36 provides a summary of the comparative assessment between the ANSI/ISA 60079-15 and the IEC 60079-15. This appendix contains the analysis for equipment protection by type of protection.

Table 36: Comparative Assessment Results - ANSI/ISA 60079-15 and the IEC 60079-15

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-15 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
2	Reference Standards - Add	3	2. References	Type 3 - Does Not Meet	DR Modification U.S. National Electrical Code® (NEC®) defines devices as carrying electricity, e.g. fuse, switch, connector, rather than utilizing electricity. Definitions 3.7.1, 3.7.2, 3.7.2.1, 3.7.2.2 and 3.7.2.4 were changed to reflect the NEC® definition.
3	Marking - several sections	6.3.1 6.3.2 8.8.3 13 20.2.7.2	6.3.1 6.3.2 8.8.3 13 20.2.7.2	Type 2 - Meets	Requirements for "X" mark after Certificate reference have been replaced with installation instructions or reference to specific installation instructions in ISA Standard. Reference with installation instructions or reference to specific installation instructions is consistent with current U.S. industry practice.
4	Electric strength - Insulation from earth or frame	6.5.1	6.5.1	Type 3 - Does Not Meet	Permit normal Dielectric Strength Test to be based upon the applicable industrial standard where on exists.
5	Connection facilities and terminal compartments	7.1 f)	7.1 f)	Type 3 - Does Not Meet	ISA standard deleted 7.1 9f) regarding Earth Continuity Test as the test has been deleted in ISA-60079-0

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-15 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
6	Pluggable connections	7.3.5	7.3.5	Type 2 - Meets	ISA standard revised the requirement for pluggable connections to reflect that a 15 N retention force is adequate and the use of a mechanical retaining device eliminates the need for the 15 N test.
7	Supplementary requirements for non-sparking electrical rotating machines	8	8	Type 1 - Exceeds	ISA standard has a note that some general purpose induction motors are permitted by Article 505 of the NEC®. Similar consideration is not included for IEC Standard.
7a	Supplementary requirements for non-sparking electrical rotating machines - General	8.1	8.1	Type 2 - Meets	ISA standard add a note that normal operating condition is full-load steady conditions. Neither start-up nor shut-down would be considered as a normal operating condition. This is similar to the Note #1 already included in IEC Standard.
8	Alternative type test by calculation	8.10.2.3	8.10.2.3	Type 1 - Exceeds	Special consideration included in IEC standard is not included in ISA standard
9	External Plugs and sockets for external field wiring connections	10.1	10.1	Type 3 - Does Not Meet	ISA standard have additional clarification regarding external wiring
10	Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Cable glands	20.2.2.1	20.2.2.1	Type 3 - Does Not Meet	ISA standard identify that only flameproof “d” cable glands are recognized by the NEC®.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-15 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
11	Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Conduit entries	20.2.2.2	20.2.2.2	Type 3 - Does Not Meet	ISA standard have additional requirement that the installation instruction specify the need for an explosion proof or flameproof conduit seal.
12	Supplementary requirements for restricted-breathing enclosures protecting equipment producing arcs, sparks or hot surfaces - Gasket and seal requirements	20.2.5	20.2.5	Type 3 - Does Not Meet	ISA standard have additional requirement for gasket retention per ISA-60079-0.
13	Luminaires	20.2.7.2.1	20.2.7.2.1	Type 2 - Meets	ISA standard delete requirement for fixing the gasket or seal.
14	Tests for enclosed break equipment and non incendive components	22.4	22.4	Type 2 - Meets	ISA standard to align with the use of the terms in the National Electrical Codeâ, ANSI/NFPA 70â.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-15 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
15	Type Test for sealed components–Conditioning	22.5.1	22.5.1	Type 3 - Does Not Meet	ISA standard identify that three samples must be tested.
16	Tests for sealed component	22.5	22.5	Type 2 - Meets	ISA standard to align with the use of the terms in the National Electrical Codeâ, ANSI/NFPA 70â.
17	Electric strength test	23.2.1	23.2.1	Type 2 - Meets	ISA standard added clarification regarding routine dielectric strength test as per relevant industry standard

18. Appendix J. ANSI/ISA 60079 vs IEC 60079 - Part 18: Equipment Protection by Encapsulation

Table 37 provides a summary of the comparative assessment between the ANSI/ISA 60079-18 and the IEC 60079-18. This appendix contains the analysis for equipment protection by encapsulation.

Table 37: Comparative Assessment Results - ANSI/ISA 60079-18 and the IEC 60079-18

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-18 Section #	IEC Standard IEC 60079-18 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References 7.1 7.6.2 7.8.5 7.9.3 9.2	1. Scope 2. Normative References	Type 2 - Meets	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
2	Reference Standards - Add	2. References	2. References	Type 2 - Meets	DR Modification
3	Water absorption	5.3.1	5.3.1	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with reference to specific Conditions of Use
4	Marking	10	10	Type 2 - Meets	

19. Appendix K. ANSI/ISA 60079 vs IEC 60079 - Part 25: Intrinsically Safe Electrical Systems

Table 38 provides a summary of the comparative assessment between the ANSI/ISA 60079-25 and the IEC 60079-25. This appendix contains the analysis for Intrinsically Safe Electrical Systems.

Table 38: Comparative Assessment Results - ANSI/ISA 60079-25 and the IEC 60079-25

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-25 Section #	IEC Standard IEC 60079-25 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References Throughout the standard	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
2	Reference Standards - Add	2. References	2. References	Type 3 - Does Not Meet	DR Modification Additional references in ISA Standard to align with U.S. practice and the National Electrical Code:
3	All sections	All sections	All sections	Type 2 - Meets	No change in requirement except for using different terms
4	All sections	All sections	All sections	Type 2 - Meets	NA
5	Terms and definitions	3.1.3	3.1.3	Type 2 - Meets	This term is not used elsewhere in the ISA or IEC standard
6	Interconnecting wiring / cables used in an intrinsically safe electrical system	8	8	Type 3 - Does Not Meet	ISA Standard references NEC standard
7	Requirements of cables and multi-conductor cables	9.1	9.1	Type 3 - Does Not Meet	ISA standard require that the information regarding cable is to be added to the descriptive system document
8	Earthing and bonding of intrinsically safe systems	11	11	Type 2 - Meets	ISA standard refers to NEC standard instead of IEC 60079-14

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-25 Section #	IEC Standard IEC 60079-25 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
9	Protection against lightning and other electrical surges	12	12	Type 3 - Does Not Meet	ISA standard added requirement that surge protection device is also required to meet requirement for ordinarily location also.
10	Assessment of an intrinsically safe system	13.1	13.1	Type 2 - Meets	Informational note has been removed in the ISA standard
11	Predefined systems	15	15	Type 3 - Does Not Meet	Reference is made to ANSI/ISA 60079-27 for FISCO Systems. FISCO systems are not covered in IEC standard.
12	Assessment of circuits with more than one source of power	Annex B	Annex B	Type 3 - Does Not Meet	Reference to IEC 60079-14 is deleted in the ISA standard. IEC 60079-14 has simplified procedure for determining max system voltages and currents in intrinsically safe circuits

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-25 Section #	IEC Standard IEC 60079-25 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
13	Interconnection of non-linear and linear intrinsically safe circuits	Annex C	Annex C	Type 3 - Does Not Meet	Reference to IEC 60079-14 is deleted in the ISA standard. The installation rules of IEC 60079-14 permits the designer, constructor or operator of an electric installation in a hazardous area to handle such combinations at his own responsibility if a calculated or measured proof of the safety of the interconnection is carried out. Since the operator has, generally, no facility for a measured proof (the required equipment is not available to the operator), the operator is left with a suitable calculation procedure. IEC 60079-14 has up to now provided only a procedure that can be used exclusively for sources with purely linear internal resistance and even this does not always result in safe configurations. In practice however, sources with non-linear characteristic occur frequently, and up till now the combination of these were only possible with the support of a testing station.
14	Testing of cable electrical parameters	Annex G	Annex G	Type 2 - Meets	
15	FISCO systems	Annex I	Annex 1	Type 3 - Does Not Meet	ISA standard deletes the consideration to have a simplified safety documentation

20. Appendix L. ANSI/ISA 60079 vs IEC 60079 - Part 26: Equipment with Equipment Protection Level (EPL) Ga

Table 39 provides a summary of the comparative assessment between the ANSI/ISA 60079-26 and the IEC 60079-26. This appendix contains the analysis for equipment with equipment protection level (EPL) Ga.

Table 39: Comparative Assessment Results - ANSI/ISA 60079-26 and the IEC 60079-26

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-26 Section #	IEC Standard IEC 60079-26 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Scope	Scope	Scope	Type 3 - Does Not Meet	DR Modification The scope of the UL standard has been modified from the IEC Scope
2	Scope	Scope	Scope	Type 3 - Does Not Meet	DR Modification Reference to malfunction of the equipment has been removed in the UL Standard
3	Reference Standards	2	2	Type 3 - Does Not Meet	DC Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
4	Reference Standards	2	2	Type 3 - Does Not Meet	DC Modification Additional standards adopted in U.S. has been added
5	Protection measures against ignition hazards of the electrical circuits	4.1.1	4.1.1	Type 2 - Meets	DR Modification UL standard do not have reference to application of two independent type of protection
6	Application of two independent Types of Protection providing EPL Gb	4.1.2	4.1.2	Type 3 - Does Not Meet	DR Modification Section 4.1.2 has been deleted in the UL standard as this section is not applicable. More than one protection method is not applicable to U.S. standards
7	Partition walls	4.1.3.2	4.1.3.2	Type 1 - Exceeds	IEC has specific requirement for partition wall materials

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-26 Section #	IEC Standard IEC 60079-26 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
8	Partition walls	4.1.3.2	4.1.3.2	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with reference to specific Conditions of Use
9	Table 1 – Separation elements	Table 1	Table 1	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with reference to specific Conditions of Use
10	Example of a separation element with a cylindrical shaft joint and natural ventilation	Figure 2	Figure 2	Type 2 - Meets	UL Standard states Class and Zone reference to indicate an area shown as area requiring EPL Ga in IEC standard.
11	Type Test	5.1	5.1	Type 3 - Does Not Meet	DR Modification More than one protection method is not applicable to U.S. standards
12	Marking	6.1	6.1	Type 3 - Does Not Meet	DR Modification More than one protection method is not applicable to U.S. standards
13	Examples of marking	6.2	6.2	Type 3 - Does Not Meet	DR Modification More than one protection method is not applicable to U.S. standards. UL standard require Class and Zone also indicated in the marking

21. Appendix M. ANSI/ISA 60079 vs IEC 60079 – Past 27: Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive

Table 40 provides a summary of the comparative assessment between the ANSI/ISA 60079-27 and the IEC 60079-27. This appendix contains the analysis for Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive.

Table 40: Comparative Assessment Results - ANSI/ISA 60079-27 and the IEC 60079-27

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-27 Section #	IEC Standard IEC 60079-27 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards. ISA standard clearly indicate that FISCO can be used in Class 1 Zone 0 and FNICO is for use in Class I Zone 2
2	Reference Standards - Add	2. References	2. References	Type 3 - Does Not Meet	DR Modification Additional references in ISA Standard to align with U.S. practice and the National Electrical Code:
3	All sections	All sections	All sections	Type 2 - Meets	
4	Terms and definitions - control drawing	3.4	reference not in IEC	Type 3 - Does Not Meet	The definition for control drawing has been added in ISA Standard
5	Power supplies - General	4.1	4.1	Type 2 - Meets	A difference to allow a reduction in the number of faults in wiring for FNICO systems has been added to align with ANSI/ISA-12.12.01.
6	FNICO field devices	5.3 c 7.3	5.3 7.3	Type 2 - Meets	The National Electrical Code does not recognize the term “nL” and therefore the alternative code “nC” which is recognized, has been used, together with a reference to the applicable clauses of ANSI/ISA-60079-15.
7	System requirements	7.1 7.3	7.1 7.3	Type 3 - Does Not Meet	ISA Standard require control drawing whereas IEC standard only require a simplified list of equipment

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-27 Section #	IEC Standard IEC 60079-27 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
8	Marking	8.1	8.1	Type 2 - Meets	A requirement to differentiate between FNICO and intrinsically safe system has been added in ISA Standard. Bothe ISA and IEC requires that the marking differentiate between the FISCO marking and the marking for the intrinsically safe system
9	Marking	8.2	8.2	Type 3 - Does Not Meet	A requirement to differentiate between FNICO and nonincendive field wiring has been added ISA Standard

22. Appendix N. ANSI/ISA 60079 vs IEC 60079 – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases

Table 41 provides a summary of the comparative assessment between the ANSI/ISA 60079-29-1 and the IEC 60079-29-1. This appendix contains the analysis for performance requirements for gas detectors of detectors for flammable gases.

Table 41: Comparative Assessment Results - ANSI/ISA 60079-29-1 and the IEC 60079-29-1

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-1 Section #	IEC Standard IEC 60079-29-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	1. Scope 2. References	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
2	Reference Standards - Add	2. References	2. References	Type 3 - Does Not Meet	DR Modification Additional references in ISA Standard to align with U.S. practice and the National Electrical Code:
3	Scope	1	1	Type 2 - Meets	The provision of testing the equipment to additional requirement exceeding the minimum requirement has been deleted from the scope of the ISA standard and included in the body of the standard.
4	Ambient Temperature	4.1.2	4.1.2	Type 2 - Meets	ISA standard has precise requirement to the ambient temperature range of equipment conforming to the standard ISA 60079-29-1
5	Indicating devices	4.2.2.1	4.2.2.1	Type 2 - Meets	ISA standard has provided additional guidance regarding the type of indicating device to be used.
6	Indicating devices – Fault Signals	4.2.4	4.2.4	Type 3 - Does Not Meet	ISA std: (Fault signals) requirement of under-range values has been added to establish a maximum allowed negative drift criterion to ensure minimal affect to alarm set-points.
7	Labelling and marking	4.3	4.3	Type 3 - Does Not Meet	Marking with symbol "s" has been removed in the ISA standard Additional details are to be marked as per ISA standard

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-1 Section #	IEC Standard IEC 60079-29-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
8	Instruction manual	4.4	4.4	Type 3 - Does Not Meet	ISA standard requires instruction manual to have additional details
9	Samples and sequence of tests - General	5.2.1.1	5.2.1.1	Type 2 - Meets	Requirement regarding use of the test samples is clarified in ISA standard
10	IR-sensors using optical filters	5.2.1.1	5.2.1.1	Type 1 - Exceeds	Requirements for IR sensors using optical filters has been deleted in ISA Standard since special filter production by the manufacturer is impractical and filter validation by the test laboratory is impractical.
11	Test Methods – Sample and sequence of tests	5.2.1.2	5.2.1.2	Type 3 - Does Not Meet	ISA Std: (Samples and sequence of tests) requirements now include the drop and vibration tests as pre-conditioning tests (along with unpowered storage) since these pre-conditioning tests may have an adverse effect on the equipment's ability to pass subsequent test requirements.
12	Standard test gas	5.3.3	5.3.3	Type 2 - Meets	ISA Standard has clarified the requirement
13	Pressure	5.3.7	5.3.7	Type 3 - Does Not Meet	ISA standard added additional clarification on the test procedure
14	Calibration curve (accuracy)	5.4.3.2	5.4.3.2	Type 3 - Does Not Meet	ISA Std: (Calibration curve/Accuracy) requirements now include a 10% measuring range test in order to establish minimum detection accuracy at low range.
15	Long-term stability (fixed and transportable apparatus – Group II only)	5.4.4.4	5.4.4.4	Type 3 - Does Not Meet	ISA Std: Long-term stability requirements have included the calibration curve/accuracy test in accordance with existing U.S. practice since the standard allows a separate sample to be used for the test which necessitates verification of proper functionality of the apparatus prior and at the conclusion of test.
16	Alarm set point(s) - General	5.4.6	5.4.6	Type 2 - Meets	Minor changes

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-1 Section #	IEC Standard IEC 60079-29-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
17	Humidity	5.4.9	5.4.9	Type 1 - Exceeds	ISA Std: (Humidity) requirements have been restructured for administering the test in accordance with past U.S. practice for ease of administering the test to the minimum level requirements of the standard. IEC Standard is more stringent
18	Time of response (not applicable to spot-reading apparatus)	5.4.16	5.4.16	Type 3 - Does Not Meet	ISA Std: Response time requirements have been modified to include testing with claimed accessories which could directly affect response and recovery time used for proper product selection.
19	High gas concentration operation above the measuring range	5.4.18	5.4.18	Type 3 - Does Not Meet	ISA Std: High gas concentration operation above the measuring range was modified to define the sequence of tests.
20	Short interruption of power supply	5.4.21.2	5.4.21.2	Type 2 - Meets	
21	Voltage transients	5.4.21.3	5.4.21.3	Type 2 - Meets	ISA standard uses the term "equipment" whereas IEC uses the term "apparatus"
22	Step changes of voltage without interruption	5.4.21.4	5.4.21.4	Type 3 - Does Not Meet	ISA Standard added additional clarification/steps for testing
23	Electromagnetic immunity	5.4.25	5.4.25	Type 3 - Does Not Meet	ISA standard has reference to ISO/IEC 17025 regarding EMC testing verification by testing laboratory
24	Fault signals	5.4.28	no reference in IEC Standard	Type 3 - Does Not Meet	ISA standard has additional requirement for Fault signals
25	Verification of ingress protection claims	5.4.29	no reference in IEC Standard	Type 3 - Does Not Meet	ISA standard added requirement for Dust proof and Water proof protection as per ANSI/IEC 60529

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-1 Section #	IEC Standard IEC 60079-29-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
26	Performance requirements	Annex A	Annex A	Type 3 - Does Not Meet	Major changes added to ISA standard related to performance requirement. Requirement to test fault signal for spurious alarms and Environmental exposure added

23. Appendix O. ANSI/ISA 60079 vs IEC 60079 – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen

Table 42 provides a summary of the comparative assessment between the ANSI/ISA 60079-29-2 and the IEC 60079-29-2. This appendix contains the analysis for gas detectors; selection, installation, use and maintenance of detectors for flammable gases and oxygen.

Table 42: Comparative Assessment Results - ANSI/ISA 60079-29-2 and the IEC 60079-29-2

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 Section #	IEC Standard IEC 60079-29-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Reference Standards	Introduction 1. Scope 2. References 3.17, 4,5.1, 5.2.1, 6.1, 10.8, 14, Table 5, 15, 18, 19, Annex C, Annex E	1. Scope 2. Normative References	Type 3 - Does Not Meet	DR Modification Standards not adopted in U.S. has been deleted and replaced with U.S. standards
2	Scope	1	1	Type 3 - Does Not Meet	The equipment should be safe for use in a hazardous area. ISA Standard refers to NEC standard.
3	Reference Standards - Add	2. References	2. References	Type 3 - Does Not Meet	DR Modification Additional references in ISA Standard to align with U.S. practice and the National Electrical Code:
4	Terms and Definitions group II apparatus	3.23	3.2.9	Type 2 - Meets	ISA standard references NEC requirements
5	Terms and Definitions Span	3.5	3.6.9	Type 2 - Meets	
6	Terms and Definitions - volume fraction	3.57	3.1.19	Type 2 - Meets	DR Modification

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 Section #	IEC Standard IEC 60079-29-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
7	Terms and Definitions -	no reference in ISA Standard	3	Type 1 - Exceeds	Latest Edition of IEC standard have requirements for Open path gas detection. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
8	Terms	Throughout		Type 2 - Meets	change in terminology used
9	Detecting gases and vapors - General	4.1	4.1.1	Type 2 - Meets	Additional clarification in IEC. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
10	Calibration considerations	4.3.2.2	4.3.2.2	Type 2 - Meets	Additional clarification in IEC. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
11	Calibration considerations	4.3.2.1	4.3.2.2	Type 2 - Meets	Intent of the guidance provided in both ISA and IEC is the same.
12	Calibration considerations	4.3.2.2	4.3.2.2	Type 1 - Exceeds	Latest Edition of IEC standard have requirements for Open path gas detection. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
13	Detection of vapors - General	4.3.3.1	4.3.3.1	Type 2 - Meets	IEC standard have additional clarification. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 Section #	IEC Standard IEC 60079-29-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
14	Propagation and sampling considerations	4.3.3.3	4.3.3.3	Type 2 - Meets	Additional clarification in IEC. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
15	Oxygen deficiency	4.4	4.4.1	Type 3 - Does Not Meet	ISA specify that Oxygen detector is to confirm to requirement in ANSI/ISA 92.04.01
16	Oxygen deficiency	4.4	4.4	Type 2 - Meets	ISA Standard has reworded the requirement in IEC Standard
17	Dilution of the air by displacement by some other gas or vapour	4.4.3 a	4.4.4 a	Type 2 - Meets	Additional details (note) provided in IEC standard. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
18	Dilution of the air by displacement by some other gas or vapour	4.4.3 d	4.4.4 d	Type 2 - Meets	Additional details provided in ISA Standard
19	Specific applications of gas detection	reference not in ISA Standard	4.5 Specific applications of gas detection	Type 3 - Does Not Meet	IEC Standard has added additional requirement in this section for Gas detection special application - Gas detection as means of reducing risk of explosion. This method is not included in ISA Standard. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 Section #	IEC Standard IEC 60079-29-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
20	Specific considerations for open path detection	NA	4.6 Specific considerations for open path detection	Type 1 - Exceeds	IEC Standard has additional requirement for open path gas detection. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
21	Measuring Principles	5.1	5.1 Measuring Principles	Type 2 - Meets	IEC Standard has added general consideration requirement. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
22	Measuring Principles	5	5.1 Measuring Principles	Type 3 - Does Not Meet	IEC Standard has added alternative detection technologies. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
23	Catalytic sensors	5.1	5.2	Type 2 - Meets	ISA Standard has added the temperature values Similar requirements in both ISA and IEC standard
24	Catalytic sensors - Limitations	5.1.2	5.2.3	Type 2 - Meets	ISA Standard has added the more clarification. Similar requirements in both ISA and IEC standard
25	Interferences	5.1.3	5.2.4	Type 2 - Meets	Additional clarification in ISA. Similar requirements in both ISA and IEC standard
26	Poisoning	5.1.4	5.2.5	Type 2 - Meets	Additional clarification in ISA. IEC ISA have similar requirements
27	Thermal conductivity sensors - Common Applications	5.2.1	5.3.2	Type 2 - Meets	Additional clarification in ISA. The requirements in ISA standard is general clarification regarding the application of the thermal conductivity sensors. Has no effect on the safety.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 Section #	IEC Standard IEC 60079-29-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
28	Thermal conductivity sensors - Limitations	5.2.1	5.3.4	Type 2 - Meets	Additional clarification in ISA. The requirements in ISA standard is general clarification regarding the application of the thermal conductivity sensors. Has no effect on the safety.
29	Infrared sensors - Common Applications	5.3.1	5.4.2 Infrared sensors - Common Applications	Type 1 - Exceeds	Additional details in IEC regarding the use of infrared sensors with open path equipment ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
30	Infrared sensors - Interferences	5.3.3	5.4.4 Infrared sensors - Interferences	Type 1 - Exceeds	Additional details in IEC regarding the use of infrared sensors with open path equipment ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
31	Semiconductor sensors	5.4	5.5.1	Type 2 - Meets	Additional clarification in ISA. Similar requirement in both IEC and ISA standard.
32	Semiconductor sensors - Limitations	5.4.2	5.5.3	Type 2 - Meets	Additional clarification in IEC. Similar requirement in both IEC and ISA standard ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
33	Limitations	5.5.2	5.6.3	Type 2 - Meets	ISA Standard have additional clarification. Both standards are referring to limitation of electrochemical sensors

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 Section #	IEC Standard IEC 60079-29-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
34	Selection of apparatus	6	6.1	Type 2 - Meets	For ISA standard the oxygen concentration is not to exceed 21%. Both IEC and ISA standard is stating that zoning and explosion protection is not valid in Oxygen enriched atmosphere
35	Fixed apparatus and fixed systems	6.2.3.1	6.2.3.1	Type 2 - Meets	IEC Standard provide a list of main classes of fixed equipment.
36	Point detection equipment	no reference in ISA Standard	6.2.3.2	Type 2 - Meets	IEC Standard provide additional details. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
37	Remote sensors with centralized control equipment	no reference in ISA Standard	6.2.3.3	Type 1 - Exceeds	IEC Standard provide additional details. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
38	Sample systems with centralized sensor package	no reference in ISA Standard	6.2.3.4	Type 1 - Exceeds	IEC Standard provide additional details. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
39	Open path equipment	no reference in ISA Standard	6.2.3.5	Type 1 - Exceeds	IEC Standard has additional requirement for open path gas detection. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 Section #	IEC Standard IEC 60079-29-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
40	Transportable apparatus	6.2.4.1	6.2.4.3	Type 1 - Exceeds	IEC Standard provide additional details. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
41	Intended location(s) of use	6.3.2	6.3.2	Type 2 - Meets	As per ISA standard gas detection equipment should be safe for use in a hazardous area. Reference is made to NEC
42	Basic considerations for the installation of fixed systems	8.1	8.2.1	Type 1 - Exceeds	System consisting of point detection equipment and open path which are not included in ISA Standard. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
43	Basic considerations for the installation of fixed systems	8.1	8.2.4	Type 3 - Does Not Meet	Open Path or LOS gas detection systems are not recommended for applications where gas detection is used as a protection technique, as permitted in ANSI/NFPA 70 (NEC) Articles 500.7(K) and 505.8(I).
44	Adverse weather conditions	8.2.2.1	8.3.3.2	Type 1 - Exceeds	This requirement in IEC is for open path equipment. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
45	Vibration	8.2.2.3	8.3.3.4	Type 1 - Exceeds	This additional requirement in IEC is for open path equipment
46	Galvanic corrosion	no reference in ISA Standard	8.3.3.6 Galvanic corrosion	Type 1 - Exceeds	Galvanic Corrosion is not listed in ISA

No.	Section Title / Subject Issue	Baseline Standard ANSI/ISA-60079-29-2 Section #	IEC Standard IEC 60079-29-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
47	Additional considerations for open path equipment	no reference in ISA Standard	8.6	Type 1 - Exceeds	This additional requirement in IEC is for open path equipment. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
48	Summary of considerations for the location of sensors or sampling points	8.5	8.7	Type 2 - Meets	Similar requirements were found in IEC and ISA standard
49	Installation of sensors	8.6	8.8	Type 1 - Exceeds	Additional clarification in IEC. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
50	Initial Gas Calibration	8.9.2	8.11.2 Initial Gas Calibration	Type 1 - Exceeds	This additional requirement in IEC is for sensor systems and open path equipment. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.
51	Electrical safety in hazardous atmospheres	9.3.1	9.3.1	Type 2 - Meets	Additional clarification in IEC. ISA standard was harmonized with previous edition of IEC Standard. This analysis is done between ISA standard and latest edition of IEC Standard.

24. Appendix P. Analysis of National Electrical Code, ANSI/NFPA 70 – 505 and ANSI/ISA 60079-0 to the IEC 60079-0

Table 43 provides a summary of the comparative assessment between National Electrical Code, ANSI/NFPA 70 – 505 and ANSI/ISA 60079-0 to the IEC 60079-0.

Table 43: Comparative Assessment - National Electrical Code, ANSI/NFPA 70 – 505 and ANSI/ISA 60079-0 to the IEC 61892 and the IEC 60079-0

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Listing - of equipment for Zone 0, 1, 2	NEC 505.9 (B)	IEC 61892-1:2015 Section 4.8 IEC 61892-7: 2014 Section 8	Type 2 - Meets	Installation requirement in NEC and IEC has similar requirement
2	Suitability - Documentation	NEC 505.9 (A)	IEC 60079-0: 2011 Section 28.2 IEC 61892-7: 2014 Section 27	Type 3 - Does Not Meet	NEC requires that the equipment installed in hazardous area be evaluated by a qualified testin laboratory for suitability. IEC requires relevant equipment certificate, however do not specify certificate is to be issued by a nationally recognized independent laboratory.

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
3	Marking	NEC 505.9 (C) (2)	IEC 60079-0 Section 29	Type 3 - Does Not Meet	In general the marking in both standards are providing similar details with regard to protection technique, temperature class, gas group. IEC marking doesn't indicate Zone 0, 1 or 2 whereas NEC marking indicates Zone 0, 1 or 2 Marking with symbol "X" to indicate specific conditions of use is not provided for NEC. Identification of Specific installation instructions or reference to a specific installation document when it is necessary to indicate specific conditions of use
4	Marking - Symbol & protection technique	NEC 505.9 (C) (2)	IEC 60079-0 Section 29.4 (a) & (b)	Type 3 - Does Not Meet	Marking of protection techniques are the same. Comparative standards for each protection techniques analyzed separately for specific marking requirements. Refer to the analysis as indicated the following rows
5	Marking - Group	NEC 505.9 (C) (2) 505.9 (B) (2)	IEC 60079-0 Section 29.4 (c) and 4.2	Type 2 - Meets	Both standards has similar markings for Gas Group
6	Marking - Temperature Class	NEC 505.9 (C) (2)	IEC 60079-0 Section 29.4 (d) and 5.3.2.2	Type 2 - Meets	Both standards has similar markings for Temperature Class

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
7	Marking - EPL	NEC 505.9 (C) (2)	IEC 60079-0 section 29.4 (e) and 3.26	Type 2 - Meets	Definitions of different EPL levels are provided in IEC Standard. Although the definitions of EPL is similar in NEC and IEC standard. The marking with EPL level is an operational marking for NEC. Also, it can be concluded that the EPL marking can be used to determine the Zone where the equipment is suitable for installation. Zone 0 - Ga Zone 1 - Gb Zone 2 - Gc
8	Marking for associated apparatus	NEC 505.9 (C) (2)	IEC 60079-0 Section 29.4	Type 2 - Meets	Both standards have similar marking requirements with regard to associated apparatus marking
9	Marking - Ambient Temperature	NEC 505.9 (C) (2)	IEC 60079-0 Scope - Note 1 and Section 29.4 (f) and 5.1.1	Type 2 - Meets	Both standards have similar requirement regarding Ambient temperature marking
10	Alternate marking of equipment protection levels (EPLs)	NEC Table 505.9 (C)(2)(4)	IEC 60079-0 Section 29.13	Type 2 - Meets	The protection technique marking is similar in both standards

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
11	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.3	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.3	Type 2 - Meets	DR Modification The requirement for a Certificate has been revised to include only the name or mark of the Certificate issuer. The name or mark is consistent with U.S. NRTL Listing practice. IEC required "X" mark after Certificate reference ISA standard requires installation instructions or reference to specific installation instructions. Reference with installation instructions or reference to specific installation instructions is consistent with current U.S. industry practice.
12	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.4	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.4	Type 3 - Does Not Meet	DR Modification ANSI required Zone marking also An "A" prefix has been added to "Ex." Added marking is to designate apparatus conforming to these U.S. requirements and the marking requirements of the NEC. Additional markings of "Class I" and "Zone" have been added.
13	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.4 (b)	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.4 (b)	Type 3 - Does Not Meet	DR Modification ISA Standard added markings for optical radiation to align with U.S. adoption of 60079-28

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
14	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.4 (e)	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.4 (e)	Type 2 - Meets	DR Modification ISA Standard make EPL marking optional. This is not an NEC required marking
15	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.8- Ga equipment using two independent Gb types (or levels) of protection	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.8	Type 3 - Does Not Meet	D1 Modification Basic safety principles and requirements, elimination of which would compromise safety Delete marking for Ga equipment using two independent types of protection Concept not recognized in the NEC or the adoption of 60079-26
16	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.9 Marking - Ex Components	29.9	Type 3 - Does Not Meet	DR Modification The marking of Ex components has been revised to accommodate the marking required by the NEC Added marking complies with the marking requirements of the NEC and conforms to U.S. industry practice.
17	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.10.Marking on Small Ex equipment and components	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.1	Type 3 - Does Not Meet	DR Modification The marking of Ex components and small components has been revised to accommodate the marking required by the NEC and to allow for marking of the smallest unit package. Added marking complies with the marking requirements of the NEC and conforms to U.S. industry practice.

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
18	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	28.18.1	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 28.18.1	Type 2 - Meets	DR Modification - Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC. IEC Standard do not have requirements for Division marking of hazardous area. Therefor the U.S. national standards has added requirements for Division marking of hazardous area.
19	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.18.2	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.18.2	Type 2 - Meets	DR Modification - Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC. IEC Standard do not have requirements for Division marking of hazardous area. Therefor the U.S. national standards has added requirements for Division marking of hazardous area.
20	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.18.3	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.18.3	Type 2 - Meets	DR Modification - Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC. IEC Standard do not have requirements for Division marking of hazardous area. Therefor the U.S. national standards has added requirements for Division marking of hazardous area.

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
21	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.18.4	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.18.4	Type 2 - Meets	DR Modification - Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC. IEC Standard do not have requirements for Division marking of hazardous area. Therefor the U.S. national standards has added requirements for Division marking of hazardous area.
22	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.19	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.19	Type 2 - Meets	DR Modification - Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC. IEC Standard do not have requirements for Division marking of hazardous area. Therefor the U.S. national standards has added requirements for Division marking of hazardous area.
23	Marking - ANSI/ISA-60079-0 (12.00.01)-2013 Explosive atmospheres – Part 0: Equipment – General Requirements	29.24	IEC 60079-0 Ed. 6.0 2011-06 Explosive atmospheres – Part 0: Equipment – General requirements 29.24	Type 2 - Meets	DR Modification - Requirements for alternate “Division” marking of “Zone” apparatus as permitted by the NEC. IEC Standard do not have requirements for Division marking of hazardous area. Therefore the U.S. national adopted standards has added requirements for Division marking of hazardous area.

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
24	Marking - ANSI/ISA-60079-1 (12.22.01)-2009 (R2013) Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures “d”	20.1	IEC 60079-1 Edition 7.0 2014-06 Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures “d” 20.1	Type 2 - Meets	Marking requirement are similar in both standards
25	Marking - ANSI/ISA-60079-1 (12.22.01)-2009 (R2013) Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures “d”	Table 9	IEC 60079-1 Edition 7.0 2014-06 Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures “d” Table 9	Type 2 - Meets	DR Modification. The modifiation in the Warning label has no affect on the safety of the equipment.
26	Marking -ANSI/ISA-60079-2 (12.04.01)-2010 (R2015) Explosive Atmospheres – Part 2: Equipment protection by pressurized enclosures “p”	18.6	IEC 60079-2 Edition 6.0 2014-07 - Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "p" 18.6	Type 3 - Does Not Meet	IEC standard uses the marking differently than the ISA Standard

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
27	Marking -ANSI/ISA-60079-2 (12.04.01)-2010 (R2015) Explosive Atmospheres – Part 2: Equipment protection by pressurized enclosures “p”	18.7	IEC 60079-2 Edition 6.0 2014-07 - Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "p" 18.7	Type 1 - Exceeds	Warnings in IEC Standard exceeds the list provided in ISA standard
28	Marking -UL 60079-5 Fourth Edition, Dated April 29, 2016, Explosive Atmospheres - Part 5: Equipment protection by powder filling "q"	6	IEC 60079-5, Explosive Atmospheres • Part 5: Equipment Protection by Powder Filling "q" (fourth edition Issued by IEC February 2015) 6	Type 2 - Meets	Marking is to be in accordance with corresponding IEC and UL 60079-0 standard
29	Marking -UL 60079-6 STANDARD FOR SAFETY, Fourth Edition, Dated April 29, 2016, Explosive atmospheres - Part 6: Equipment protection by liquid immersion "o"	7	IEC 60079-6, Explosive Atmospheres - Part 6: Equipment Protection by Liquid Immersion "o" (fourth edition Issued by IEC February 2015) 7	Type 2 - Meets	Marking requirement in IEC and ISA standard is the same

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
30	Marking- ANSI/ISA-60079-7 (12.16.01)-2008 (R2013) Explosive Atmospheres - Part 7: Equipment protection by increased safety "e"	9.1	IEC 60079-7 Edition 4.0 2006-07 Explosive atmospheres – Part 7: Equipment protection by increased safety «e» 9.1	Type 1 - Exceeds	IEC and ISA standard differs in the marking for level of protection type ISA standard has marking requirements for Group II motor
31	Marking- ANSI/ISA-60079-7 (12.16.01)-2008 (R2013) Explosive Atmospheres - Part 7: Equipment protection by increased safety "e" - For Batteries	9.1	IEC 60079-7 Edition 4.0 2006-07 Explosive atmospheres – Part 7: Equipment protection by increased safety «e» 9.1	Type 1 - Exceeds	IEC Standard has additional requirements for battery marking
32	Marking- ANSI/ISA-60079-7 (12.16.01)-2008 (R2013) Explosive Atmospheres - Part 7: Equipment protection by increased safety "e"	no reference in ISA standard	IEC 60079-7 Edition 4.0 2006-07 Explosive atmospheres – Part 7: Equipment protection by increased safety «e» 9.2	Type 1 - Exceeds	IEC Standard: Requirements for Ex Component "e" enclosures introduced based on those for Ex Component "d" enclosures. Even if the other technical aspects on the product are unchanged and comply with the revised requirements, a change in the marking will be required.

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
33	Marking - ANSI/ISA-60079-11 (12.02.01)-2014 Explosive Atmospheres – Part 11: Equipment protection by intrinsic safety "i" (Edition 6.2)	6.3.13 10.7 12.1 Annex F3.1	IEC 60079-11 Edition 6.0 2011-06 - Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i" 6.3.13 10.7 12.1 Annex F3.1	Type 2 - Meets	DR Modification Marking with U or X is not used for American standards. Requirements for "X" mark after certificate reference have been replaced with installation instructions or reference to specific installation instructions I ISA Standard
34	Marking -ANSI/ISA-60079-15 (12.12.02)-2012 Explosive atmospheres – Part 15: Equipment protection by type of protection "n" (Edition 4)	6.3.1 6.3.2 8.8.3 13 20.2.7.2	IEC 60079-15 Edition 4.0 2010-01 - Explosive atmospheres – Part 15: Equipment protection by type of protection "n" 6.3.1 6.3.2 8.8.3 13 20.2.7.2	Type 2 - Meets	Requirements for "X" mark after Certificate reference have been replaced with installation instructions or reference to specific installation instructions in ISA Standard. Reference with installation instructions or reference to specific installation instructions is consistent with current U.S. industry practice.

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
35	Marking - UL 60079-18 STANDARD FOR SAFETY, Fourth Edition, Dated December 14, 2015 Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"	10	IEC 60079-18, Explosive Atmospheres- Part 18: Equipment Protection by Encapsulation "m", (fourth edition Issued December 2014) 10	Type 2 - Meets	Similar requirements in ISA and IEC Standard for Marking for Group G (Gas)
36	Marking - UL 60079-26 STANDARD FOR SAFETY, Third Edition, Dated April 21, 2017, Explosive Atmospheres - Part 26: Equipment with Equipment Protection Level (EPL) Ga	6.1	IEC 60079-26, Edition 3, published October, 2014, Explosive Atmospheres - Part 26: Equipment with Equipment Protection Level (EPL) Ga 6.1	Type 3 - Does Not Meet	DR Modification More than one protection method is not applicable to U.S. standards
37	Examples of marking - UL 60079-26 STANDARD FOR SAFETY, Third Edition, Dated April 21, 2017, Explosive Atmospheres - Part 26: Equipment with Equipment Protection Level (EPL) Ga	6.2	IEC 60079-26, Edition 3, published October, 2014, Explosive Atmospheres - Part 26: Equipment with Equipment Protection Level (EPL) Ga 6.2	Type 3 - Does Not Meet	DR Modification More than one protection method is not applicable to U.S. standards. UL standard require Class and Zone also indicated in the marking

No.	Section Title / Subject Issue	Baseline Standard National Electrical Code®, ANSI/NFPA 70 – 505 and ANSI/ISA 60079 Section #	IEC Standard IEC61892 and IEC 60079 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
38	Marking - "ANSI/ISA-60079-27 (12.02.04)-2006 Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)"	8.1	IEC 60079-27:2005 Explosive atmospheres - Part 27: Fieldbus intrinsically safe concept (FISCO) 8.1	Type 2 - Meets	A requirement to differentiate between FNICO and intrinsically safe system has been added in ISA Standard. Bothe ISA and IEC requires that the marking differentiate between the FISCO marking and the marking for the intrinsically safe system
39	Marking - "ANSI/ISA-60079-27 (12.02.04)-2006 Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)"	8.2	IEC 60079-27:2005 Explosive atmospheres - Part 27: Fieldbus intrinsically safe concept (FISCO) 8.2	Type 3 - Does Not Meet	A requirement to differentiate between FNICO and nonincendive field wiring has been added ISA Standard
40	ANSI/ISA-60079-29-1 (12.13.01)-2013 Explosive Atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases	4.3	IEC 60079-29-1 Edition 1.0 2007-08 Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases 4.3	Type 3 - Does Not Meet	Marking with symbol "s" has been removed in the ISA standard Additional details are to be marked as per ISA standard

25. Appendix Q. Factory Mutual (FM) 3600 vs IEC 60079-0

Table 44 provides a summary of the comparative assessment between the Factory Mutual (FM) 3600 vs IEC 60079-0.

Table 44: Comparative Assessment Results – FM 3600 and the IEC 60079-0

No.	Section Title / Subject Issue	Baseline Standard FM 3600 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Introduction - Scope	1.2	1	Type 2 - Meets	ANSI/ISA 60079 series are within the scope of FM approval, which are equivalent to IEC 60079 series
2	Introduction - Scope	1.2.1		Type 2 - Meets	Division is used by NEC standard in U.S.A, and it can be viewed as equivalent to IEC Zone system although there are some differences.
3	Introduction - Scope	1.2.2	1	Type 2 - Meets	60079 series are used by FM and IEC; IEC uses 61241-4 which is not used by FM in 5 of 61241 series;
4	Application	1.2.3 a)	1 4	Type 2 - Meets	NFPA 70 Class I and II can be considered as equivalent in IEC Group II, I,
5	Application	1.2.3 b)	1 5.1.2	Type 2 - Meets	No details are given FM; IEC provide detailed examples of what should be considered.
6	Basis for Approval	1.3.1 2.3	6.1	Type 3 - Does Not Meet	IEC Standards of ANSII versions are used by FM. Some requirements are modified by ANSI as noted in comparison between IEC standards with ANSi version, therefore, type 3 is chosen.
7	Basis for Approval	1.3.2	26 27 28	Type 3 - Does Not Meet	IEC specifies the requirements for type tests, routine tests and manufacturers' responsibilities. 3rd party surveillance audit is not as a part of requirements of this standard. But IEC does have standards for test labs, certifying body qualifications IEC 17025 and 17065.
8	Basis for Continued Approval	1.4	26.1	Type 3 - Does Not Meet	Prototype tests are required, but not specify the tests should be carried out or witnessed by 3rd party.

No.	Section Title / Subject Issue	Baseline Standard FM 3600 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
9	Effective date	1.5	forward 2	Type 2 - Meets	IEC specifies more precisely indispensable reference, dated and undated reference.
10	system of units	1.6		Type 3 - Does Not Meet	IEC standards uses SI units.
11	General Information - Requirements	2.1	1	Type 2 - Meets	IEC temperature range is broader than FM standard specified, particularly in high temperature end. IEC note 1 clarifies temperature to +40°C
12	Mechanisms of Ignition	2.2	1	Type 2 - Meets	IEC specifies more items to be excluded such as adiabatic compression, shock waves, exothermic chemical reaction, self-ignition of dust, naked flames & hot gases/liquids; which are not mentioned, but use a generic term electrical characteristic in FM standards
13	Applicability of other standards	2.3	2 6.1	Type 3 - Does Not Meet	FM requires compliance with requirements for ordinary locations. IEC requires that references are indispensable, verification is not required in this standard,
14	Classification & Grouping System	2.4	4 5	Type 2 - Meets	FM & IEC both have similar classification and grouping systems, but using different terms.
15	Marking Requirements	3.1.1 a)	29	Type 3 - Does Not Meet	FM required Class and Group info can be identified equivalent in IEC Group; Div. 2 required by FM can be identified in IEC protection types
16	Marking Requirements	b)	29.4 d) 29.5 d)	Type 2 - Meets	Marking requirements for Temperature class in FM and IEC are considered equivalent.
17	Marking Requirements	c)	29.4 f) & 5.1.1 29.5 f)	Type 2 - Meets	the requirements are the same in both FM and IEC standards
18	Marking Requirements	d)	5.1.1	Type 2 - Meets	IEC requires temperature marking 5 deg.C higher than FM in the low temperature end
19	Marking Requirements	3.1.1 Exceptions: 1)	29.4 d) 29.5 d)	Type 2 - Meets	IEC have similar exemption, but J-box is not listed in exemption.

No.	Section Title / Subject Issue	Baseline Standard FM 3600 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
20	Marking Requirements	2)	29.4 f) 29.5 f)	Type 3 - Does Not Meet	IEC specifies more details marking for this type of equipment. FM refers to ISA 60079-0 which is harmonized standard with national differences
22	Marking Requirements	4)	29	Type 2 - Meets	IEC doesn't specify this province, but professional people in this field understand the same.
23	Temperature class marking	3.1.1 Table 3	5.3.2.2 Table 2	Type 3 - Does Not Meet	More temperature subclasses are defined in FM.
24	Temperature class marking	i)	26.5.1.3 26.5.2	Type 1 - Exceeds	Test requirements are addressed by both FM and IEC, But IEC require more test items and provides more details test instructions.
25	Temperature class marking	ii)	26.5.1.1	Type 2 - Meets	thermocouple & wiring arrangements are addressed by both FM and IEC
26	Temperature class marking	iii)	26.5.1.3	Type 2 - Meets	Temperature interval requirements are same in FM and IEC. IEC does provide more instructions.
27	Temperature class marking	iv)	26.5.1	Type 2 - Meets	ISA MC96-1 1982 is currently withdrawn. IEC 60584-1 Thermocouples is still valid.
28	Temperature class marking	3.1.2	29	Type 2 - Meets	IEC equivalent standard ANSI/ISA 60079 is adapted by FM
29	Permanence of Labelling	3.2.1		Type 3 - Does Not Meet	not mentioned in IEC 60079
30	Permanence of Labelling	3.2.2		Type 3 - Does Not Meet	not mentioned in IEC 60080
31	Additional Marking Information	3.3		Type 2 - Meets	IEC equivalent standard ANSI/ISA 60079 is adapted by FM
32	Additional Marking Information	3.4	29.10 29.11	Type 1 - Exceeds	IEC provides detailed minimum info to be included, and marking on adjacent installation is permitted.
33	Additional Marking Information	3.5	A.4.1	Type 2 - Meets	IEC standards (Section 9) uses metric thread system (ISO 262). This FM provision is to align with IEC standard used in America.
34	Performance Requirements	4	6	Type 1 - Exceeds	IEC covers more aspects than FM, opening times, circulating current, gasket retention, electromagnet & ultrasonic radiation are not covered by FM

No.	Section Title / Subject Issue	Baseline Standard FM 3600 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
35	Mechanical Strength	4.1	6.2	Type 1 - Exceeds	FM specifies type of impacts to be considered. While IEC specifies what kinds of tests to be conducted.
36	Mechanical Strength	4.1.1	26.4.3	Type 2 - Meets	FM simply refers ANSI, ISA 60079, which is basically same with IEC 60079.
37	Mechanical Strength	4.1.2	26.4.2	Type 1 - Exceeds	IEC 60079 provides more details for various groups of enclosures: at same and even worse test conditions than FM standard
38	Mechanical Strength	4.1.3	26.5.2	Type 1 - Exceeds	IEC method is more precise to count the water applied than FM method.
39	Non-Metallic Enclosure materials	4.2	7 26.7	Type 1 - Exceeds	IEC covers more aspects than FM, material specification, thermal endurance, resistance to light, electrostatic charges, and accessible metal parts, which are not covered by FM
40	Non-Metallic Enclosure materials - chemical compatibility for class I locations	4.2.1	26.11	Type 2 - Meets	1) IEC specifies only for Group I mining equipment while FM specifies for Class I for flammable gas/vapor; 2) IEC specifies test medium #2 oil & Hydraulic liquids
41	Non-Metallic Enclosure materials - chemical compatibility for class I locations	4.2.1 Exception 1	26.11 exception	Type 2 - Meets	FM and IEC have the same approach of exclusion
42	Non-Metallic Enclosure materials - chemical compatibility for class I locations	4.2.1 Exception 2	26.11	Type 2 - Meets	FM exception for Class I is equivalent to IEC silence on this topic
43	Non-Metallic Enclosure materials - chemical compatibility for class I locations	4.2.1 Exception 3	IEC 60079-11	Type 2 - Meets	FM exception for intrinsically safe equipment is equivalent to IEC silence on this topic
44	Non-Metallic Enclosure materials - chemical compatibility for class I locations	4.2.1 Exception 4		Type 2 - Meets	FM exception for Nonincendive electrical equipment is equivalent to IEC silence on this topic

No.	Section Title / Subject Issue	Baseline Standard FM 3600 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
45	Non-Metallic Enclosure materials - chemical compatibility for class I locations	4.2.2	26.3 26.11	Type 2 - Meets	No specific test procedures can be found in IEC which is comparable to the clause in FM.
46	Non-Metallic Enclosure materials - Aging	4.3	26.8 & 26.9	Type 1 - Exceeds	IEC thermal endurance tests requirements are more stringent than FM, details see Row 57 through 62
47	Non-Metallic Enclosure materials - Aging	4.3.1	26.16 26.8 26.9	Type 1 - Exceeds	IEC has specified elastomeric sealing qualification test requirements to heat & to cold, which are more stringent than FM
47	Non-Metallic Enclosure materials - Aging		26.8 table 15	Type 1 - Exceeds	IEC test temperature is divided in 3 group, most time not lower than FM, duration is long then FM
48	Non-Metallic Enclosure materials - Aging	4.3.1 Note 1	26.4.2	Type 1 - Exceeds	IEC resistance to impact at max. & min. temperature is more stringent than simple hardness tests required by FM
49	Non-Metallic Enclosure materials - Aging	4.3.1 Note 2	26.11	Type 2 - Meets	IEC has similar test requirements & can be considered as equivalent.
50	Non-Metallic Enclosure materials - Aging	4.3.1 Exception	26.11	Type 1 - Exceeds	IEC doesn't have exception for Group II
51	Non-Metallic Enclosure materials - Aging	4.3.2	26.8 & 26.9	Type 1 - Exceeds	IEC aging requirements are more stringent than FM
52	Metallic Enclosure materials - Reactance:	4.4	8 9	Type 3 - Does Not Meet	Copper & alloys limited by FM are not mentioned in IEC; Aluminum limited by IEC is not mentioned by FM: IEC provide more comprehensive requirements on material compositions on different level of protection.
53	Operations Requirements	5		Type 3 - Does Not Meet	Quality program is not specified in IEC 60079-0, but is within IEC Ex scheme given in IEC 17065 & 17025
54	Operations Requirements	5.1.1	26	Type 2 - Meets	IEC type tests are considered as equivalent to verify design quality

No.	Section Title / Subject Issue	Baseline Standard FM 3600 Section #	IEC Standard IEC 60079-0 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
55	Operations Requirements	5.1.1	28	Type 3 - Does Not Meet	FM requirements are focused on manufacturing process and inspection procedures, while IEC defined requirements are focused on documentation and not so detailed as FM.
57	Operations Requirements	5.1.2		Type 3 - Does Not Meet	This is not specified in IEC 60079-0, but is within IEC Ex scheme given in IEC 17065 & 17025.
58	Operations Requirements	5.1.3		Type 3 - Does Not Meet	This is not specified in IEC 60079-0, but is within IEC Ex scheme given in IEC 17065 & 17025.
59	Operations Requirements	5.2		Type 3 - Does Not Meet	This is not specified in IEC 60079-0, but is within IEC Ex scheme given in IEC 17065 & 17025.
60	Operations Requirements	5.2.1		Type 3 - Does Not Meet	This is not specified in IEC 60079-0, but is within IEC Ex scheme given in IEC 17065 & 17025.
61	Operations Requirements	5.2.2		Type 3 - Does Not Meet	This is not specified in IEC 60079-0, but is within IEC Ex scheme given in IEC 17065 & 17025.
62	FM Approvals Certification Marks	Appendix A	29	Type 2 - Meets	FM specifies the limitation for usage of FM logo. This is not a technical issue.

26. Appendix R. Factory Mutual (FM) 3610 vs IEC 60079-15

Table 45 provides a summary of the comparative assessment between the Factory Mutual (FM) 3600 vs IEC 60079-15.

Table 45: Comparative Assessment Results – FM 3610 and the IEC 60079-1

No.	Section Title / Subject Issue	Baseline Standard FM 3610 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Introduction	1.1 1.1.1	Foreword 1) & 4)	Type 2 - Meets	FM 3610 serves as basis for approval; IEC standards are used to promote international uniformity
2	Introduction	1.1.2	Foreword 3)	Type 3 - Does Not Meet	IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment service and in some areas, access to IEC marks of conformity
3	Scope	1.2.1	1	Type 2 - Meets	ANSI/ISA 60079-11 is referred by FM 3010 for Class I, Div. 1, Group A.B.C.D.
4	Scope	1.2.1 Exception 1 Exception 2	12	Type 2 - Meets	Except some warning signs requirements specified by FM 3610, ANSI/ISA 60079-11 is referred by FM 3610.
5	Basis for Requirements	1.3.1	Foreword 2)	Type 2 - Meets	Both documents are consensus standards. IECis International organization, more people from different countries are involved in the standard development.
6	Basis for Requirements	1.3.2	10 11	Type 2 - Meets	FM requires tests and practice experience; IEC requires also tests and practice experience by various nations.
7	Basis for Requirements	1.3.3	10 11	Type 2 - Meets	FM requires tests and practice experience; IEC requires also tests and practice experience by various nations.
8	Basis for Requirements	1.3.4	5.5 5.6	Type 2 - Meets	Exact sentence has not be found in IEC, but the same intent can be seen in various clauses as listed

No.	Section Title / Subject Issue	Baseline Standard FM 3610 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
9	Basis for Approval	1.4	6.1	Type 3 - Does Not Meet	IEC specifies the requirements for type tests, routine tests and manufacturers' responsibilities. 3rd party surveillance audit is not as a part of requirements of this standard. But IEC does have standards for test labs, certifying body qualifications IEC 17025 and 17065.
10	Basis for Continued Approval	1.5	Foreward 5)	Type 3 - Does Not Meet	IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity
11	Effective date	1.6	Foreword	Type 2 - Meets	Publication updates from FM and IEC have similar effects.
12	Definition	1.8	3	Type 2 - Meets	ANSI/ISA 60079-11 is referred by FM 3610
13	Scope	2.1	1	Type 2 - Meets	Same scope: intrinsically safe apparatus in and outside hazardous areas for all class, divisions, and groups.
14	Requirements	2.2	IEC 60079-0 1	Type 2 - Meets	IEC temperature range is broader than FM standard specified, particularly in high temperature end. IEC note 1 clarifies temperature to +40°C
15	Mechanisms of Ignition	2.3.1	IEC 60079-0 1 7.4	Type 2 - Meets	IEC specifies more items to be excluded such as adiabatic compression, shock waves, exothermic chemical reaction, self-ignition of dust, naked flames & hot gases/liquids; which are not mentioned, but use a generic term electrical characteristic in FM standards
16	Mechanisms of Ignition	2.3.2	5	Type 2 - Meets	Both FM and IEC are dealing with low voltage circuits.
17	Applicability of other standards	2.4	2	Type 3 - Does Not Meet	FM requires compliance with requirements for ordinary locations. IEC requires that references are indispensable, verification is not required in this standard,
18	Control Drawing	2.5	13	Type 1 - Exceeds	IEC provided more detailed documentation requirements than FM

No.	Section Title / Subject Issue	Baseline Standard FM 3610 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
19	Apparatus for Class II & III locations	3.1	6	Type 1 - Exceeds	IEC has more detailed requirements than FM
20	Specific Requirements	3.2.1	6.1.2 6.1.3	Type 2 - Meets	Requirements differences for Class I and II/III in FM are similar to IEC requirements for Group I/II and III
21	Specific Requirements	3.2.2	IEC 60079-0 5.3.2	Type 2 - Meets	Similar requirements are defined for maximum surface temperature limitation for various classes in FM and groups in IEC.
22	Specific Requirements	3.2.3	6.1	Type 2 - Meets	the requirements in FM and IEC for enclosures can be considered as equivalent
23	Specific Requirements	3.2.4	Table 5 Table F.1 Table F.2	Type 1 - Exceeds	More detailed creepage and clearance requirements are defined in IEC.
24	Dust-Tight Enclosure	3.3	6.1.3	Type 2 - Meets	IEC IP5X is defined as dust protected; IP2X is accepted for special conditions as mentioned, which can be considered as equivalent to FM dust tight requirements.
25	Dust-Tight Enclosure	3.3.1	6.1.3 b)	Type 2 - Meets	IEC IP5X ingress is not sufficient to interfere with operation, IP6X will be considered as equivalent to FM requirements.
26	Dust-Tight Enclosure	3.3.2	6.6	Type 1 - Exceeds	IEC has specified more detailed requirements for encapsulation of conductive parts than FM
27	Test Procedures: Drop Test	4.1 4.1.1	IEC 60079-0 26.4.3	Type 3 - Does Not Meet	IEC required drop tests are less 2 times that FM
28	Test Procedures: Drop Test	4.1.2	IEC 60079-0 26.4.3	Type 1 - Exceeds	No guide is mentioned in drop tests in IEC standards
29	Dust-Tight Enclosure Test	4.2 4.2.1	IEC 60529 13.4	Type 2 - Meets	Same dust test requirements in FM and IEC standards.
30	Dust-Tight Enclosure Test	4.2.2	IEC 60529 13.4	Type 2 - meets	Same dust test requirements in FM and IEC standards.
31	Dust-Tight Enclosure Test	4.2.3	IEC 60529 13.6.2	Type 2 - Meets	requirements in FM and IEC can be considered as equivalent

No.	Section Title / Subject Issue	Baseline Standard FM 3610 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
32	Dust Blanketing Temperature test	4.3 4.3.1	IEC 60079-0 5.3.2.3.2 26.5.1	Type 1 - Exceeds	IEC provides more detailed and concise requirements for testing for surface temperature with specified dust layers than FM
33	Dust Blanketing Temperature test	4.3.2	IEC 60079-0 26.5.1	Type 1 - Exceeds	IEC provides more detailed and concise requirements for testing for surface temperature with specified dust layers than FM
34	Dust Blanketing Temperature test	4.3.3	IEC 60079-0 26.5.1	Type 1 - Exceeds	IEC provides more detailed and concise requirements for testing for surface temperature with specified dust layers than FM
35	Marking Intrinsically Safe Apparatus	5.1	IEC 60079-0 29.3 IEC 60079-11 12.1 12.3	Type 3 - Does Not Meet	FM specifies several warning for repair, maintenance and operational issues, which are not addressed by IEC
36	Associated Apparatus	5.2	12.2 12.3	Type 2 - Meets	FM specifies several warning for repair, maintenance and operational issues, which are not addressed by IEC
37	Marking Battery-Powered apparatus	5.3 5.3.1	12.3	Type 2 - Meets	Warning markings provided by FM are covered also by IEC
38	Marking Battery-Powered apparatus	5.3.1.1	12.3 Table 11 a)	Type 2 - Meets	Warning markings provided by FM are covered also by IEC
39	Marking Battery-Powered apparatus	5.3.1.2	12.3 Table 11 c)	Type 2 - Meets	Warning markings provided by FM are covered also by IEC
40	Marking Abbreviations	5.4	12.4	Type 2 - Meets	FM and IEC use different marking systems, IEC has protection level ia, ib, ic, can be identify for Zone 0, 1, or2. FM's marking cannot provide this information. FM refers to ISA 60079 standards.

No.	Section Title / Subject Issue	Baseline Standard FM 3610 Section #	IEC Standard IEC 60079-15 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
41	Marking Drawings	5.5.1	13	Type 2 - Meets	FM is focusing Approval by FM; while IEC emphasizes the document requirements. FM refers to ISA 60079 standards.
42	Marking Drawings	5.5.2	13 b)	Type 2 - Meets	FM requirements can be considered as covered by IEC
43	Operations Requirements	6	IEC 60079-0 28	Type 3 - Does Not Meet	Manufacturer's responsibilities are defined, audit and issuing certification are not in the scope of IEC 60079 series, but they are in IEC Ex scheme given in IEC 17065 & 17025.
44	Operations Requirements	6.1.1	28	Type 3 - Does Not Meet	FM requirements are focused on manufacturing process and inspection procedures, while IEC defined requirements are focused on documentation and not so detailed as FM.
45	Operations Requirements	6.1.2	28 IEC 60079-0 30	Type 3 - Does Not Meet	Documents for users in IEC exceed FM requirements, but no quality assurance for manufacturers is specified in IEC 60079 series.
46	Operations Requirements	6.1.3		Type 3 - Does Not Meet	This aspect is not specified in IEC 660079 series
47	Operations Requirements	6.1.4		Type 3 - Does Not Meet	This aspect is not specified in IEC 660079 series
48	Operations Requirements	6.2		Type 3 - Does Not Meet	This aspect is not specified in IEC

27. Appendix S. Factory Mutual (FM) 3611 vs IEC 60079-15

Table 46 provides a summary of the comparative assessment between the Factory Mutual (FM) 3600 vs IEC 60079-15.

Table 46: Comparative Assessment Results – FM 3611 and the IEC 60079-1

No.	Section Title / Subject Issue	Baseline Standard FM 3611 Section #	IEC Standard IEC 60079-15 Section#	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Introduction	1.1 1.1.1	1	Type 1 - Exceeds	IEC 60079-15 covers not only Nonincendive component, but also arc creating devices protected by "n" used in Zone II.
2	Introduction	1.1.2	1	Type 3 - Does Not Meet	IEC established the requirements, but doesn't have facility examining, quality audit & follow-up program,
3	Basis for Requirements	1.2	1	Type 2 - Meets	IEC temperature range is broader than FM, pressure and O2 contents are same.
4	Basis for Approval	1.3	1	Type 3 - Does Not Meet	Approval is based on standards, IEC is not certifying body. If 3rd parties certifies the equipment to IEC standards, all requirements therein should be met.
5	Basis for Continued Approval	1.4	1 (IEC60079-0/ 26.1)	Type 3 - Does Not Meet	IEC specifies the requirements for type tests, routine tests and manufacturers' responsibilities. 3rd party surveillance audit is not as a part of requirements of this standard. But IEC does have standards for test labs, certifying body qualifications IEC 17025 and 17065.
6	Effective date	1.5	1 (IEC60079-0/ 2)	Type 1 - Exceeds	IEC specifies more precisely indispensable reference, dated and undated reference.
7	Definitions	1.7	3	Type 2 - Meets	FM simply refers to ANSI/ISA-12.12.01; IEC specifies 8 items in addition to IEC 60070-0.
8	Scope	2.1	1	Type 1 - Exceeds	Nonincendive component is only one of equipment covered by IEC, arc creating devices protected by "n" used in Zone II are also covered in IEC 60079-15.
9	Applicability of other standards	2.2.1	2	Type 1 - Exceeds	See comparison for ISA 12.12.01 vs IEC 60079-15

No.	Section Title / Subject Issue	Baseline Standard FM 3611 Section #	IEC Standard IEC 60079-15 Section#	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
10	Applicability of other standards	2.2.2	2 6.1	Type 3 - Does Not Meet	FM requires compliance with requirements for ordinary locations. IEC requires that references are indispensable, verification is not required in this standard,
11	Marking	3.1.1	24	Type 3 - Does Not Meet	FM required Class and Group info can be identified equivalent in IEC;
12	Marking		24.2	Type 2 - Meets	IEC provides additional marking requirements, which are not covered in FM. FM refers to ISA 60079 standards
13	Operations Requirements	4		Type 3 - Does Not Meet	Manufacturer's responsibilities are defined, audit and issuing certification are not in the scope of IEC 60079 series, but they are in IEC Ex scheme given in IEC 17065 & 17025.
	Comparison Analysis between ISA 12.12.01 and IEC 60079-15				
	ISA 12.12.01 2015	ISA 12.12.01			Main points of ISA 12.12.01 are listed for reference only
14	Scope	2	1	Type 2 - Meets	IEC 60079-15 covers not only Nonincendive component, but also arc creating devices protected by "n" used in Zone II.
15	General Requirements	4	6 6.2 6.3 6.4 6.5	Type 2 - Meets	IEC has more detailed, quantified, more stringent requirements, while ISA provides only a generic consideration.
16	Requirements for Class I, Div.2 equipment	5.1.1	17 17.1 17.2 17.3.2 17.3.3	Type 2 - Meets	All requirements in ISA clause 10 are addressed equivalently in IEC listed sections, plus enclosed break devices are also covered by IEC.

No.	Section Title / Subject Issue	Baseline Standard FM 3611 Section #	IEC Standard IEC 60079-15 Section#	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
17	Requirements for Class I, Div.2 equipment	5.1.2	5 5.1 5.3.3	Type 2 - Meets	All requirements in ISA clause 10 are addressed equivalently in IEC listed sections.
18	Requirements for Class I, Div.2 equipment	5.2	6.3	Type 2 - Meets	IEC provides more detailed requirements for enclosures for various applications
19	Requirements for Class I, Div.2 equipment	5.3	9	Type 3 - Does Not Meet	IEC clearly define non-sparking, temperature class, & mount requirements; ISA only fuses subject overloads
20	Requirements for Class I, Div.2 equipment	5.4	9.5	Type 3 - Does Not Meet	same issue is addressed both IEC and FM.
21	Requirements for Class I, Div.2 equipment	5.5	17	Type 2 - Meets	ISA requirements apply to circuit breaker with accessible handle with more options; IEC specifies the requirements for enclosed break devices, no alternative option is mentioned, and does not limit to breaker with accessible handle only.
22	Requirements for Class I, Div.2 equipment	5.6	12	Type 1 - Exceeds	IEC specifies more comprehensive requirements for 3 types of batteries: Max. capacity, connections, charging & discharging modes, etc. not mentioned in ISA.
23	Nonincendive circuits & field wiring	7.1	60079-11 10.1 6.2.3 6.3.3	Type 2 - Meets	IEC define nonincendive circuits with max. voltage and current, which are higher than ISA value, also ISA provides more detailed diagram for various applications. In addition, ISA provides test machine and method to define non-incendive circuit.

No.	Section Title / Subject Issue	Baseline Standard FM 3611 Section #	IEC Standard IEC 60079-15 Section#	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
24	Nonincendive circuits & field wiring	7.2	12 8 14 16	Type 2 - Meets	Effects of Capacitor, inductive circuits, making/breaking (connectors) are addressed in IEC with more detailed requirements.
25	Nonincendive circuits & field wiring	7.3	60079-11 7, 8 Annex A	Type 2 - Meets	IEC define nonincendive circuits with max. voltage and current, which are higher than ISA value, also ISA provides more detailed diagram for various applications.
26	Nonincendive circuits & field wiring	7.4	60079-11 Annex A	Type 2 - Meets	ISA defines max. output voltage and current for various applications. IEC defines only max. ratings.
27	Nonincendive circuits & field wiring	7.5	60079-11 Annex A	Type 2 - Meets	ISA defines max. internal capacitance & internal inductance for various applications, which is not covered by IEC.
28	Nonincendive circuits & field wiring	7.6	60079-11 Annex A	Type 2 - Meets	ISA defines max. input voltage & input current, which are not covered by IEC.
29	Nonincendive circuits & field wiring	7.7	60079-11 Annex A	Type 2 - Meets	IEC has same requirements with different wording.
30	Normally nonarching components	8.1 8.2	7.3.5	Type 2 - Meets	ISA and IEC all use a separation force of at least 15 N for defining non-arching components, IEC further use 10 times of component weight for light weight components as an alternative.
31	Normally nonarching components	8.3	9	Type 1 - Exceeds	IEC has more requirements on fuses compared with ISA
32	Normally nonarching components	8.4	17	Type 1 - Exceeds	IEC has more requirements for break than ISA
33	Normally nonarching components	8.5	11	Type 1 - Exceeds	IEC has much more requirements than ISA.
34	Normally nonarching components	8.6	9.5 12.5.2.8	Type 2 - Meets	ISA requires non-interchangeable in connector in generic terms. IEC specifies it in multiple places.

No.	Section Title / Subject Issue	Baseline Standard FM 3611 Section #	IEC Standard IEC 60079-15 Section#	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
35	Normally nonarching components	8.7	7.3.5	Type 2 - Meets	IEC has more requirements than ISA although tool for opening is not directly mentioned here, but in 7.1 general section.
36	Normally nonarching components	8.8.1	7.3.5	Type 2 - Meets	Similar requirements in both standards, IEC specifies in more details.
37	Normally nonarching components	8.8.2	7.2.2	Type 2 - Meets	Both ISA and IEC refer to separate standards for wiring connection methods. Comparison to those referred standards is not in this scope.
38	Normally nonarching components	8.8.3	7.2.2	Type 2 - Meets	Both ISA and IEC refer to separate standards for wiring connection methods. Comparison to those referred standards is not in this scope.
39	Normally nonarching components	8.8.4	8.3 & 8.4	Type 2 - Meets	Similar requirements in both standards, IEC specifies in more details.
40	Normally nonarching components	8.8.5	8.5& 7.3	Type 2 - Meets	Similar requirements in both standards, IEC specifies in more details.
41	Marking	9.1 thu 9.11	24	Type 2 - Meets	IEC general marking 60079-0, additional marking for batteries is specified, examples are given for various type of equipment and warning. marking is considering as equivalent to ISA
42	Surface temperature requirements	10.1	5.1	Type 2 - Meets	surface temperature is addressed in both IEC and ISA, with minor wording difference
43	Surface temperature requirements	10.2	IEC 60079-0 5.3.2.2	Type 2 - Meets	Temperature Code is similar in IEC and ISA.
44	Surface temperature requirements	10.3	5.2	Type 2 - Meets	Same 60079-0 test methods are used.
45	Spark ignition testing of nonincendive circuits	11.1	60079-11 Annex A&B	Type 1 - Exceeds	ISA 60079-11 is referred for spark testing apparatus, safety factor of 1.0 is defines. IEC contains selection of safety factor for various conditions, 1.5 is used for several cases.
46	Spark ignition testing of nonincendive circuits	11.2	60079-11 10.1.4.1	Type 2 - Meets	same requirement in IEC & ISA

No.	Section Title / Subject Issue	Baseline Standard FM 3611 Section #	IEC Standard IEC 60079-15 Section#	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
47	Evaluation of nonincendive components	12.1	22.4.2 A.2	Type 2 - Meets	Same preconditioning procedures
48	Spark ignition test	12.2	22.4.3	Type 2 - Meets	Similar tests in IEC and ISA. IEC defines more details for gas concentration, test methods, etc.
49	Evaluation of sealed device	13.1.2	19	Type 2 - Meets	ISA and IEC both require tests for sealed devices
50	Evaluation of sealed device	13.1.3	19.3	Type 2 - Meets	same requirement in IEC & ISA
51	Evaluation of sealed device	13.1.4	19.5	Type 2 - Meets	same requirement in IEC & ISA with different wording
52	Evaluation of sealed device	13.1.5	19.5	Type 1 - Exceeds	IEC requires COT 10K above Max. service temp., or 20 K for onerous rated service conditions. Minimum temperature is not mentioned.
53	Evaluation of sealed device	13.1.6	19.2, 19.4	Type 3 - Does Not Meet	Contamination and corrosive compounds are considered in ISA, not mentioned in IEC.
54	Evaluation of sealed device	13.2	22.5.3.2	Type 1 - Exceeds	Test procedure is same, IEC required water temperature is higher than ISA (IEC 65°C vs. ISA 50°C).
55	Evaluation of enclosed-break devices	14.1	17.2.1 17.3.1 17.3.2 17.3.3 17.1	Type 2 - Meets	ISA required 6 items, 4 items are same with IEC; ISA required COT include min. service temperature, it is not mentioned in IEC, seems to be implied. ISA refers to U.S. nationalized IEC 60079-1, which is also indispensable for IEC requirements.
56	Evaluation of enclosed-break devices	14.2	22.4	Type 3 - Does Not Meet	Test methods defined in both ISA and IEC are the same except some gas mixture concentrations defined by IEC are lower than ISA.
57	Drop Tests and Impact Tests	16.1 16.2	22.3.1.2	Type 2 - Meets	IEC drop test 2 times less than ISA but height is higher than ISA. Overall is equivalent

No.	Section Title / Subject Issue	Baseline Standard FM 3611 Section #	IEC Standard IEC 60079-15 Section#	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
58	Drop Tests and Impact Tests	16.3	21 60079-0 26.4.2 Annex C	Type 2 - Meets	Impact test is required by both ISA and IEC.
59	Manufacturer's instructions	16.1 thu 16.6	26	Type 2 - Meets	Similar information is required in both IEC and ISA standards.

28. Appendix T. Factory Mutual (FM) 3615 vs IEC 60079-1

Table 47 provides a summary of the comparative assessment between the Factory Mutual (FM) 3600 vs IEC 60079-15.

Table 47: Comparative Assessment Results – FM 3615 and the IEC 60079-1

No.	Section Title / Subject Issue	Baseline Standard FM 3615 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Introduction	1.1	Forward 1)	Type 2 - Meets	Introduction only, not real technical requirements
2	Scope	1.2	1	Type 2 - Meets	Introduction only, not real technical requirements
3	Basis for Approval	1.3	Forward 2)	Type 3 - Does Not Meet	IEC is not certifying body. This is not in IEC scope.
4	Basis for Continued Approval	1.4	Forward 5)	Type 3 - Does Not Meet	IEC is not certifying body. This is not in IEC scope.
5	Basis for Requirements	1.5	Forward 2) & 3)	Type 2 - Meets	Both documents are consensus standards. IEC is International organization, more people from different countries are involved in the standard development.
6	Effective date	1.6	Forward	Type 2 - Meets	IEC specifies more precisely indispensable reference, dated and undated reference.
7	Definitions	2	3	Type 2 - Meets	Different terms used for most items, but means are the same.
8	General Information (other than performance Requirements)	3.1	4.1 20	Type 3 - Does Not Meet	IEC markings provide more comprehensive information about equipment and protections provided. FM standard refers to ISA 60079 for Zone hazardous area
9	General Information	3.1.1	20.2	Type 2 - Meets	IEC markings provide more comprehensive information about equipment and protections provided.
10	General Information	3.1.2	20.2 20.3	Type 2 - Meets	different wordings are used, equivalent effects
11	General Information	3.1.3	20.3	Type 2 - Meets	different wordings and focuses are used, equivalent effects

No.	Section Title / Subject Issue	Baseline Standard FM 3615 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
12	Required documentation for approval examination	3.2	5 6 7 8 9 10 11	Type 3 - Does Not Meet	IEC doesn't specify document submission requirements, no submission of documentation is specified, however information related construction is contained in requirements in various sections. Independent certification bodies can request documentation for verifying the compliance.
13	Construction Requirements	3.3.1	6	Type 2 - Meets	FM repeats enclosure mechanical strength, while IEC refers to IEC60079-0, without special requirements, but focus on possible flame path.
14	Construction Requirements	3.3.2	5 5.2.2	Type 2 - Meets	same requirements in both FM and IEC
15	Construction Requirements	3.3.3	5 5.2 to 5.5	Type 3 - Does Not Meet	IEC 60079-1 is referred by FM 3615. IEC tables have more detailed and comprehensive data than FM, but for same length, FM required gaps are smaller than IEC.
16	Construction Requirements	3.3.3 continue	5.2 5.2.3 5.2.4 5.2.5 5.2.6 5.2.8 5.2.9 5.3 5.4 5.5	Type 3 - Does Not Meet	IEC 60079-1 is referred by FM 3615. IEC tables have more detailed and comprehensive data than FM, but for same length, FM required gaps are smaller than IEC.
17	Construction Requirements	3.3.3 continue	13 13.1	Type 2 - Meets	NPS is not applicable for IEC

No.	Section Title / Subject Issue	Baseline Standard FM 3615 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
18	Construction Requirements	3.3.4	19 19.2 19.3	Type 1 - Exceeds	requirement A in FM are generic, IEC has similar requirements, in addition, IEC required resistance to tracking and creepage distances on internal surfaces of the enclosure walls; FM Flame resistance tests are the same for all gas types, IEC tests are specifically designed for gas types. Test numbers are same, see below 4.3 & 4.7 comparisons.
19	Construction Requirements	3.3.5	5.4	Type 1 - Exceeds	Basic requirements in FM and IEC are same permissible gap and length shall be maintained. FM permits non-metallic gaskets be used for explosion protection with additional strength requirements, which is not mentioned in IEC. i.e. IEC has more stringent requirements.
20	Construction Requirements	3.3.6	6.1	Type 1 - Exceeds	Both standards require that mechanical strength of assembly does not depend upon the cement alone, and minimum joint length required are the same. FM defines softening point of sealing material, which is not mentioned by IEC; while IEC requires over-pressure test with water, which is not required by FM.
21	Construction Requirements	3.3.7	13.4 13.5 13.6 13.7 13.8	Type 2 - Meets	Flame path Issue concerned in FM are addressed in IEC through cable glands, conduit sealing, etc, and Annex C flameproof joints.
22	Construction Requirements	3.3.8	5.1	Type 2 - Meets	Almost same requirements with different wording in FM and IEC
23	Construction Requirements	3.3.9	11	Type 2 - Meets	Same requirements in both FM and IEC, IEC with more details.
24	Construction Requirements	3.3.10	IEC 60529	Type 3 - Does Not Meet	IEC doesn't specify requirements in 60079-1 for outdoor hazardous area, but does have similar requirements
25	Construction Requirements	3.3.11	17.2	Type 1 - Exceeds	IEC provides more for isolation means for more external sources.

No.	Section Title / Subject Issue	Baseline Standard FM 3615 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
26	Performance Tests and Evaluation	4.1.1	21	Type 1 - Exceeds	IEC specifies test order to be followed. FM just mentions general test coverage.
27	Performance Tests and Evaluation	4.1.2	15.1 15.3 15.5.2	Type 1 - Exceeds	All FM required items are covered by IEC, and IEC have more comprehensive descriptions for various tests, different equipment type,
28	Conduit Opening Torque test	4.2.1	C.3.3.1	Type 1 - Exceeds	torque test values for NPT thread are same in both FM and IEC, IEC provides also metric system value and additional values for stopping plugs (higher than thread adapter, which is not in FM.
28	Conduit Opening Torque test	4.2.2	C.3.4.1 C.3.4.2	Type 1 - Exceeds	After torque test, IEC requires impact test for assembly, which is not stated in FM.
29	Explosion Pressure tests	4.3	15.2.2 15.5.	Type 2 - Meets	FM requires 10 times tests for all groups; IEC specifies test times for different gas groups; IIC is 10 in total, equal to FM, IIA & IIB are less than FM, but testing gas concentration, temperature and pressure are controlled more precise in IEC than FM. and various types equipment is also specified. Overall, "dc" devices IEC is more stringent, others are considered equivalent to FM.
30	Flame Propagation tests	4.4.1	15.3 4.2	Type 2 - Meets	test conditions in IEC are controlled more precisely than FM, e.g. more accurate gas mixture, temperature, different materials, various groups, enrich O2, increased pressure, etc.. FM required test times (10) are more than IEC (5), IEC "da" 50 times test, higher. Overall, it is considered that test results from IEC & FM can give equivalent indication if products can stop flame propagation.
31	Flame Propagation tests	4.4.2	15.3.1 thru 15.3.3.5	Type 2 - Meets	Compliant joins are basis for the tests, contained thru the clauses, key points are listed above cell (F40). Conclusion is the same as above.

No.	Section Title / Subject Issue	Baseline Standard FM 3615 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
32	Flame Propagation tests	4.4.3	15.3.1 thru 15.3.3.5	Type 2 - Meets	Modified joints are considered in variations contained in Table 9, 11, and sub-paragraphs. Conclusion is the same as above.
33	Flame Propagation tests	4.4.4	13.3	Type 2 - Meets	same as above
34	Flame Propagation tests	4.4.5	13.3.1 Table 10	Type 2 - Meets	Test factors for group A/B in FM are higher than IEC group IIC. But gas mixture concentration is controlled more precise in IEC.
35	Hydrostatic Tests	4.5	15.2.3	Type 2 - Meets	IEC 60079 provides more details for various groups of enclosures: at same and even worse test conditions than FM standard
36	Hydrostatic Type Test	4.5.1	15.2.3.2 15.2.3.3	Type 3 - Does Not Meet	IEC maximum static test pressure is same as FM, but permitted 1.5 times ignition pressure for certain cases. FM does not have dynamic test.
37	Hydrostatic Routine Test	4.5.2	16	Type 2 - Meets	IEC provides more options and exemptions for overpressure routine tests. Test requirements in FM and IEC can be considered as equivalent.
38	Impact Test	4.6	IEC 60079-0 26.4.2 Annex C	Type 1 - Exceeds	IEC provides more details for various groups of enclosures for impact tests: at same and even worse test conditions than FM standard as analyzed for FM3600. vs. IEC 60079-0
39	Flammability Test	4.7	19.4	Type 2 - Meets	FM test method is different with IEC with the same intention. Both test methods can reflect flammability of non-metallic materials. It can be considered as equivalent.
40	Operation Requirements	5	IEC 60079-0 28	Type 3 - Does Not Meet	Quality program is not specified in IEC 60079-0, but is within IEC Ex scheme given in IEC 17065 & 17025
41	References	6	2	Type 2 - Meets	IEC 60079-1 is one of references by FM 3615.
42	Group D- Min. widths/Max Gaps	Annex B/C	5 Table 2	Type 3 - Does Not Meet	IEC divides more ranges in table, gaps is larger in small V, but smaller in Large V than FM.
43	Group C- Min. widths/Max Gaps	Annex D/E	5 Table 2	Type 3 - Does Not Meet	IEC divides more ranges in table, gaps is larger in small V, but smaller in Large V than FM.

No.	Section Title / Subject Issue	Baseline Standard FM 3615 Section #	IEC Standard IEC 60079-1 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
44	Group B- Min. widths/Max Gaps	Annex F/G	5 Table 3	Type 3 - Does Not Meet	FM divides more ranges in table, gaps is smaller than IEC.
45	Group A- Min. widths/Max Gaps	Annex H/I	5 Table 3	Type 3 - Does Not Meet	FM divides more ranges in table, gaps is smaller than IEC.
46	Threaded Joint Groups:	Annex J	5 Table 4 Table 5	Type 2 - Meets	FM specifies 3 classes fit class for various gas group. IEC specifies engagements vs. volume sizes. Requirements can be considered as equivalent
47	Shaft/Rod - Sleeve/Bearing Joints	Annex K	5 Fig. 1 through 13	Type 2 - Meets	IEC provides more examples than FM.

29. Appendix U. Factory Mutual (FM) 3620 vs IEC 60079-2

Table 48 provides a summary of the comparative assessment between the Factory Mutual (FM) 3620 vs IEC 60079-2.

Table 48: Comparative Assessment Results – FM 3620 and the IEC 60079-2

No.	Section Title / Subject Issue	Baseline Standard FM 3620 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
1	Introduction	1.1	Introduction	Type 2 - Meets	IEC provides more details about protection coverage.
2	Scope	1.2	1	Type 2 - Meets	IEC defines more clearly exclusions,
3	Basis for Approval	1.3	2	Type 3 - Does Not Meet	Standards may be met but IEC does not perform certification.
4	Basis for Approval	1.3.1	Forward 2) & 3) 5)	Type 3 - Does Not Meet	IEC specifies requirements, but does not provide attestation of conformity.
5	Basis for Approval	1.3.2	Forward 5)	Type 3 - Does Not Meet	IEC specifies the requirements for type tests, routine tests and manufacturers' responsibilities. 3rd party surveillance audit is not as a part of requirements of this standard. But IEC does have standards for test labs, certifying body qualifications IEC 17025 and 17065.
6	Basis for Continued Approval	1.4	Forward 5)	Type 3 - Does Not Meet	IEC specifies requirements, but does not provide attestation of conformity, as stated above
7	Basis for Requirements	1.5.1	Forward 2) & 3)	Type 2 - Meets	IEC is internationally recognized
8	Basis for Requirements	1.5.2	Forward 2) & 3)	Type 2 - Meets	IEC is internationally recognized
9	Effective date	1.6	Forward	Type 2 - Meets	Publication updates from FM and IEC have similar effects.
10	Definitions	2	3	Type 2 - Meets	More terms are defined in IEC
11	General Information	3.1	1 2	Type 1 - Exceeds	Comparison between IEC 60079-2 and NFPA 496 is included below. Most parts of requirements of IEC 60079-2 exceed NFPA 496.

Comparative Assessment: Other Gap Analysis Assessment

No.	Section Title / Subject Issue	Baseline Standard FM 3620 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
12	Required Documentation for approval examination	3.2		Type 3 - Does Not Meet	IEC doesn't specify documentation requirements, but the technical information is required through the all sections of the standard
13	Performance and construction requirements	4.1	4, through 17	Type 2 - Meets	Comparison between IEC 60079-2 and NFPA 496 is included below. Most parts of requirements of IEC 60079-2 exceed NFPA 496.
14	Clarification of ANSI/NFPA 496 requirements	4.2 NFPA 496: 4.3.1.1	16.1 16.2	Type 3 - Does Not Meet	Max operating pressure is defined by manufacturer. FM takes Safety factor =3 while IEC SF=1.5. As for enclosure strength, requirements in both standards are adequate, testing time IEC is longer.
15	Clarification of ANSI/NFPA 496 requirements	4.2 NFPA 496: 4.3.1	5.2 5.3 5.3	Type 1 - Exceeds	IEC doesn't have similar exemption,
16	Clarification of ANSI/NFPA 496 requirements	4.2 NFPA 496: 5.4 & 5.5.1	5.5.2 5.5.4 A.1	Type 2 - Meets	Internal compartment purging issue is covered in separate places as listed.
17	Pressurized enclosure where the protective gas is air	4.2 NFPA 496: 5.4 & 5.5.1	16.4.2	Type 2 - Meets	Both IEC and FM use the same test procedure.
18	Criteria for compliance where the protective gas is air	4.2 NFPA 496: 5.4 & 5.5.1	16.4.2 A.2	Type 2 - Meets	same criteria is used by IEC and FM.
19	Pressurized enclosure where the protective gas is inert gas	4.2 NFPA 496: 5.4 & 5.5.1	16.4.3	Type 2 - Meets	Test procedures used by IEC and FM are the same.

No.	Section Title / Subject Issue	Baseline Standard FM 3620 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
20	criteria for compliance where the protective gas is inert gas	4.2 NFPA 496: 5.4 & 5.5.1	26.5.1.3 26.5.2	Type 2 - Meets	same criteria is used by IEC and FM.
21	Operations Requirements	5	IEC 60079-0 28	Type 3 - Does Not Meet	Manufacturer's responsibilities are defined, audit and issuing certification are not in the scope of IEC 60079 series, but they are in IEC Ex scheme given in IEC 17065 & 17025.
22	References	6	2	Type 2 - Meets	Temperature interval requirements are same in FM and IEC. IEC does provide more instructions.
	Comparison analysis between NFPA 496 and IEC 60079-2				
23	General Requirements for Pressurized Enclosures	4.3	5.1	Type 2 - Meets	Enclosure are addressed by both NFPA 496 and IEC
24	Enclosure	4.3.1 4.3.1 is modified by FM 3620	5.2 5.3 5.4 7.4.1-7.4.3	Type 2 - Meets	NFPA 496 focus on strength and protections, IEC details construction and strength with the same goal
25	Enclosure	4.3.2	5.5 5.9	Type 1 - Exceeds	NFPA 496 concerns outlets risk outside enclosure, IEC requires spark & particle barrier & cares also purging out vapor.
26	Enclosure	4.3.3	5.8	Type 3 - Does Not Meet	NFPA 496 specifies explosion proof on sealing conduit. IEC requires to maintain IP rating for seals.
27	Enclosure	4.3.4	4	Type 2 - Meets	The issue in this clause of NFPA 496 is covered by IEC protection level.
28	Pressurizing System	4.4.1	7.12	Type 1 - Exceeds	IEC requires overpressure is higher than NFPA for X, Y type

No.	Section Title / Subject Issue	Baseline Standard FM 3620 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
29	Pressurizing System	4.4.2	7.11	Type 1 - Exceeds	IEC provides more details on how safety device be installed
30	Pressurizing System	4.4.3	7.15	Type 1 - Exceeds	IEC require Ga/Gb protection, NFPA requires identified.
31	Pressurizing System	4.4.4	19	Type 2 - Meets	Instructions are required by both standards, even details or wording are not the same.
32	Protective Gas System	4.5.1	9.3	Type 2 - Meets	gas types are same for both standard, NFPA 496 addresses contamination, IEC advise warning if special type gas is used
33	Protective Gas System	4.5.2	9.1	Type 2 - Meets	protection is self-clear basic requirement, IEC requires backup supply if deemed necessary
34	Protective Gas System	4.5.3 4-5.4	7.1 8.1 7.2 8.2	Type 2 - Meets	NFPA provides detailed description on compressor, piping route, IEC gives general requirements with the same principles.
35	Protective Gas System	4.5.5	7.15 8.7 D.3	Type 2 - Meets	same electrical supply required in IEC Annex D as NFPA, In addition, IEC address remain energized issue by EPL
36	Protective Gas System	4.5.6	9,2	Type 2 - Meets	same requirement is in both standards
37	Determination of temperature marking	4.6.1	6	Type 2 - Meets	Almost same way to determine T class, IEC provides more details for various protection levels. NFPA also provide some exception
38	Determination of temperature marking	4.7	6.2	Type 2 - Meets	same method for determine temperature class is mentioned by both standards
39	Determination of temperature marking	4.8	5.2	Type 2 - Meets	Although power equipment is not defined in IEC. But non-combustible construction and tight requirements are covered through various places
40	Type Z Pressurizing	4.9.1	7.4.1 7.11	Type 2 - Meets	almost same requirements from both standards with more or less differences in details

No.	Section Title / Subject Issue	Baseline Standard FM 3620 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
41	Type Z Pressurizing	4.9.2	7.11 d)	Type 1 - Exceeds	NFPA 496 requires that for Type Z protection, all components energized in absence of protective gas be identified; while IEC 60079-2 requires equipment that may remain energized when level of protection “pzc” is not in operation be protected by EPL Ga, Gb, or Gc.
42	Type Z Pressurizing	4.9.3	7.11 d)	Type 2 - Meets	almost same requirements from both standards with more or less differences in details
43	Type Z Pressurizing	4.9.4	7.11 d)	Type 2 - Meets	almost same requirements from both standards with more or less differences in details
44	Type Y Pressurizing	4.10.1	7.4.2	Type 2 - Meets	same as "pzc" above
45	Type Y Pressurizing	4.10.2	7.16	Type 2 - Meets	same as "pzc" above
46	Type Y Pressurizing	4.10.3	7.16	Type 2 - Meets	same as "pzc" above
47	Type Y Pressurizing	4.10.4	7.10	Type 2 - Meets	IEC has the same requirements although it doesn't specify for "pyb" type
48	Type X Pressuring	4.11.1	7.4.3 7.5	Type 2 - Meets	Requirements in NFPA 496 are covered in various sections of IEC 60079-2.
49	Type X Pressuring	4.11.2	7.1 15	Type 2 - Meets	Equipment overload is not considered, but min. flow rate is required to be considered during design. So it is considered as equivalent
50	Type X Pressuring	4.11.3	7.10 7.15	Type 2 - Meets	Ventilated Equipment is not specifically addressed, but min flow rate is required to be considered during design. So it is considered as equivalent
51	Markings	4.12.1 4.12.2 4.12.3 4.12.4 4.12.5 4.12.6	18	Type 3 - Does Not Meet	IEC requires more detailed info in marking. Comparison between IEC and ISA standard in section 4. FM refers to ISA standard for Zone hazardous area classification.
52	Pressurizing Enclosures for Class I	5.1		Type 2 - Meets	This topic is covered by both NFPA 496 and IEC 60079-2

No.	Section Title / Subject Issue	Baseline Standard FM 3620 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
53	General requirements	5.2	5.3 5.5 & 5.6 5.8 7 & 8	Type 2 - Meets	NFPA 496 addresses operational issues, open, failed gas supply. IEC focuses on design issues to cover issues related to operations, door cover, safety devices, etc. that can be considered equivalent.
54	General requirements	5.2.6	5.5.2 7.13	Type 2 - Meets	IEC 60079-2 has similar requirements are in various sections to NFPA 496.
55	General requirements	5.2.6.1 5.2.6.2	5.5.4	Type 2 - Meets	the same requirements can be found in both NFPA and IEC
56	Markings	5.3	18	Type 3 - Does Not Meet	IEC organizes marking requirements in one place - section 18 covering all types and levels protections. Comparison between IEC and ISA standard in section 4. FM refers to ISA standard for Zone hazardous area classification.
57	additional requirements: Y / Z This section is modified by FM 3620	5.4.1 5.4.2	7.8 c) 7.12	Type 1 - Exceeds	IEC flow rate is to be decided by manufacturer, overpressure for pyb is higher than NFPA required
58	additional requirements: X type This section is modified by FM 3620	5.5.1	7.5 7.7 5.3.3	Type 2 - Meets	same requirements in both standards

No.	Section Title / Subject Issue	Baseline Standard FM 3620 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
59	Pressurized enclosures w/ internal source flammable gas	8.1	10	Type 1 - Exceeds	NFPA covers only gas/vapor release, IEC covers gas and liquid release
60	General requirements	8.2.1		Type 2 - Meets	similar requirements are in both standards
61	General requirements	8.2.2	11 11.1 11.2 11.3	Type 1 - Exceeds	NFPA defined limited using LFL, IEC using predictable, IEC defines liquid which is not covered in NFPA
62	General requirements	8.2.3	4 13 14	Type 2 - Meets	Both standards give tables to specify the protection level requirements, which are comparable/equivalent
63	General requirements	8.2.4	12.3 14 15	Type 2 - Meets	All NFPA required are covered in IEC in various tables. And sections
64	Specific Requirements	8.3.1	13.3.3	Type 1 - Exceeds	IEC require O2 <2% while NFPA requires O2<5%
65	Specific Requirements	8.3.2	7.12 8.8	Type 1 - Exceeds	IEC requirements for pxb and pyb are higher than NFPA
66	Specific Requirements	8.3.3	Annex F	Type 2 - Meets	IEC provides examples to show the arrangements, that can be considered equivalent to NFPA
67	Specific Requirements	8.3.4		Type 1 - Exceeds	IEC doesn't have such relaxation as NFPA
68	Specific Requirements	8.3.5	14 note	Type 2 - Meets	Issue is addressed in a note, not as a requirement, NFPA is also A REMINDER.
69	Specific Requirements	8.3.6	13.3.3	Type 2 - Meets	same requirements in both standards

Comparative Assessment: Other Gap Analysis Assessment

No.	Section Title / Subject Issue	Baseline Standard FM 3620 Section #	IEC Standard IEC 60079-2 Section #	Impact Type (Meets, Exceeds, Does Not Meet)	Analysis
70	Specific Requirements	8.3.7		Type 3 - Does Not Meet	this concern has not be seen in IEC
71	Specific Requirements	8.3.8	5 16.1	Type 2 - Meets	the concern is addressed in design and test even not listed as a precaution clause as NFPA
72	Specific Requirements		16	Type 1 - Exceeds	Type verification test is not covered by NFPA 496
73	Specific Requirements		17	Type 1 - Exceeds	Routine tests are not covered by NFPA 496.
74	Pressurized Enclosures for Class II	6			Class II - Combustible dusts is not in BSEE's concerns, no further analysis is conducted.
75	Pressurized Control Rooms	7	IEC 60079-13		This subject is not in FM 3620's scope, no further analysis is conducted.
76	Pressurized Analyzer Room containing a Source of Flammable Gas, Vapor or liquid	9	IEC 60079-13		This subject is not in FM 3620's scope, no further analysis is conducted.

30. Appendix V. OSHA Recognized Standards and NRTLs

Table 60 provides a list of OSHA recognized standards for electrical equipment for use in classified locations and NRTL recognized for certifying to those standard.

Table 49: OSHA recognized standards for electrical equipment for use in classified locations and NRTL

Standards for use under NRTL Program		CSA	FM	Intertek	MET	QPS	SGS	UL
FM 3010	Approval Standard for Fire Alarm Signaling Systems		x					
FM 3210	Heat Detectors for Automatic Fire Alarm Signaling		x					
FM 3260	Flame Radiation Detectors for Automatic Fire Alarm Signaling		x	x				
FM 3600	Electrical Equipment for Use in Hazardous (Classified) Locations, General Requirements	x	x	x			x	
FM 3610	Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1 Hazardous (Classified) Locations	x	x	x			x	
FM 3611	Electrical Equipment for Use in Class I, Division 2; Class II, Division 2; and Class III, Division 1 and 2 Hazardous Locations	x	x	x			x	
FM 3615	Explosion-proof Electrical Equipment, General Requirements	x	x	x				
FM 3620	Purged and Pressurized Electrical Equipment for Hazardous (Classified) Locations	x	x					
FM 6310	Combustible Gas Detectors	x	x					
ISA 12.12.01	Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations	x	x	x	x	x	x	x
ISA 60079-0	Explosive Atmospheres - Part 0: Equipment – General Requirements	x		x			x	x
ISA 60079-1	Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"	x		x			x	x
ISA 60079-2	Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures "p"	x		x			x	x
ISA 60079-5	Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"	x		x			x	x
ISA 60079-6	Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"	x		x			x	x

Standards for use under NRTL Program		CSA	FM	Intertek	MET	QPS	SGS	UL
ISA 60079-7	Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"	x		x			x	x
ISA 60079-11	Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"	x		x			x	x
ISA 60079-15	Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"	x		x			x	x
ISA 60079-18	Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"	x		x			x	x
ISA 60079-25	Explosive Atmospheres – Part 25: Intrinsically Safe Electrical Systems			x				
ISA 60079-26	Explosive Atmospheres - Part 26: Equipment for Use in Class I, Zone 0 Hazardous (Classified) Locations	x		x			x	x
ISA 60079-28	Explosive Atmospheres - Part 28: Protection of Equipment and Transmission Systems Using Optical Radiation	x		x			x	x
ISA 60079-31	Explosive Atmospheres - Part 31: Equipment Dust Ignition Protection by Enclosure "t"	x		x			x	x
ISA 61241-0	Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations – General Requirements	x		x				x
ISA 61241-1	Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations – Protection by Enclosures "tD"	x		x				x
ISA 61241-2	Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations – Protection by Pressurization "pD"	x		x				x
ISA 61241-11	Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations – Protection by Intrinsic Safety "iD"	x		x				x
ISA 61241-18	Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations – Protection by Encapsulation "mD"	x		x				x
NFPA 496	Purged and Pressurized Enclosures for Electrical Equipment			x			x	x
UL 33	Heat Responsive Links for Fire-Protection Service							x
UL 193	Alarm Valves for Fire-Protection Service			x				x
UL 199	Automatic Sprinklers for Fire-Protection Service							x

Standards for use under NRTL Program		CSA	FM	Intertek	MET	QPS	SGS	UL
UL 674	Electric Motors and Generators for Use in Hazardous (Classified) Locations	x	x	x				x
UL 698A	Industrial Control Panels Relating to Hazardous (Classified) Locations			x				x
UL 783	Electric Flashlights and Lanterns for Use in Hazardous Locations, Class I, Group C and D	x		x			x	x
UL 823	Electric Heaters for Use in Hazardous (Classified) Locations	x	x	x				x
UL 844	Electric Lighting Fixtures for Use in Hazardous (Classified) Locations	x	x	x			x	x
UL 864	Control Units and Accessories for Fire Alarm Systems	x	x	x				x
UL 913	Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division I, Hazardous (Classified) Locations	x	x	x	x	x	x	x
UL 1203	Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations	x	x	x		x	x	x
UL 1424	Cables for Power-Limited Fire-Protective-Signaling Circuits	x		x				x
UL 1425	Cables for Non-Power Limited Fire-Alarm Circuits	x						x
UL 1480	Speakers for Fire Protective Signaling Systems		x	x				x
UL 1481	Power Supplies for Fire Protective Signaling Systems			x				x
UL 1711	Amplifiers for Fire Protective Signaling Systems	x		x				x
UL 2225	Cables and Cable Fittings for Use in Hazardous (Classified) Locations							x
UL 60079-0	Explosive Atmospheres - Part 0: Equipment - General Requirements			x	x			x
UL 60079-1	Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"			x				x
UL 60079-2	Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosure "p"			x	x			
UL 60079-5	Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"			x				x
UL 60079-6	Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"			x				x
UL 60079-7	Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"			x				x

Standards for use under NRTL Program		CSA	FM	Intertek	MET	QPS	SGS	UL
UL 60079-11	Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"			x	x			x
UL 60079-15	Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"			x	x			x
UL 60079-18	Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"			x				x

31. Appendix W. OSHA and IEC Standards

Table 61 provides some examples of OSHA and IEC standards for electrical equipment for use in both ordinary locations and in classified location.

Table 50: Examples of OSHA Standards and IEC Standards

OSHA Standards	Standards Titles	IEC Standard	Standards Title
FM 1321	Controllers for Electric Motor Driven Fire Pumps	IEC TS 62091	Low-voltage switchgear and control gear - Controllers for drivers of stationary fire pumps (withdrawn)
FM 1333	Diesel Engine Fire Pump Drivers	IEC TS 62091	Low-voltage switchgear and control gear - Controllers for drivers of stationary fire pumps (withdrawn)
FM 2000	Automatic Sprinklers for Fire Protection	ISO 61821-1	*Equipment for fire protection and fire fighting- Automatic sprinkler systems*
FM 2008	Early Suppression-Fast Response (ESFR) Automatic Sprinklers	ISO 61821-1	*Equipment for fire protection and fire fighting- Automatic sprinkler systems*
FM 3010	Approval Standard for Fire Alarm Signaling Systems	IEC 62599-2	Alarm systems - Part 2: Electromagnetic compatibility - Immunity requirements for components of fire and security alarm systems
FM 3210	Heat Detectors for Automatic Fire Alarm Signaling	ISO 7240-18	*Fire detection and alarm systems*:
FM 3260	Flame Radiation Detectors for Automatic Fire Alarm Signaling	ISO 7240-18	*Fire detection and alarm systems*:
FM 3600	Electrical Equipment for Use in Hazardous (Classified) Locations, General Requirements	60079-0	Explosive Atmospheres - Part 0: Equipment – General Requirements
FM 3610	Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1 Hazardous (Classified) Locations	60079-11	Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"
FM 3611	Electrical Equipment for Use in Class I, Division 2; Class II, Division 2; and Class III, Division 1 and 2 Hazardous Locations	60079-15	Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"
FM 3615	Explosion-proof Electrical Equipment, General Requirements	60079-1	Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"
FM 3620	Purged and Pressurized Electrical Equipment for Hazardous (Classified) Locations	60079-2	Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures "p"

OSHA Standards	Standards Titles	IEC Standard	Standards Title
ISA 12.12.01	Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations	60079-15	Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"
ISA 60079-0	Explosive Atmospheres - Part 0: Equipment – General Requirements	60079-0	Explosive Atmospheres - Part 0: Equipment - General Requirements
ISA 60079-1	Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"	60079-1	Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"
ISA 60079-2	Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures "p"	60079-2	Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosure "p"
ISA 60079-5	Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"	60079-5	Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"
ISA 60079-6	Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"	60079-6	Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"
ISA 60079-7	Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"	60079-7	Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"
ISA 60079-11	Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"	60079-11	Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"
ISA 60079-15	Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"	60079-15	Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"
ISA 60079-18	Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"	60079-18	Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"
ISA 60079-25	Explosive Atmospheres – Part 25: Intrinsically Safe Electrical Systems	60079-25	Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems
ISA 60079-26	Explosive Atmospheres - Part 26: Equipment for Use in Class I, Zone 0 Hazardous (Classified) Locations	60079-26	Explosive Atmospheres - Part 26: Equipment with Equipment Protection Level (EPL) Ga
ISA 60079-28	Explosive Atmospheres - Part 28: Protection of Equipment and Transmission Systems Using Optical Radiation	60079-28	Explosive Atmospheres - Part 28: Protection of Equipment and Transmission Systems Using Optical Radiation
ISA 60079-31	Explosive Atmospheres - Part 31: Equipment Dust Ignition Protection by Enclosure "t"	60079-31	Explosive Atmospheres - Part 31: Equipment Dust Ignition Protection by Enclosure "t"
ISA 61241-0	Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations – General Requirements	61241-0	Electrical apparatus for use in the presence of combustible dust - Part 0: General requirements

OSHA Standards	Standards Titles	IEC Standard	Standards Title
ISA 61241-1	Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations – Protection by Enclosures "tD"	61241-1	Electrical apparatus protected by enclosures and surface temperature limitation – Specification for apparatus
ISA 61241-2	Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations – Protection by Pressurization "pD"	61241-2	Electrical apparatus for use in the presence of combustible dust - Part 2: Test methods - Section 1: Methods for determining the minimum ignition temperatures of dust
ISA 61241-11	Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations – Protection by Intrinsic Safety "iD"	61241-11	Electrical apparatus for use in the presence of combustible dust, Part 11: Protection by intrinsic safety 'ID'
ISA 61241-18	Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations – Protection by Encapsulation "mD"	61241-18	Electrical apparatus for use in the presence of combustible dust, Part 11: Protection by encapsulation 'mD'
NFPA 496	Purged and Pressurized Enclosures for Electrical Equipment	60079-2	Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosure "p"
UL 248-1	Low-Voltage Fuses - Part 1: General Requirements	60269-1	Low Voltage Fuses - General requirements
UL 248-2	Low-Voltage Fuses - Part 2: Class C Fuses	60269-2	Supplementary requirements for fuses for use by authorized persons
UL 248-3	Low-Voltage Fuses - Part 3: Class CA and CB Fuses	60269-3	Supplementary requirements for fuses for use by unskilled persons
UL 248-4	Low-Voltage Fuses - Part 4: Class CC Fuses	60269-4	Supplementary requirements for fuse-links for the protection of semiconductor devices
UL 248-5	Low-Voltage Fuses - Part 5: Class G Fuses	60269-5	Guidance for the application of low-voltage fuses
UL 248-6	Low-Voltage Fuses - Part 6: Class H Non-Renewable Fuses	60269-6	Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
UL 486A-486B	Wire Connectors	60228	Conductors of Insulated Cables
UL 60079-0	Explosive Atmospheres - Part 0: Equipment - General Requirements	60079-0	Explosive Atmospheres - Part 0: Equipment - General Requirements
UL 60079-1	Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"	60079-1	Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"
UL 60079-2	Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosure "p"	60079-2	Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosure "p"

OSHA Standards	Standards Titles	IEC Standard	Standards Title
UL 60079-5	Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"	60079-5	Explosive Atmospheres - Part 5: Equipment Protection by Powder Filling "q"
UL 60079-6	Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"	60079-6	Explosive Atmospheres - Part 6: Equipment Protection by Oil Immersion "o"
UL 60079-7	Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"	60079-7	Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"
UL 60079-11	Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"	60079-11	Explosive Atmospheres - Part 11: Equipment Protection by Intrinsic Safety "i"
UL 60079-15	Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"	60079-15	Explosive Atmospheres - Part 15: Equipment Protection by Type of Protection "n"
UL 60079-18	Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"	60079-18	Explosive Atmospheres - Part 18: Equipment Protection by Encapsulation "m"
UL 60079-25	Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems	60079-25	Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems

Appendix F. Task 5 Report: Exhibit of BSEE Personnel Using Standards for Ensuring Compliance

Comparative Assessment of Electrical Standards and Practices

Task 5 Final Report

Exhibit of BSEE Personnel Using Standards for Ensuring Compliance

Submitted to
The Bureau of Safety and Environmental Enforcement

Submitted by
ABSG CONSULTING INC.
1525 Wilson Blvd., Suite 625
Arlington, VA 22209
(703) 351-3700

Contract #E16PC00014
Deliverable #F.4.8 (Task 5)
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List of Acronyms

ABSG	ABSG Consulting, Inc.
ANSI	American National Standards Institute
APD	Application for Permit to Drill
API	American Petroleum Institute
BSEE	Bureau of Safety and Environmental Enforcement
CFR	Code of Federal Regulations
DOCD	Development Operations Coordination Document
DPP	Develop and Production Plan
DWOP	Deepwater Operating Plan
EP	Exploration Plan
ExCB	IECEx Certification Body
ExMC	IECEx Management Committee
ExTL	IECEx Testing Laboratory
FAA	Federal Aviation Administration
FM	Factory Mutual Research Cooperation
FTCA	Federal Torts Claims Act
INC	Incidents of Non-compliance
IBR	Incorporated by Reference
IEC	International Electrotechnical Commission
NEC	National Electrical Code
NFPA	National Fire Protection Association
NGOs	Non-Governmental Organizations
OCS	Outer Continental Shelf
OIG	Office of Inspector General
OSHA	Occupational Safety & Health Administration
OORP	Office of Offshore Regulatory Programs
PINC	Potential Incidents of Non-Compliance
RP	Recommended Practise
UL	Underwriters Laboratories
US	United States

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1 Introduction

On September 16, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) Office of Offshore Regulatory Programs (OORP) contracted ABSG Consulting, Inc. (ABSG) to conduct the Comparative Assessment of Electrical Standards and Practices study (GS-00F-026A, #E16PC00014). BSEE currently incorporates various industry standards by reference into Title 30 Code of Federal Regulations (CFR) 250.198, and with authorization given by the Outer Continental Shelf (OCS) Lands Act, performs the assessment of electrical-related incidents of noncompliance (INC). With more facilities and components being manufactured overseas, this has become a more challenging process. The purpose of this study was to conduct a gap analysis to compare BSEE and other U.S.-based electrical-related regulations to other commonly used regulations. The regulations included in this analysis are the American Petroleum Institute (API) Recommended Practices (RP), the International Electrotechnical Commission (IEC), NFPA 70, *National Electrical Code* (NEC) published by the National Fire Protection Association (NFPA), and the American National Standard Institute (ANSI)/Underwriters Laboratories (UL) harmonized standards. As part of this study, the following comparative assessments were conducted:

- Task 1 – IEC vs. NEC Gap Analysis
- Task 2 – IEC vs. API Gap Analysis
- Task 3 – IEC vs. ANSI/UL Gap Analysis
- Task 4 – Other Gap Analysis Assessments
- Task 5 – Exhibit of BSEE Personnel using Standards for Ensuring Compliance
- Task 6 – United States vs International Accreditation Practices

This report presents the results of Task 5, Exhibit of BSEE Personnel using Standards for Ensuring Compliance. This task is a comparative assessment that will demonstrate how BSEE's field and office personnel can utilize IEC, NEC, API RP 14F, API RP 14FZ, API RP 500, API RP 505 and ANSI/UL harmonized standards to determine whether operators are in compliance as they conduct offshore operations. Areas of particular interest include installation, maintenance, safe work practices and operating procedures.

Task 5 is organized into three main sections. Section 2 provides a discussion on whether BSEE should regulate compliance with the IEC, NEC, API RP 14F, API RP 14FZ, API RP 500, API RP 505 and ANSI/UL harmonized standards through inspections, audits or both. Sections 3 and 4 provide a list of Potential Incidents of Non-Compliance (PINCs) and an audit protocol for use by BSEE field and office personnel to determine compliance of offshore operators with these standards. This report also contains recommendations on how BSEE could include elements from these standards in its own regulations, legal liabilities and any additional skills and training necessary for BSEE personnel to successfully implement the recommended changes. These recommendations are presented in Section 5.

The objective of this report is to demonstrate how BSEE can determine compliance with the portions of the IEC, NEC, API RP 14F, API 14FZ, API RP 500, API RP 505 and ANSI/UL harmonized standards applicable for offshore operators.

2 Methodology: How BSEE Should Determine Compliance (SOW 3.1.5.2)

BSEE inspectors use Potential Incidents of Non-Compliance (PINCs) as a job aid when conducting regulatory inspections. PINCs provide inspectors with information on the item being inspected, the inspection procedure, enforcement policy and the regulatory authority from Title 30 CFR Part 250. BSEE currently incorporates API RP 14F, API RP 14FZ, API RP 500, and API RP 505 into regulation by reference in Title 30 CFR 250.198. The other standards analyzed during this project include the NEC, IEC/ISA, NEC and ANSI/UL. These standards are not currently incorporated into regulation by reference. See Figure 1.

Essentially, standards that are directly incorporated by reference into current BSEE regulations were identified as standards enforceable by the regulatory inspections, as discussed in Section 3. For standards that are not incorporated by reference into regulation, BSEE should determine compliance through the use of an audit protocol, as discussed in Section 4.

Refer to Appendix B for a complete list of standards that were used to perform these evaluations.

Figure 1: Analysis Approach Methodology

2.1 Analysis of API RP 14F,14FZ, 500 and 505

The ABSG team performed a detailed review of API RP 14F/14FZ and API RP 500/505, which are incorporated by reference in various locations in Title 30 CFR Part 250. The CFR's reference of API RP 14F/14FZ and API RP 500/505 are consolidated into a list in Title 30 CFR 250.198. The objective of this review was to determine the adequacy of the current PINC system at enforcing the requirements of the API RP 14F/14FZ and RP 500/505 standards.

A gap analysis between the current electrical PINCs and API RP 14F/14FZ and API RP 500/505 was performed using the steps below.

1. **Map the API RPs to Existing Regulations and PINCs**
   The ABSG team first utilized the list of API RPs incorporated by reference in 30 CFR 250.198 to map the API RPs to existing CFR citations. To supplement this mapping, the team also used keyword searches to find any instances of the CFR regulations referencing the API RPs that are not included in 30 CFR 250.198. The team then used a combination of the PINCs' authority citation and keyword searches to match the existing PINCs to their associated CFR citation. This process creates a clear map from the API RPs to the regulations of 30 CFR and then to the PINCs and is illustrated below in Figure 2.

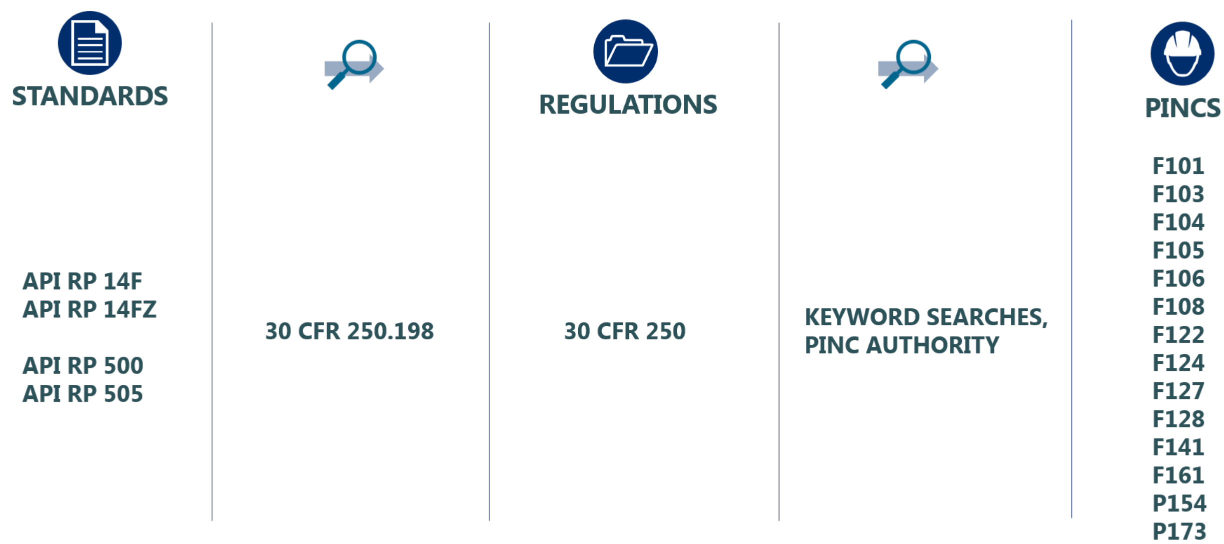


Figure 2: Analytical Approach of Matching API RPs with CFR Regulations and PINCs

2. **Improvement of Existing PINCs that reference API RP's**
   The project team then performed an in depth examination of each of the CFR citations that are used as the authority for the existing PINCs. Keyword searches were used in addition to PINC authorities to match regulations to existing PINCs. The team aimed to verify that the PINC used the correct authority and the correct language from the CFR. In the event that the PINC and the CFR citation did not clearly mirror the referenced API RP text, ABSG recommended either an improvement to the PINC text or a change to the referenced authority.
3. **Create PINCs from existing regulations that reference API RP's**
   ABSG then examined the list of CFR citations listed in 30 CFR 250.198 that are not currently included as the regulatory authority for any of the identified existing PINCs or recommended to be incorporated in existing PINCs (Step 2). These remaining regulations were used to generate new electrical PINCs.

4. **Create PINCs from API RPs by using 30 CFR 250.114(a) and (c) as "umbrella" authorities**
   Lastly, the team performed a review of API RP 14F/14FZ and API RP 500/505 to search for items that could assist inspectors better determine compliance with the API RPs. Title 30 CFR 250.114 (a) and (c) provide BSEE with the authority to enforce PINCs that stem from API RP 500/505 and API RP 14F/14FZ as necessary to ensure safe operations on the OCS and protection of the environment; therefore, the ABSG team used 30 CFR 250.114(a) and 30 CFR 250.114(c) as needed as the regulatory authority for any new PINCs that are recommended.

The review of these API RPs and any proposed changes to the current PINC inspection system are presented below in Section 3.

2.2 Analysis of IEC/ISA/UL and NEC

ABSG also performed a detailed review of the electrical standards referenced in Tasks 1 through 3 that are not currently incorporated by reference in Title 30 CFR 250.198. These electrical standards are the IEC/ISA/UL 60079, IEC 61892 and NEC. The objective of this review was to identify items that could be enforceable by the implementation of an audit protocol that would further promote safety during operations on the OCS, protection of the environment and a reduction in injuries, loss of life and property.

Items in the IEC and NEC were flagged appropriate for an audit checklist if an inspector would be able to assess compliance during an inspection either through observation, testing, or verification. Replicating the PINC system, the audit checklist was organized by categories.

- **Marking**
  Inspection items related to equipment and facility markings
- **Documentation**
  Inspection items related to facility documentation
- **Installation**
  Inspection items related to the installation of electrical equipment
- **Maintenance**
  Inspection items related to the maintenance of electrical equipment
- **Operational Procedures**
  Inspection items related to facility or manufacturer operational requirements
- **Safe Work Practices**
  Inspection items that require on-going facility effort in order to promote safety to people and electrical equipment

The audit checklist is discussed further in Section 4 below, along with information about how BSEE may be able to utilize such an audit checklist during inspections.

3 Exhibit of BSEE Personnel using Standards for Ensuring Compliance by use of PINC Inspection System (SOW 3.1.5.1)

Utilizing the methodology presented above in Section 2.1, the gaps between the current electrical PINCs and API RP 14F, 14FZ, 500 and 505 were evaluated with the objective of identifying areas where the current PINC system could be improved or changed in order to better enforce compliance with those standards. Ultimately, API RP 14F, 14FZ, 500 and 505 were able to be linked to sections of the regulations utilizing 30 CFR 250.198. Using keyword searches, ABSG was able to match sections of the regulations to associated PINCs and also identify areas where new PINCs could be generated to better enforce the standards. The results of our findings are illustrated below in Figure 3 and are discussed further in the following sections.

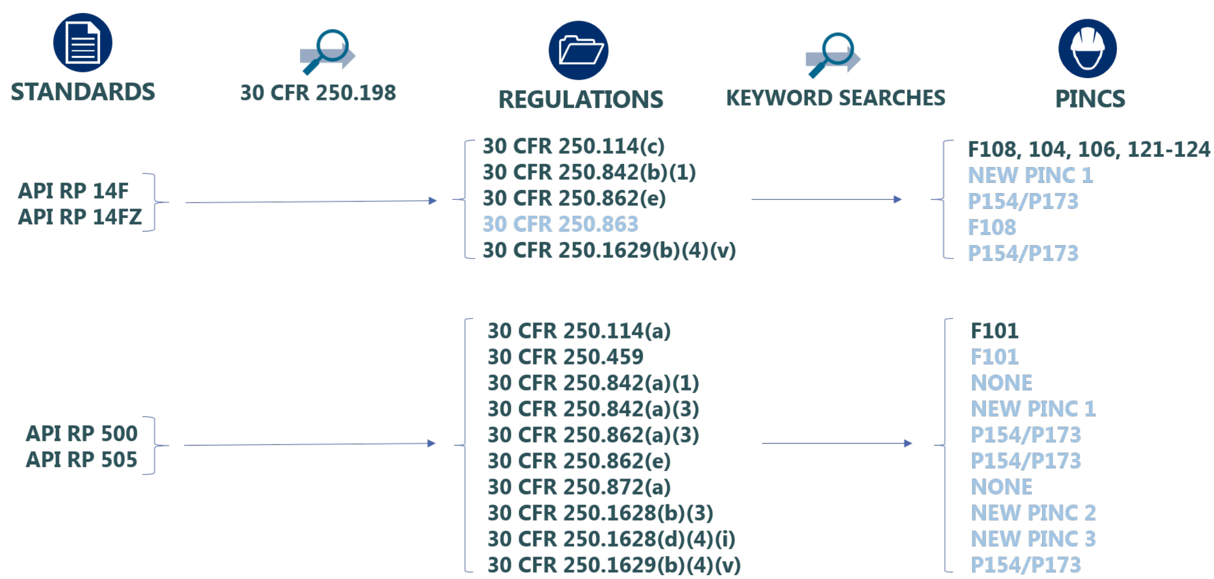


Figure 3: API RPs and their associated CFR Regulations and PINCs[1]

3.1 Modifying Existing PINCs Referencing API RP 14F, 14FZ, 500 and 505

Table 1 summarizes ABSG's recommendations to enhance existing PINCs that currently reference API RP 14F, 14FZ, 500 and 505. The recommended changes either modify the PINC text description, the referenced authority, or both, in order to better capture Title 30 CFR 250 regulatory requirements, and better incorporate API RP 14F, 14FZ, 500 and 505.

[1] Highlighted areas illustrate where ABSG recommendation changes.

Table 1: Modifications to existing PINCs that reference API 14F/14FZ and API 500/505

PINC	Current Authority	Description	Modified Authority	Modified Description
F-101	30 CFR 250.114, 250.802(e)(4)	Has the lessee submitted a plan classifying all hazardous areas? Enforcement action(s): W	30 CFR 250.114(a) 30 CFR 250.459 30 CFR 250.198	Has the lessee classified all areas, including drilling fluid-handling areas, according to API RP 500 or API RP 505, and has the lessee submitted a plan classifying all hazardous areas? Enforcement action(s): W
F-108	30 CFR 250.114(a), 114(c), 198, 459	Are electrical installations made in accordance with API RP 500 and API RP 14F or API RP 505 and API RP 14FZ? Enforcement action(s): W/C/S	30 CFR 250.114(a) 30 CFR 250.114(c) 30 CFR 250.863 30 CFR 250.198	Is all electrical equipment designed, installed and maintained in accordance with API RP 500 and API RP 14F or API RP 505 and API RP 14FZ? Enforcement action(s): W/C/S
P-154	30 CFR 250.803(b)(9)(v)	Is each gas-detection system installed in accordance with API RP 14C, API RP 14G, and API RP 14F? Enforcement action(s): C	30 CFR 250.803(b)(9)(v) 30 CFR 250.862(e) 30 CFR 250.1629(b)(4)(v) 30 CFR 250.198	Is each gas-detection system an approved type, and designed and installed in accordance with API RP 14C, API RP 14G, and API RP 14F in all inadequately ventilated, enclosed classified areas, following the guidelines of API RP 500 or 505? Enforcement action(s): C
P-173	30 CFR 25.803(b)(9)(v)	Is each fire-detection system installed in accordance with API RP 14C, API RP 14G, and API RP 14F? Enforcement action(s): C	30 CFR 250.803(b)(9)(v), 250.862(a)(3), 250.862(e), 250.1629(b)(4)(v)	Is each fire-detection system an approved type, and designed and installed in accordance with API RP 14C, API RP 14G, and API RP 14F in all enclosed classified areas, following the guidelines of AP RP 500 or 505? Enforcement action(s): C

3.2 Proposed PINCs from other Regulations that Incorporate API RP 14F, 14FZ, 500 and 505

Title 30 CFR 250.198 Documents incorporated by reference, lists all CFR regulations in which API RP 14F/14FZ and 500/505 are incorporated by reference. Table 2 proposes a list of new PINCs from the regulations that were not adequately captured by the existing PINCs. Of these regulations, the ABSG team found that 30 CFR 250 842(b)(1), 250.842(a)(3), 250.1628(b)(3) and 250.1628(d)(4)(ii) were not properly enforced by existing PINCs and developed three new PINCs to assist BSEE inspectors assess compliance with them.

Table 2: Recommended PINCs referencing regulations in 30 CFR 250.198

PINC	Authority	Description
NEW PINC 1 (F-TBD)	30 CFR 250.842(b)(1) 30 CFR 250.842(a)(3) 30 CFR 250.198	Has a production safety system application been submitted to the district manager before installing or modifying a production safety system, certifying that all electrical installations were designed according to API RP 14F or API RP 14FZ, as applicable, including a plan for each platform deck and outlining classified areas according to API RP 500 or API RP 505? Enforcement action(s): W
NEW PINC 2 (F-TBD)	30 CFR 250.1628(b)(3) 30 CFR 250.198	Did the sulphur production system application submitted to the district manager for approval, include electrical system information classified according to API RP 500 or API RP 505? Enforcement action(s): W
NEW PINC 3 (F-TBD)	30 CFR 250.1628(d)(4)(i) 30 CFR 250.198	Did the fuel gas safety system application submitted to the district manager for approval, include electrical system information classified according to API RP 500 or API RP 505? Enforcement action(s): W

3.3 Other Proposed PINCs from API RP 14F, 14FZ, 500 and 505

The ABSG team then performed a detailed analysis of API RP 14F, 14FZ, 500 and 505 in order to identify items that do not explicitly exist in the regulations but that would further promote safety during operations on the OCS, protection of the environment and a reduction in injuries, loss of life and property. The project team specifically examined the API RPs standards for items relating to installation, maintenance and operation by offshore operators. Title 30 CFR 250.114(a) and 30 CFR 250.114(c) require that all areas are classified according to API RP 500 or 505 and that all electrical installations are made in accordance with API RP 14F or 14FZ. These two authorities enable BSEE to enforce any section of these standards that they see fit. The results of ABSG's analysis is presented in Table 3.

Table 3: Recommended PINCs developed from API language

PINC	Authority	Description
NEW PINC 4 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are alarms or safety interlocks installed that activate upon loss of ventilation in the battery room? Enforcement action(s): C
NEW PINC 5 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Provisions should be furnished to disconnect battery charging systems when a loss of room ventilation is detected, if the maximum battery charger output is greater than 2 kW. Enforcement action(s): C

PINC	Authority	Description
NEW PINC 6 (F-TBD)	30 CFR 250.114(a),(c) 30 CFR 250.198	Are batteries installed in unclassified locations? Batteries should not be installed in areas classified as Division 1 because of adjacent potential sources of release. Enforcement action(s): C
NEW PINC 7 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are equipment installed in hazardous areas are properly marked as required by API RP 14F Paragraph 4.6.2 or API RP 14FZ Paragraph 4.6.2? Enforcement action(s): W
NEW PINC 8 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are reciprocating engine controls provided to shut down the engine that is driving generator and open generator breaker when specified abnormal condition occur as required by API RP 14F Paragraph 5.2.5.1 or API RP 14FZ Paragraph 5.2.5.1? Enforcement action(s): C
NEW PINC 9 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are gas turbine controls provided to shut down the engine that is driving generator and open generator breaker when specified abnormal condition occur as required by API RP 14F Paragraph 5.2.6.1 or API RP 14FZ Paragraph 5.2.6.1? Enforcement action(s): C
NEW PINC 10 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is a fail-closed fuel shutdown valve provided on natural gas-fueled prime movers as required by API RP 14F Paragraph 5.2.8.2 or API RP 14FZ Paragraph 5.2.9? Enforcement action(s): C
NEW PINC 11 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is an air intake shut-off valve provided on diesel-fueled prime movers as required by API RP 14F Paragraph 5.2.8.2 or API RP 14FZ Paragraph 5.2.9? Enforcement action(s): C
NEW PINC 12 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are switchgear and switchboards arranged to provide convenient and safe access to qualified personnel to operate and perform maintenance on all electrical apparatus and equipment? Switchgear and switchboards should be provided with working space in accordance API RP 14F Paragraph 5.5.1.1 or API RP 14FZ Paragraph 5.5.3.1. Enforcement action(s): W/C

PINC	Authority	Description
NEW PINC 13 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are all devices on the switchgear and switchboards have nameplates showing the device's function? Each interrupting device including power circuit breakers should have a nameplate showing the electrical load served and the continuous rating of the interrupting device as required by API RP 14F Paragraph 5.5.2.6 or API RP 14FZ Paragraph 5.5.4.6. Enforcement action(s): W/C
NEW PINC 14 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are doors and hinged panels on which electrical devices are mounted grounded with a ground wire of minimum size No. 14 AWG? The metal cases of all instruments, relays, meters, and instrument transformers should be grounded as required by API RP 14F Paragraph 5.5.2.7 or API RP 14FZ Paragraph 5.5.4.6. Enforcement action(s): C
NEW PINC 15 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is the facility (floating) furnished with an emergency power system designed for a minimum of 18 hours of continuous operation as required by API RP14F Paragraph 5.6.3 or API RP14FZ Paragraph 5.6.3? Enforcement action(s): S
NEW PINC 16 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is the installation of an emergency generator on the floating facility in accordance with the API RP 14F Paragraph 5.6.5 or API RP 14FZ Paragraph 5.6.5? Enforcement action(s): W/C/S
NEW PINC 17 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is installation of conduits, cable seals and sealing methods approved type and in accordance with the requirements of API RP 14F Section 6.8 or API RP 14FZ Section 6.8? Enforcement action(s): W/C
NEW PINC 18 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is a ground fault indication system installed on each separately-derived AC electrical power distribution system (e.g. generators and transformers) that is not solidly or low impedance grounded in accordance with API RP 14F Paragraph 6.10.4.1 or API RP 14FZ Paragraph 6.10.4.1? Enforcement action(s): W/C
NEW PINC 19 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	For the monitored area containing a source of hydrocarbons, are combustible gas detection control units installed outside the monitored area in accordance with the API RP 14F Paragraph 11.2.3.1 or API RP 14FZ Paragraph 11.2.3.1? Enforcement action(s): C

PINC	Authority	Description
NEW PINC 20 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are Aids-to-Navigation Equipment such as obstruction lights and fog signals installed & maintained in accordance with API RP 14F Paragraph 11.4.1.1 or API RP 14FZ Paragraph 11.4.1.1? Enforcement action(s): W
NEW PINC 21 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are electric fire pumps installed with a wiring system that will withstand direct flame impingement for a minimum of 30 minutes in accordance with API RP 14F Paragraph 11.7.2 or API RP 14FZ Paragraph 11.7.2? Enforcement action(s): W/C/S
NEW PINC 22 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Are alarms provided in a location normally occupied by personnel to annunciate the loss of mechanical ventilation in accordance with API RP 14F Paragraph 11.13.3 or API RP 14FZ Paragraph 11.13.5? Enforcement action(s): W/C
NEW PINC 23 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Do cargo tanks contain any electrical equipment except Intrinsically safe equipment and submerged cargo pump motors and their associated cable, in accordance with API RP 14F Paragraph 11.14 or API RP 14FZ Paragraph 11.14? Enforcement action(s): W/C/S
NEW PINC 24 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is electrical installation in cargo handling rooms in accordance with API RP 14F Paragraph 11.15.1 or API RP 14FZ Paragraph 11.15.1? Enforcement action(s): W/C/S
NEW PINC 25 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is General Alarm System in accordance with the API RP 14F Paragraph 11.16.1 or API RP 14FZ Paragraph 11.16.1? Enforcement action(s): W/C/S
NEW PINC 26 (F-TBD)	30 CFR 250.114(c) 30 CFR 250.198	Is General Alarm System (for floating platform) in accordance with the API RP 14F Paragraph 11.16.2 or API RP 14FZ Paragraph 11.16.2? Enforcement action(s):W/C/S

4 Exhibit of BSEE Personnel using Standards for Ensuring Compliance by use of Audit Checklist (SOW 3.1.5.1)

As discussed above in Section 2, the IEC/ISA/UL harmonized standards as well as the NEC were determined to be more appropriately enforced by use of an audit checklist. The following standards were reviewed in detail to determine the requirements to ensure compliance:

- IEC/ISA/UL 60079 (series): *Explosive Atmospheres*
- IEC 61892 (series): *Mobile and Fixed Offshore Units – Electrical Installations*
- *NEC*

It is important to note that Task 4 included a detailed comparison of IEC 60079 and ISA/UL 60079 which concluded that these standards were practically identical in content and organization. For this reason, the analysis of the IEC 60079 series herein is considered to be comprehensive for ISA/UL 60079.

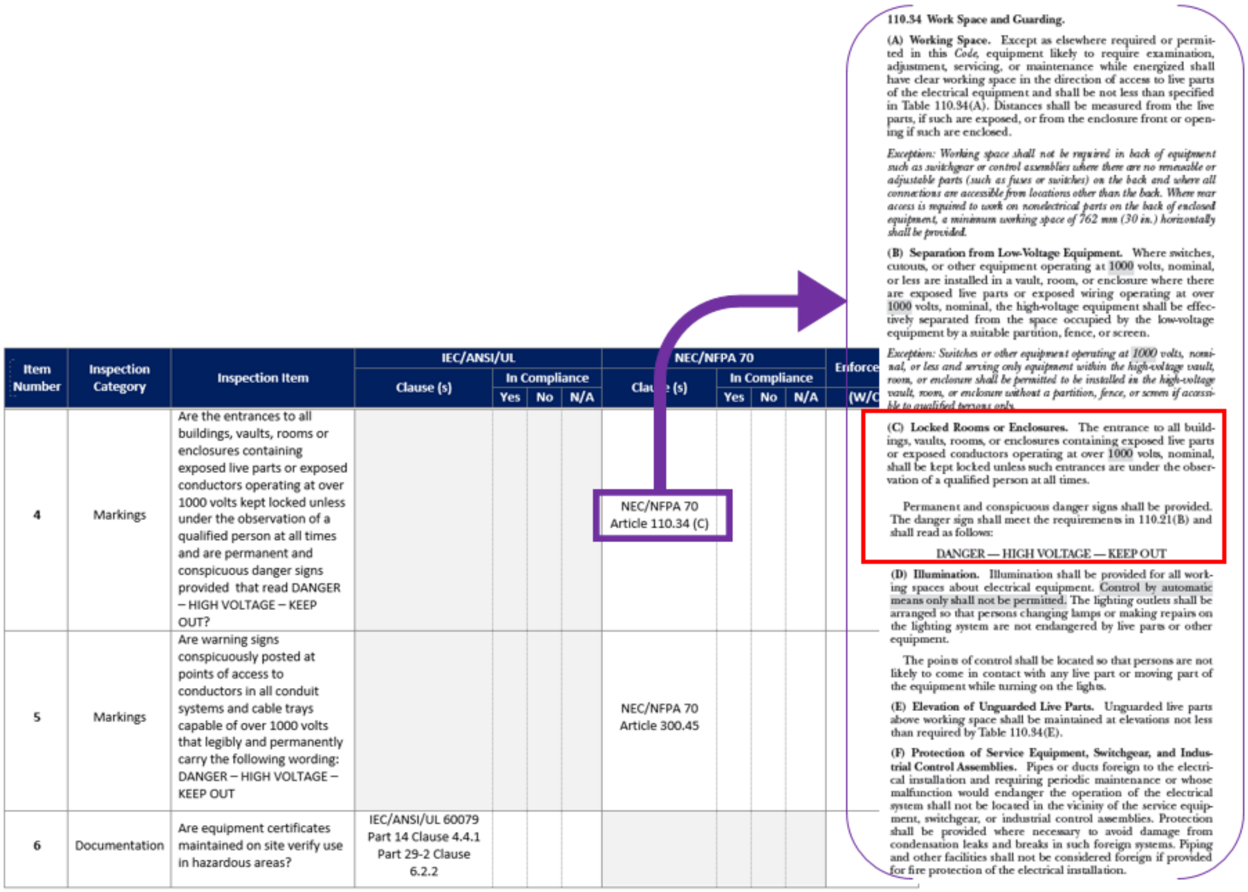
4.1 Generation of Audit Checklist

A single combined checklist was generated instead of separate checklists for each standard in order to expedite the audit process and reduce redundancy as several inspection items are addressed in multiple standards. The recommended audit checklist for use by BSEE field and office personnel to ensure IEC/ISA/UL 60079, IEC 61892 and NEC compliance is presented in Appendix A.

4.2 Use of Audit Checklist

The intended use of the Audit Checklist provided in Appendix A is comparable to how BSEE currently utilizes the PINC list. Inspectors would have the audit checklist loaded onto their laptops while they conduct the audit. The referencing standard would then be hyperlinked to the applicable section of the standard where the inspector could get more information as needed.

For example, if an auditor wanted more information on Item Number 4, they would be able to select the hyperlink for the source clause "NEC Article 110.34 (C)" illustrated below in Figure 4 and be taken to the NEC section that describes the inspection item in more detail. This type of system would come in very handy with items related to marking as it would be very cumbersome to try to capture the specific marking requirements for each standard inside the checklist itself.



Item Number	Inspection Category	Inspection Item	IEC/ANSI/UL				NEC/NFPA 70				Enforce
			Clause (s)	In Compliance			Clause (s)	In Compliance			(W/C
				Yes	No	N/A		Yes	No	N/A	
4	Markings	Are the entrances to all buildings, vaults, rooms or enclosures containing exposed live parts or exposed conductors operating at over 1000 volts kept locked unless under the observation of a qualified person at all times and are permanent and conspicuous danger signs provided that read DANGER – HIGH VOLTAGE – KEEP OUT?					NEC/NFPA 70 Article 110.34 (C)				
5	Markings	Are warning signs conspicuously posted at points of access to conductors in all conduit systems and cable trays capable of over 1000 volts that legibly and permanently carry the following wording: DANGER – HIGH VOLTAGE – KEEP OUT					NEC/NFPA 70 Article 300.45				
6	Documentation	Are equipment certificates maintained on site verify use in hazardous areas?	IEC/ANSI/UL 60079 Part 14 Clause 4.4.1 Part 29-2 Clause 6.2.2								

110.34 Work Space and Guarding.

(A) Working Space. Except as elsewhere required or permitted in this *Code*, equipment likely to require examination, adjustment, servicing, or maintenance while energized shall have clear working space in the direction of access to live parts of the electrical equipment and shall be not less than specified in Table 110.34(A). Distances shall be measured from the live parts, if such are exposed, or from the enclosure front or opening if such are enclosed.

Exception: Working space shall not be required in back of equipment such as switchgear or control assemblies where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on nonelectrical parts on the back of enclosed equipment, a minimum working space of 762 mm (30 in.) horizontally shall be provided.

(B) Separation from Low-Voltage Equipment. Where switches, cutouts, or other equipment operating at 1000 volts, nominal, or less are installed in a vault, room, or enclosure where there are exposed live parts or exposed wiring operating at over 1000 volts, nominal, the high-voltage equipment shall be effectively separated from the space occupied by the low-voltage equipment by a suitable partition, fence, or screen.

Exception: Switches or other equipment operating at 1000 volts, nominal, or less and serving only equipment within the high-voltage vault, room, or enclosure shall be permitted to be installed in the high-voltage vault, room, or enclosure without a partition, fence, or screen if accessible to qualified persons only.

(C) Locked Rooms or Enclosures. The entrance to all buildings, vaults, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 1000 volts, nominal, shall be kept locked unless such entrances are under the observation of a qualified person at all times.

Permanent and conspicuous danger signs shall be provided. The danger sign shall meet the requirements in 110.21(B) and shall read as follows:

DANGER — HIGH VOLTAGE — KEEP OUT

(D) Illumination. Illumination shall be provided for all working spaces about electrical equipment. Control by automatic means only shall not be permitted. The lighting outlets shall be arranged so that persons changing lamps or making repairs on the lighting system are not endangered by live parts or other equipment.

The points of control shall be located so that persons are not likely to come in contact with any live part or moving part of the equipment while turning on the lights.

(E) Elevation of Unguarded Live Parts. Unguarded live parts above working space shall be maintained at elevations not less than required by Table 110.34(E).

(F) Protection of Service Equipment, Switchgear, and Industrial Control Assemblies. Pipes or ducts foreign to the electrical installation and requiring periodic maintenance or whose malfunction would endanger the operation of the electrical system shall not be located in the vicinity of the service equipment, switchgear, or industrial control assemblies. Protection shall be provided where necessary to avoid damage from condensation leaks and breaks in such foreign systems. Piping and other facilities shall not be considered foreign if provided for fire protection of the electrical installation.

Figure 4: Excerpt from IEC/ISA/UL & NEC Audit Checklist

Another functionality that BSEE may find useful to ensure inspection data is attributed to the correct clause is to only allow editing in the applicable column for each item. For example, for Item Numbers 4 and 5 in Figure 4, the IEC column is grayed out and for Item 6 the NEC column is grayed out. This is intended to deter inspectors from marking in the irrelevant column; however, BSEE could prevent this mistake entirely by making those cells read-only thus ensuring that the information is marked in the applicable column.

One final thought on how inspectors can use the Audit Checklist to enforce compliance with IEC/ISA/UL 60079, IEC 61892 and NEC is to consider treating the inspection items that are assigned to the "Documentation" category similar to how BSEE currently treats the Office PINC category. While it is important that this information is maintained onsite (either as an electronic or hard copy) so that inspectors can reference it as needed, documentation is something that can be verified outside the time constraints of an onsite inspection. This would allow inspectors to capitalize on their time onsite by being able to focus on the inspection items that require first hand observation under operating conditions.

4.3 Enforcement of Audit Checklist

The use of an audit checklist could certainly help BSEE determine if operators are in compliance with the standards as they conduct offshore operations. However, since the standards included in the checklist in Appendix A are not incorporated by reference into BSEE's regulation, BSEE would need to determine its regulatory authority to enforce compliance with these standards. BSEE inspectors may be limited in their regulations that could be used to enforce compliance with items on the audit checklist.

The regulations in Title 30 CFR 250.101(a) provide a possible citation to use. However, this regulation does not contain language related to "established industry standards."

5 Recommendations to BSEE (SOW 3.1.5.3)

This project involved conducting a comparative assessment between various U.S. and international electrical standards as outlined in Section 1 and Appendix B of this report. This assessment concluded that the current BSEE PINC system falls short in regards to providing a method of ensuring compliance to each of the standards analyzed in Tasks 1 through 4 of this project. This section contains recommendations on how BSEE could include elements from each of these standards in an inspection system that utilizes an enhanced version of the current PINC system as well as an audit protocol. In addition, the training requirements to help BSEE personnel determine compliance with the regulations and standards are explored.

These recommendations are provided to help make BSEE's electrical-related regulations easier to follow, easier to enforce and more inclusive of international approaches, where appropriate. The intent of these recommendations is to promote safer operations on the OCS, better protection of the environment and a reduction in injuries, loss of life and property.

5.1 Recommended changes to the PINCs

BSEE should review the recommended changes to the PINCs discussed in Section 3. These include revisions to existing PINCs as well as the addition of new PINCs to better evaluate compliance with the standards currently incorporated into BSEE's regulations.

5.2 Implementation of an Audit Protocols

Neither the IEC, NEC nor ISA/UL harmonized standards are incorporated by reference into BSEE's regulations. In order to assess compliance with these standards, BSEE could implement an audit protocol by using the Audit Checklist discussed above in Section 4. This checklist will provide inspectors with the necessary areas of focus in order to ensure BSEE facilities conduct offshore operations in a manner that is compliant with the various international electrical standards that extend beyond current regulation. BSEE should also consider its authority to enforce these standards and provide the appropriate enforcement guidance to inspectors and engineers.

5.3 Treat Documentation Audit Items Similar to Office PINCs

In order to allow inspectors to focus their time on items that require onsite observation while conducting the audit recommended in Section 5.2, BSEE could determine compliance with the "documentation" category on the audit checklist similarly to the way inspectors determine compliance to the Office PINCs. While it is important for documentation to be available onsite during inspections, compliance with these items do not necessarily require onsite observation to enforce.

5.4 Recommendations to Current Regulations (SOW 3.1.5.3.1)

BSEE incorporates standards into federal regulation by reference in Title 30, Code of Federal Regulations Part 250.198. Currently BSEE only incorporates a limited number of the standards analyzed during this project; namely API RP 14F, API RP 14FZ, API RP 500 and API RP 505. Since the federal regulations represent minimum requirements, BSEE may want to consider incorporating clauses in the various standards not currently incorporated into regulations that exceed the comparable clauses of the standards that are currently incorporated into the regulations.

5.4.1 How BSEE could incorporate standards into regulation

To consider incorporating other standards into regulation by reference, BSEE may want to consider the approach outlined in Table 4 and Table 5.

Table 4 provides a recommended approach for how BSEE could include elements from the IEC 60079 and incorporate them into regulation by reference.

Table 4: How BSEE could include elements from the IEC 60079 into regulation

Step	Approach
1	Refer to the comparative assessment results in **Task 1** to become familiar the differences between the baseline standards and the international standards, especially the areas in which the international standards *exceed* the baseline standards • Task 1: Compared the NEC to the IEC 60079 Series
1a	Identify parts of the IEC 60079 that exceed the NEC. For sections of the IEC 60079 that exceed the NEC, would incorporating these sections into BSEE's regulation by reference provide an acceptable level of safety?
1b	**IF YES:** 1) Consider incorporating those sections of the IEC 60079 series into regulation by reference. 2) Use the draft regulatory language provided in Section 5.4.2 to incorporate the IEC into regulation by reference. 3) Once incorporated, BSEE could then develop PINCs that include provisions in the IEC.
1c	**IF NO:** Consider using the audit protocol discussed in Section 4 and provided in Appendix A of this report to determine if operators are in compliance with the IEC.

Step	Approach
2	Refer to the comparative assessment results in **Tasks 2** to become familiar the differences between the API RP 500 and 505 to the IEC 60079 Series, especially the area in which the international standards exceed the baseline standards.
2a	Identify sections of the IEC 60079 that exceed the API RP 500 and 505. For sections of the IEC 60079 that exceed the API RP 500 and 505, would incorporating these sections into BSEE's regulation by reference provide an acceptable level of safety?
2b	**IF YES:** 1) Consider incorporating those sections of the IEC 60079 series into regulation by reference. 2) Use the draft regulatory language provided in Section 5.4.2 to incorporate the IEC into regulation by reference. 3) Once incorporated, BSEE could then develop PINCs that include provisions in the IEC.
2c	**IF NO:** Consider using the audit protocol discussed in Section 4 and provided in Appendix A of this report to determine if operators are in compliance with the IEC.

Table 5 provides a recommended approach for how BSEE could include elements from the IEC 61892 and incorporate them into regulation by reference.

Table 5: How BSEE could include elements from the IEC 61892 and the NEC into Regulation

Step	Approach
1	Refer to the comparative assessment results in **Tasks 2** to become familiar the differences between the baseline standards and the international standards, especially the area in which the international standards *exceed* the baseline standards • Task 2: Compared API RP 14F and API RP 14FZ to the IEC 61892 Series
2a	Identify sections of the IEC 61892 that exceed the API RP 14F and 14FZ. For sections of the IEC 61892 that exceed the API RP 14F and 14FZ, would incorporating these sections into BSEE's regulation by reference provide an acceptable level of safety?
2b	**IF YES:** 1) Consider incorporating those sections of the IEC 61892 series into regulation by reference. 2) Use the draft regulatory language provided in Section 5.4.2 to incorporate the IEC into regulation by reference. **3)** Once incorporated, BSEE could then develop PINCs that include provisions in the IEC.
2c	**IF NO:** Consider using the audit protocol discussed in Section 4 and provided in Appendix A of this report to determine if operators are in compliance with the IEC.

5.4.2 Modified Text of the BSEE Regulations

Should BSEE decided to incorporate some of the international standards referenced in Tasks 1 through 4, updates to the regulations in Title 30 CFR 250.198 would be needed. Table 6 provides the recommended modified text of the BSEE regulations.

Table 6: Recommended Modified Text of the BSEE Regulations

Standard to be Incorporated	Modified Text of BSEE Regulations in Title 30 CFR 250.198
IEC 60079-0 *Explosive atmospheres - Part 0: Equipment – General requirements* (Ed. 6)	IEC 60079-0 *Explosive atmospheres - Part 0: Equipment – General requirements* (Ed. 6), IBR approved at §250.114(c).
IEC 60079-1, *Explosive Atmospheres—Part 1: Equipment Protection by Flameproof Enclosures "d"* (Ed. 7)	IEC 60079-1, *Explosive Atmospheres—Part 1: Equipment Protection by Flameproof Enclosures "d"* (Ed. 7), IBR approved at §250.114(c).
IEC 60079-2 *Explosive Atmospheres Part 2: Equipment Protection by Pressurized Enclosures "p"* (Ed. 6)	IEC 60079-2 *Explosive Atmospheres Part 2: Equipment Protection by Pressurized Enclosures "p"* (Ed. 6), IBR approved at §250.114(c).
IEC 60079-5 *Explosive atmospheres – Part 5: Equipment Protection by Powder Filling "q"* (Ed. 4)	IEC 60079-5 *Explosive atmospheres – Part 5: Equipment Protection by Powder Filling "q"* (Ed. 4), IBR approved at §250.114(c).
IEC 60079-6 *Explosive atmospheres – Part 6: Equipment Protection by Oil Immersion "o"* (Ed 4)	IEC 60079-6 *Explosive atmospheres – Part 6: Equipment Protection by Oil Immersion "o"* (Ed 4), IBR approved at §250.114(c).
IEC 60079-7 *Explosive atmospheres – Part 7: Equipment Protection by Increased Safety "e"* (Ed 5)	IEC 60079-7 *Explosive atmospheres – Part 7: Equipment Protection by Increased Safety "e"* (Ed 4), IBR approved at §250.114(c).
IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres* (Ed. 2)	IEC 60079-10-1 *Explosive atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres* (Ed. 2), IBR approved at §250.114(c).
IEC 60079-11 *Explosive atmospheres – Part 11: Equipment Protection by Intrinsic Safety "i"* (Ed. 6)	IEC 60079-11 *Explosive atmospheres – Part 11: Equipment Protection by Intrinsic Safety "i"* (Ed. 6), IBR approved at §250.114(c).
IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection* (Ed. 5)	IEC 60079-14 *Explosive atmospheres – Part 14: Electrical installations design, selection and erection* (Ed. 5), IBR approved at §250.114(c).
IEC 60079-15 *Explosive atmospheres – Part 15: Equipment Protection by Type of Protection "n"* (Ed. 4)	IEC 60079-15 *Explosive atmospheres – Part 15: Equipment Protection by Type of Protection "n"* (Ed. 4), IBR approved at §250.114(c).
IEC 60079-18 *Explosive atmospheres – Part 18: Equipment Protection by Encapsulation "m"* (Ed. 4)	IEC 60079-18 *Explosive atmospheres – Part 18: Equipment Protection by Encapsulation "m"* (Ed. 4), IBR approved at §250.114(c).
IEC 60079-25 *Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems* (Ed. 2)	IEC 60079-25 *Explosive Atmospheres - Part 25: Intrinsically Safe Electrical Systems* (Ed. 2), IBR approved at §250.114(c).
IEC 60079-26 *Explosive Atmospheres - Part 26: Electrical Apparatus for Use in Class I, Zone 0 Hazardous (Classified) Locations* (Ed. 3)	IEC 60079-26 *Explosive Atmospheres - Part 26: Electrical Apparatus for Use in Class I, Zone 0 Hazardous (Classified) Locations* (Ed. 3), IBR approved at §250.114(c).
IEC 60079-27 *Explosive Atmospheres - Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)* (Ed. 1)	IEC 60079-27 *Explosive Atmospheres - Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)* (Ed. 1), IBR approved at §250.114(c).

Standard to be Incorporated	Modified Text of BSEE Regulations in Title 30 CFR 250.198
IEC 60079-29-1 *Explosive atmospheres – Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases* (Ed. 1)	IEC 60079-29-1 *Explosive atmospheres – Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases* (Ed. 1), IBR approved at §250.114(c).
IEC 60079-29-2 *Explosive Atmospheres - Part 29-2: Gas Detectors - Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen* (Ed. 2)	IEC 60079-29-2 *Explosive Atmospheres - Part 29-2: Gas Detectors - Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen* (Ed. 2), IBR approved at §250.114(c).
IEC 61892-1 , *Mobile and fixed offshore units—Electrical Installations—Part 1: General requirements and conditions* (Ed. 3)	IEC 61892-1, *Mobile and fixed offshore units – Electrical installations, Part 1: General requirements and conditions* (Ed. 3), IBR approved at §250.114(c).
IEC 61892-2, *Mobile and fixed offshore units—Electrical Installations—Part 2: System design* (Ed. 2)	IEC 61892-2, *Mobile and fixed offshore units – Electrical installations, Part 2: System design* (Ed. 2), IBR approved at §250.114(c).
IEC 61892-3, *Mobile and fixed offshore units – Electrical installations, Part 3: Equipment* (Ed. 3)	IEC 61892-3, *Mobile and fixed offshore units – Electrical installations, Part 3: Equipment* (Ed. 3), IBR approved at §250.114(c).
IEC 61892-4, *Mobile and fixed offshore units – Electrical installations, Part 4: Cables* (Ed. 1)	IEC 61892-4, *Mobile and fixed offshore units – Electrical installations, Part 4: Cables* (Ed. 1), IBR approved at §250.114(c).
IEC 61892-5, *Mobile and fixed offshore units – Electrical installations, Part 5: Mobile Units* (Ed. 3)	IEC 61892-5, *Mobile and fixed offshore units – Electrical installations, Part 5: Mobile Units* (Ed. 3), IBR approved at §250.114(c).
IEC 61892-6, *Mobile and fixed offshore units – Electrical installations, Part 6: Installation* (Ed. 3)	IEC 61892-6, *Mobile and fixed offshore units – Electrical installations, Part 6: Installation* (Ed. 3), IBR approved at §250.114(c).
IEC 61892-7, *Mobile and fixed offshore units – Electrical installations, Part 7: Hazardous Areas* (Ed. 3)	IEC 61892-7, *Mobile and fixed offshore units – Electrical installations, Part 7: Hazardous Areas* (Ed. 3), IBR approved at §250.114(c).

5.4.3 Incorporate the latest version of the API Recommended Practices into Regulation by Reference

Refer to Appendix B for the complete list of standards included in this assessment. BSEE's regulations in Title 30 CFR 250.198 incorporate several API Recommended Practices into regulation by reference. Table 7 includes a list of the electrical-related API standards incorporated into regulation by reference along with the most current versions of these standards.

Table 7: Comparison of the current edition and latest edition of standards

API Standard Incorporated into BSEE's Regulation	The Edition Incorporated into BSEE's Regulation	Latest Edition of these Standards	Recommended Action
API RP 14F	Fifth Edition, July 2008, Reaffirmed: April 2013;	Fifth Edition, July 2008, Reaffirmed: April 2013	No action recommended. The latest edition is incorporated.

API Standard Incorporated into BSEE's Regulation	The Edition Incorporated into BSEE's Regulation	Latest Edition of these Standards	Recommended Action
API RP 14FZ	First Edition, September 2001, Reaffirmed: March 2007	Second Edition, May 2013.	Recommend analyzing this edition to determine the difference and whether BSEE should incorporate the section edition.
API RP 500	Second Edition, November 1997; Errata (August 17, 1998), Reaffirmed November 2002	API Recommended Practice 500,Third Edition, December 2012; Errata, January 2014	Recommend analyzing this edition to determine the difference and whether BSEE should incorporate the section edition.
API RP 505	First Edition, November 1997; Reaffirmed, August 2013	First Edition, November 1997; Reaffirmed, August 2013	No action recommended. The latest edition is incorporated.

In some cases, as noted in Table 7, the latest editions of these standards are not incorporated by reference into BSEE's regulation by reference. BSEE should analyze the differences in the latest editions of these standards to determine whether BSEE should change the regulations to incorporate by reference the most current version of these standards.

BSEE is proceeding with this recommendation. On December 29, 2017, BSEE issued a proposed rule (FR 2017-27309). If finalized, the rule *"would update the incorporation by reference of superseded standards currently incorporated in Subpart H to the current edition of the relevant standard. This includes incorporating new or recently reaffirmed editions of a number of standards referenced in Subpart H, as well as replacing one standard currently incorporated in the regulations, that was withdrawn by API, with a new standard. However, BSEE is still evaluating the newer editions of these standards to analyze the specific changes between the incorporated editions and the current editions and to assess the potential impacts of those changes on offshore operations. BSEE may decide not to replace the incorporated edition of a specific standard before the publication of the final rule. BSEE is soliciting comments that will inform our decision on updating these standards, including comments on potential risks and costs associated with the new editions. If BSEE decides to replace the incorporated documents with new editions in the final rule, the new editions would apply to all sections of 30 CFR part 250 where those documents are incorporated."*

5.5 Recommendations for Personnel Training (SOW 3.1.5.3.3)

Paramount to the successful implementation of the recommended changes to the current BSEE inspection system is training. Inspections of electrical components and the engineering review of electrical systems during plan review and approval require extensive knowledge of the applicable regulations and standards in order to adequately promote safety for personnel and equipment. Electrical inspections focus on marking, documentation, installation, maintenance, operational procedures and safe work practices. Engineering plan reviews involve a review of plans such as the

Deepwater Operating Plan (DWOP), Conceptual Plans, Develop and Production Plan (DPP), Exploration Plan (EP), Development Operations Coordination Document (DOCD) and Application for Permit to Drill (APD).

Several recommendations for BSEE to consider are provided below.

5.5.1 Training on U.S. and International Standards

BSEE should provide training to inspectors and engineers on the all of the U.S. and international standards included in this project so that they are familiar with the various provisions in these standards. This training should be designed and developed so as to replicate actual on-the-job performance. For example, training scenarios could be developed that describe the current state of a particular electrical system, component or piece of equipment on an offshore facility. Participants in the training would use the PINCs and/or the audit checklist to discuss the given scenario and determine if the electrical component is in compliance with the relevant regulation and standard. Based on their conclusion, the participants would determine which enforcement option would be appropriate. ABS Group developed a similar training program in 2014 for BSEE inspectors and engineers to become familiar with the contents of API RP14F (See contract number E14PB00037), which could serve as a model for development of additional training.

The training scenarios should involve the following topics:

Marking

Particular focus should be given to training inspectors on electrical marking so that inspectors can verify electrical installations are made in approved areas. Figure 5 is an illustration of the complexity of electrical equipment markings. Inspectors should be given initial and ongoing training on the various marking requirements across the different standards.

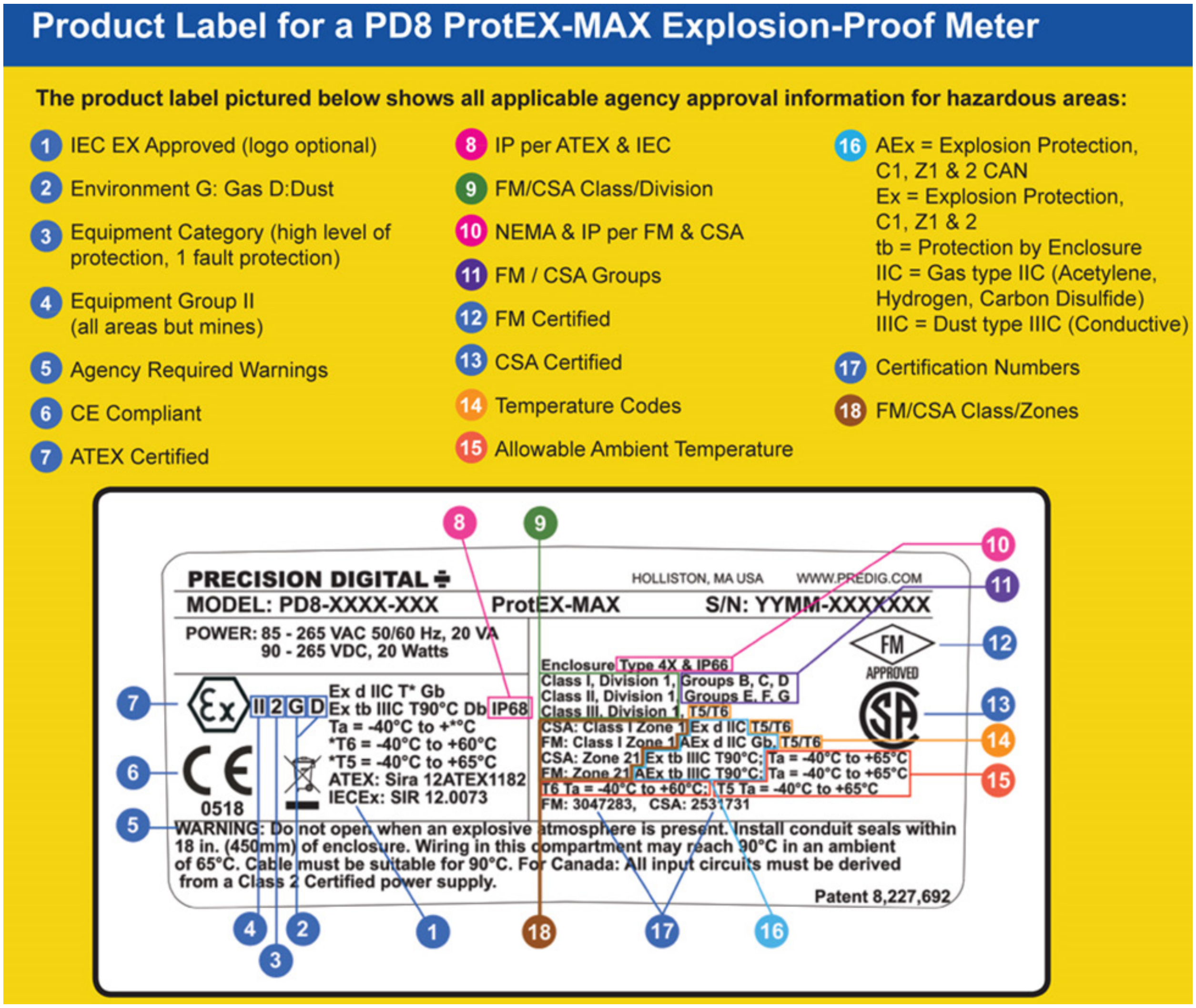


Figure 5: Example Electrical Equipment Label[2]

Documentation

Electrical inspectors will be limited on what they can observe first hand; therefore, a large focus will be made on documenting compliance if BSEE chooses to enforce the IEC/ISA/UL 60079 series, the IEC 61892 series and the NEC. BSEE personnel need to be adequately trained on what documentation is required to ensure compliance with the applicable standards.

Installations

Electrical installations will likely be verified through markings and documentation that electrical equipment was installed in an approved area; however, inspectors should be provided initial and on-

[2] https://www.predig.com/indicatorpage/hazardous-area-classifications-what-you-need-know

going training on safe electrical installations so that they are able to identify non-compliances while conducting inspections.

Maintenance

Verification that a facility adheres to the required maintenance schedule for electrical equipment will likely be verified through documentation; however, inspectors should be provided initial and on-going training so that they are familiar with the maintenance requirements for various electrical equipment and are able to identify what improperly maintained electrical equipment looks like when conducting inspections.

Operational Procedures

It will be important that manufacturer and facility operational procedures are maintained on file and that inspectors are provided with initial and on-going training on how to interpret manufacturer requirements in the event that they need to be consulted while conducting inspections.

Safe Work Practices

Safe work practices are of supreme importance. Inspectors should be given initial and on-going Occupational Safety and Health Administration (OSHA) training to ensure they are well versed in the requirements of a safe working environment.

5.5.2 Provide Reference Material to Inspectors and Engineers

BSEE should obtain copies of the all of the U.S. and international standards referenced in this project for use by engineers and inspectors during training and for use on the job. Additionally, BSEE should provide inspectors and engineers with a copy of all of the reports developed for this project so they can become familiar with the differences among the U.S. and international standards.

5.6 Legal Liabilities (SOW 3.1.5.3.2)

Considering the recommendations above, our analysis found that no credible lawsuit would be successful against a Federal agency or a Federal government entity exercising its inspection/enforcement efforts and discretion in carrying out its designed, regulatory inspection and enforcement program. The Federal Torts Claims Act (FTCA), 28 U.S. C. 2674, listed thirteen exceptions to its waiver of sovereign immunity liability under the FTCA. Under the FTCA, any “discretionary function” of a Federal agency or entity is exempt from tort liability and monetary damages. Thus any Federal government agency or entity action that involves some level of policy discretion, regardless of whose discretion is involved or on what grounds the discretion is exercised, is not subject to tort liability and monetary damages. Claims based on the exercise or performance of, or the failure to exercise or perform, a discretionary government function is completely exempt from liability

The only “legal liability” or lawsuit a Federal agency or entity’s inspection program itself could potentially be subject to is one brought as an injunction against the program based on a theory that the program or some aspect of it as carried out is irrational, arbitrary, and capricious or otherwise inconsistent with the law. Both the regulated industry and third-party non-governmental organizations (NGOs) could bring such an action if timely and with the requisite showing of harm. The only remedy to that legal liability would be for the court to set aside or enjoin that part of the inspection or enforcement program found inconsistent with the law.

To examine all possible “legal liability” under the FTCA, if an agency owned or contracted vehicle were to crash into an facility during an inspection and damage the facility, that damage might not fall within the recognized exceptions under the FTCA and the Federal agency or entity could be subject to tort liability for the damages. But that liability would not arise from either the enforcement/ inspection program or from the design/results of the program itself.

The legal liability regimes under environmental, natural resources, tort, and safety laws for industry non-compliance or activity pollution/disaster remain vigorous and sized to deter or punish the non-compliance or results of the pollution/disaster. The “legal liabilities” of the members of the regulated industry remain largely what the “legal liabilities” were before and during any inspection program—civil penalties, criminal penalties, tort, and remediation costs. Members of the regulated industry have a heightened risk of potentially being charged with falsifying any reports and documents submitted or required to be submitted to the agency. That could result in civil and criminal liabilities under 18 U.S.C. 1001.

Based on the recommendations described above, the changes to the PINCs discussed in Section 3 and the Audit protocols discussed in Section 4, BSEE’s legal liabilities would be the same. The FTCA 28 U.S.C. 2674, under its discretionary function exception, shields BSEE from almost all legal liabilities for the design, decisions, and actions under any inspection program it implements. However, given the FTCA providing such coverage, the following recommendations are offered:

1) BSEE should design any changes to its inspection process and program, including any regulatory changes, so that it meets the Administrative Procedures Act criteria of reasonableness and consistent with existing law.
2) The Federal Aviation Administration (FAA) established a best practice for BSEE to consider. The FAA encouraged key manager’s and decision-makers with responsibilities for implementing new programs to obtain personnel professional liability insurance to cover potential cost of counsel for various hearings or investigations that may be held (e.g. OIG, Congressional, or other such investigations.

As with any major change to status quo, these changes could be tested via litigation; especially new regulatory language.

Appendix A IEC/ISA/UL & NEC Audit Checklist

Table 8: IEC/ISA/UL and NEC Audit Checklist

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
1	Marking	Are electrical equipment legibly marked in a location likely to be visible after installation in accordance with the applicable standard?	IEC/ISA/UL 60079 Part 0 Clause 29				NEC Article 110.21 Article 505.9 (C)				
2	Marking	Are electrical equipment, such as switchboards, switchgear, panelboards, industrial control panels, meter socket enclosures and motor control centers that requires examination, adjustment, servicing or maintenance while energized marked to warn qualified persons of potential electric arc flash hazards?					NEC Article 110.16 (A)				
3	Marking	Are entrances to rooms and other guarded locations that contain exposed live parts operating at 1000 volts or less marked with conspicuous warning signs forbidding unqualified persons to enter					NEC Article 110.27 (C)				

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
4	Marking	Are the entrances to all buildings, vaults, rooms or enclosures containing exposed live parts or exposed conductors operating at over 1000 volts kept locked unless under the observation of a qualified person at all times and are permanent and conspicuous danger signs provided that read DANGER – HIGH VOLTAGE – KEEP OUT?					NEC Article 110.34 (C)				
5	Marking	Are warning signs conspicuously posted at points of access to conductors in all conduit systems and cable trays capable of over 1000 volts that legibly and permanently carry the following wording: DANGER – HIGH VOLTAGE – KEEP OUT					NEC Article 300.45				
6	Documentation	Are equipment certificates maintained on site verify use in hazardous areas?	IEC/ISA/UL 60079 Part 14 Clause 4.4.1 Part 29-2 Clause 6.2.2								

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
7	Documentation	Is area classification documentation maintained on site for hazardous Divisions?					NEC Article 500.5				
8	Documentation	Is area classification documentation maintained on site for hazardous Zones?	IEC/ISA/UL 60079 Part 10-1 Clause 9.1 IEC 61892 Part 7 Clause 4.1				NEC Article 505.5				
9	Documentation	Does the facility maintain documentation that demonstrates the competency of personnel that perform initial and on-going area classification?	IEC/ISA/UL 60079 Part 10-1 Clause 4.4 IEC 61892 Part 7 Clause 4.1				NEC Article 505.7 (A)				
10	Documentation	Is a complete verification dossier prepared and maintained for electrical installations?	IEC/ISA/UL 60079 Part 14 Clause 4.2 Part 17 Clause 4.1 Part 17 Clause 4.5.5 Part 19 Clause 4.3.1 Part 29.2 Clause 6.1 IEC 61892 Part 7 Clause 27				NEC Article 500.4 (A) Article 505.4				

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
11	Documentation	Does the facility maintain documentation that demonstrates the competency of personnel that perform the design of installations, selection of equipment, installation and inspection?	IEC/ISA/UL 60079 Part 14 Clause 4.5 Part 17 Clause 4.2 IEC 61892 Part 7 Clause 7.3 Part 7 Clause 26.6				NEC Article 110.3 (C) Article 505.7 (A)				
12	Documentation	Are records of repairs, overhauls, alterations and modifications maintained on file?	IEC/ISA/UL 60079 Part 19 Clause 4.3.2								
13	Installation	Is equipment suitable for use in the hazardous Division it is used in?					NEC Article 500.8				
14	Installation	Is equipment suitable for use in the hazardous Zone it is used in?	IEC/ISA/UL 60079 Part 14 Clause 5.1 IEC 61892 Part 7 Clause 8.2				NEC Article 505.9				
15	Installation	Are all electrical equipment constructed and installed to ensure safe performance under conditions of proper use and maintenance in accordance with manufacturer instructions?	IEC 61892 Part 6 Clause 19.1				NEC Article 110.3 (B)				

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
16	Installation	Are electrical equipment installed so that it is protected against external influences which could adversely affect the explosion protection?	IEC/ISA/UL 60079 Part 14 Clause 5.9 IEC 61892 Part 1 Clause 4.15 Part 1 Clause 4.16 Part 1 Clause 4.17				NEC Article 110.11				
17	Installation	Are luminaires marked to indicate maximum wattage of lamps for which they are intended for use and protected from physical damage?					NEC Article 501.130				
18	Installation	Are electrical equipment, raceways, cable assemblies, boxes, cabinets, fittings and enclosures securely fastened in place to prevent excessive movement?					NEC Article 110.13 Article 300.11 Article 314.23				
19	Installation	Are all electrical equipment constructed out of durable, flame-retardant, moisture-resistant materials, which are not subject to deterioration in the atmosphere and at the temperature to which they are likely to be exposed?	IEC 61892 Part 1 Clause 4.5 Part 1 Clause 4.10				NEC Article 300.6				

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
20	Installation	Are all cables routed on cable ladders or trays?	IEC 61892 Part 6 Clause 6.2								
21	Maintenance	Are inspection schedules followed in accordance with the type of equipment, manufacturer's guidance, factors governing deterioration, EPL requirements, the results of previous inspections and environmental conditions?	IEC/ISA/UL 60079 Part 17 Clause 4.4.2 Part 17 Clause 4.4.3 Part 17 Clause 4.5.4 Part 17 Clause 4.7								
22	Maintenance	Has equipment been properly withdrawn from service when temporarily necessary for maintenance purposes or permanently?	IEC/ISA/UL 60079 Part 17 Clause 4.6.3								
23	Operating Procedures	Does the facility have an adequate system in place to determine traceability to the certification details of specific equipment where certification plate or markings on explosion protected equipment is missing or illegible?	IEC/ISA/UL 60079 Part 17 Clause 4.3.1.2								

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
24	Operating Procedures	If a fixed gas detection system is used as a means of protection, is it properly documented and capable of giving an early warning of both the presence and the general location of an accumulation of flammable gas installed?	IEC/ISA/UL 60079 Part 29-2 Clause 8.1				NEC Article 500.6 (K)				
25	Operating Procedures	If gas detector system or channels of a system fail or are removed from service, so that areas of the plant cannot be monitored sufficiently, are additional measures put in place to preserve safety?	IEC/ISA/UL 60079 Part 29-1 Clause 8.9.1								
26	Operating Procedures	Are generating plants, switchboards and batteries separated from hazardous areas?	IEC 61892 Part 2 Clause 4.2.2 Part 7 Clause 5.1								
27	Operating Procedures	Is a self-contained emergency source of power provided as required by the appropriate authority and is it separated from the main source of power and other equipment presenting a fire risk?	IEC 61892 Part 2 Clause 4.3.1 Part 2 Clause 4.3.2								

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
28	Operating Procedures	Do doors to high voltage rooms have locks, open outwards and have a manual panic device that can be opened at all times from the interior?	IEC 61892 Part 6 Clause 9.4				NEC0 Article 110.26 (A)(4) Article 110.26 (B)(3)				
29	Operating Procedures	Are live parts of electrical equipment and luminaires in operation guarded against accidental contact?					NEC Article 110.27 (A) Article 300.31 Article 410.5				
30	Operating Procedures	Are overcurrent devices protected from physical damage and not located in the vicinity of easily ignitable material, bathrooms or over steps?					NEC Article 240.24 Article 240.30				
31	Operating Procedures	Are metal boxes, conduit bodies, and fittings corrosion resistant or properly coated inside and out to prevent corrosion?					NEC Article 314.40				
32	Operating Procedures	Are parts of electrical equipment that produce arcs, sparks, flames or molten metal separated from combustible material?					NEC Article 110.18				

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
33	Safe Work Practices	Are electrical equipment installed in a neat and workmanlike manner with adequate working space to promote safe operations, ease of access for inspection and maintenance?	IEC/ISA/UL 60079 Part 14 Clause 4.1 IEC 61892 Part 1 Clause 4.11 Part 6 Clause 9.3				NEC Article 110.12 Article 110.26 Article 110.32 Article 110.33 Article 110.34 Article 110.72 Article 110.73				
34	Safe Work Practices	Due to the risk of corrosion, do dedicated battery rooms, lockers or boxes only have batteries and related equipment in them?	IEC 61892 Part 6 Clause 11.1.3								
35	Safe Work Practices	Are the floors of battery compartments lined with watertight, impermeable and electrolyte-resistant material spanning the entire floor?	IEC 61892 Part 6 Clause 11.3								
36	Safe Work Practices	Are hazardous areas ventilated to reduce the accumulation of explosive gas?	IEC 61892 Part 7 Clause 24.1								

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
37	Safe Work Practices	Are cells and batteries recharged in a non-hazardous area unless the certificate and manufacturer's instructions permit charging in a hazardous area?	IEC/ISA/UL 60079 Part 14 Clause 5.14								
38	Safe Work Practices	Have all battery or solar powered personal equipment that are taken into hazardous areas been verified to conform to a recognized type or protection appropriate to EPL, gas group and temperature class requirements, subjected to a risk assessment or taken under safe work procedures?	IEC/ISA/UL 60079 Part 14 Clause 5.10.3								
39	Safe Work Practices	Are manhole openings free from protrusions that could injure personnel or prevent ready egress and located where they are not directly above electrical equipment or conductors?					NEC Article 110.75				

Item Number	Inspection Category	Inspection Item	IEC/ISA/UL Clause (s) In Compliance	Yes	No	N/A	NEC Clause (s) In Compliance	Yes	No	N/A	Enforcement (W/C/S)
40	Safe Work Practices	Are space-heating appliances mounted so that they are protected from damage and do not cause risk to surroundings?	IEC 61892 Part 6 Clause 13.3				NEC Article 424.12				
41	Safe Work Practices	Are generators located in well-ventilated spaces where combustible gases cannot accumulate?	IEC 61892 Part 6 Clause 7.2.2				NEC Article 430.14				

Appendix B List of Standards

The below list of standards represent the exact versions that were used for the analyses performed herein, as prescribed by BSEE regulation.

ANSI/ISA-60079-0, *Explosive atmospheres—Part 0: Equipment—General Requirements*, 12.00.01-2013

ANSI/ISA-60079-1, *Explosive Atmospheres—Part 1: Equipment Protection by Flameproof Enclosures "d"*, 12.22.01-2009

ANSI/ISA-60079-2, *Explosive Atmospheres—Part 2: Equipment protection by pressurized enclosures "p"*, 12.04.01-2010

ANSI/ISA-60079-7, *Explosive Atmospheres—Part 7: Equipment protection by increased safety "e"*, 12.16.01-2008

ANSI/ISA-60079-10-1, *Explosive Atmospheres—Part 10-1: Classification of areas—explosive gas atmospheres*, 12.24.01-2014

ANSI/ISA-60079-11, *Explosive Atmospheres—Part 11: Equipment protection by intrinsic safety "I",* Ed. 6.2, 12.02.01-2014

ANSI/ISA-60079-15, *Explosive atmospheres—Part 15: Equipment protection by type of protection "n",* Ed. 4, 12.12.02-2012

ANSI/ISA-60079-25, *Explosive atmospheres—Part 25: Intrinsically safe electrical systems,* 12.02.05-2011

ANSI/ISA 60079-27, *Explosive Atmospheres - Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO),* 12.02.04-2006

ANSI/ISA-60079-29-1, *Explosive atmospheres—Part 29-1: Gas detectors—Performance requirements of detectors for flammable gases*, 12.13.01-2013

ANSI/ISA-60079-29-2, *Explosive atmospheres—Part 29-2: Gas detectors—Selection, installation, use and maintenance of detectors for flammable gases and oxygen*, 12.13.02-2012

API RP 14F, *Recommended Practice for Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations*, Upstream Segment, Fifth Edition, July 2008, Reaffirmed: April 2013

API RP 14FZ, *Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1 and Zone 2 Locations*, First Edition, September 2001, Reaffirmed: March 2007

API RP 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*, Second Edition, November 1997; Errata (August 17, 1998), Reaffirmed November 2002

API RP 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*, First Edition, November 1997; Reaffirmed, August 2013

IEC 61892-1, *Mobile and fixed offshore units—Electrical Installations—Part 1: General requirements and conditions,* Ed. 3.0, 2015-07

IEC 61892-2, *Mobile and fixed offshore units—Electrical Installations—Part 2: System design*, Ed. 2.0, 2012-03

IEC 61892-3, *Mobile and fixed offshore units—Electrical Installations—Part 3: Equipment*, Ed. 3.0, 2012-03

IEC 61892-4, *Mobile and fixed offshore units—Electrical Installations—Part 4: Cables,* Ed. 1.0, 2007-06

IEC 61892-5, *Mobile and fixed offshore units—Electrical Installations—Part 5: Mobile Units*, Ed. 3.0, 2014-11

IEC 61892-6, *Mobile and fixed offshore units—Electrical Installations—Part 6: Installation*, Ed. 3.0, 2013-12

IEC 61892-7, *Mobile and fixed offshore units—Electrical Installations—Part 7: Hazardous Areas*, Ed. 3.0, 2014-12

IEC 60079-0, *Explosive atmosphere—Part 0: Equipment, General requirements*, Ed. 6.0, 2011-06

IEC 60079-1, *Explosive Atmospheres—Part 1: Equipment Protection by Flameproof Enclosures "d"*, Ed. 7, 2014-06

IEC 60079-2, *Explosive Atmospheres—Part 2: Equipment Protection by Pressurized Enclosures "p"*, Ed. 6, 2014-07

IEC 60079-5, *Explosive atmospheres—Part 5: Equipment Protection by Powder Filling "q"*, Ed. 4, 2015-02

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IEC 60079-7, *Explosive atmospheres—Part 7: Equipment protection by increased safety "e"*, Ed. 5, 2015-08

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IEC 60079-26, *Explosive atmospheres—Part 26: Material with Equipment Protection Level (EPL) Ga*, Ed. 3, 2014-10

IEC 60079-27, *Explosive Atmospheres - Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO),* Ed. 1, 2005-04

IEC 60079-29-1, *Explosive atmospheres—Part 29-1: Gas detectors—Performance requirements of detectors for flammable gases*, Ed. 1, 2007-08

IEC 60079-29-2, *Explosive atmospheres—Part 29-2: Gas detectors—Selection, installation, use and maintenance of detectors for flammable gases and oxygen*, Ed. 2, 2015-03

NFPA 70, *National Electrical Code,* 2017 Edition.

UL 674, *Standard for Safety for Electric Motors and Generators for Use in Hazardous (Classified) Locations,* Ed. 5, May 31, 2011

UL 823, *Standard for Safety for Electric Heaters for Use in Hazardous (Classified) Locations,* Ed. 9, October 20, 2006

UL 844, *Standard for Luminaires for Use in Hazardous (Classified) Locations,* Ed. 13, June 29, 2012

UL 913, *Standard for Safety for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations*, Ed. 8, December 06, 2013

UL 1203, *Standard for Safety for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations*, Ed. 5, November 22, 2013

UL 2225, *Standard for Safety for Cables and Cable-Fittings for Use In Hazardous (Classified) Locations*, Ed. 4, September 30, 2013

UL 60079-5, *Explosive Atmospheres—Part 5: Equipment Protection by Powder Filling "q"*, Ed. 4, April 29, 2016

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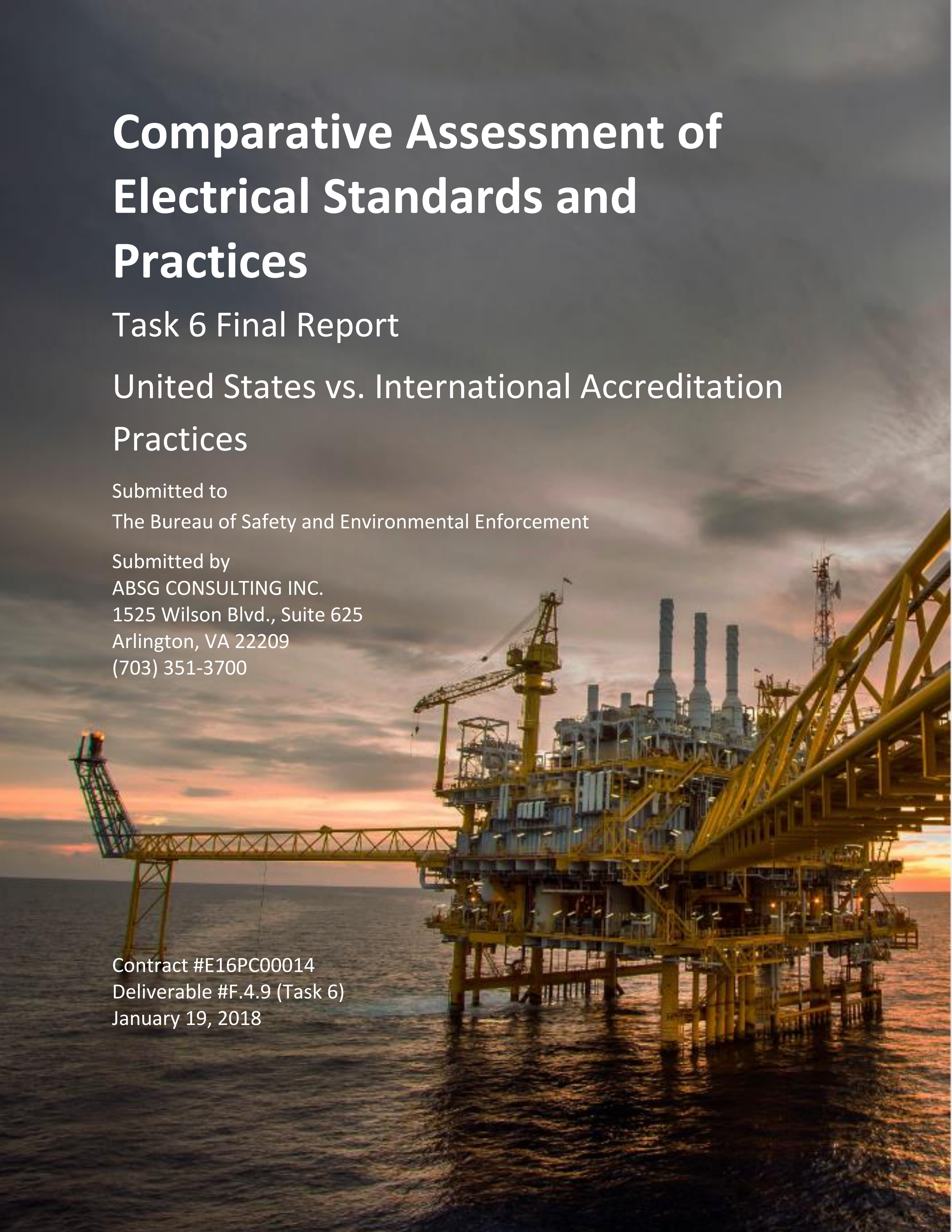
UL 60079-26, *Explosive Atmospheres—Part 26: Equipment with Equipment Protection Level (EPL) Ga*, Ed. 3, April 21, 2017

Appendix G. Task 6 Report: United States vs. International Accreditation Practices



Comparative Assessment of Electrical Standards and Practices

Task 6 Final Report

United States vs. International Accreditation Practices

Submitted to
The Bureau of Safety and Environmental Enforcement

Submitted by
ABSG CONSULTING INC.
1525 Wilson Blvd., Suite 625
Arlington, VA 22209
(703) 351-3700

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List of Acronyms

AFRAC	African Accreditation Cooperation
ANAB	ANSI-ASQ National Accreditation Board
ANSI	American National Standards Institute
APLAC	Asia Pacific Laboratory Accreditation Cooperation
ARAC	Arab Accreditation Cooperation
BASEEFA	British Approval Service for Electrical Equipment in Flammable Atmospheres (a British CAB, currently known as SGS BASEEFA)
BSEE	Bureau of Safety and Environmental Enforcement
CAB	Conformity Assessment Body
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
CENELEC	Comité Européen de Normalisation Électrotechnique (European Committee for Electrotechnical Standardisation)
COFRAC	Comité français d'accréditation (the French National Accreditation Body)
CNAS	China National Accreditation Service for Conformity Assessment
DAkkS	Deutsche Akkreditierungsstelle GmbH (the German National Accreditation Body)
DANAK	the Danish National Accreditation Body
EA	The European co-operation for Accreditation
EC	European Commission
EMA	Entidad Mexicana de Acreditación, a.c.
EU	European Union
ExCB	IECEx Certification Body
ExMC	IECEx Management Committee
ExTL	IECEx Testing Laboratory
FM	Factory Mutual Research Cooperation
IAAC	Inter-American Accreditation Cooperation
IAF	International Accreditation Forum
IEC	International Electrotechnical Commission
ILAC	International Laboratory Accreditation Cooperation
INC	Incident of Noncompliance
LCIE	Laboratoire Central des Industries Electriques (a French CAB)
MLA	Multilateral Agreement
MRA	Mutual Recognition Agreements
NB	Notified Body
NRTL	Nationally Recognised Testing Laboratory
OSHA	Occupational Safety & Health Administration
PAC	Pacific Accreditation Cooperation

PTB	Physikalisch-Technischen Bundesanstalt (a German CAB)
RoW	Rest of the World
SADCA	Southern African Development Community Cooperation in Accreditation
SCC	Standards Council of Canada
SDO	Standards Development Organization
UK	United Kingdom
UKAS	United Kingdom Accreditation Service
UL	Underwriters Laboratories
US	United States

1. Introduction

On September 16, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) Office of Offshore Regulatory Programs (OORP) contracted ABSG Consulting, Inc. (ABSG) to conduct the Comparative Assessment of Electrical Standards and Practices study (GS-00F-026A, #E16PC00014). BSEE currently incorporates various industry standards by reference into Title 30 Code of Federal Regulations (CFR) 250.198. BSEE considers it a priority to have an accurate understanding of the concepts detailed in these industry standards documents when conducting inspections of offshore oil and gas facilities to ensure compliance with regulations.

With more facilities and components being manufactured overseas to international standards, determining acceptable equivalencies between the domestic standards incorporated by reference (IBR) and the comparable international standards has become challenging. BSEE recognizes these challenges with many of the electrical standards IBR in 30 CFR 250.198. The purpose of this study was to conduct a gap analysis to compare domestic electrical standards (i.e., NEC, API, ANSI and UL standards) to international electrical standards (i.e., International Electrotechnical Commission standards). As part of this study the following comparative assessments were conducted:

- Task 1 – IEC vs. NEC standards
- Task 2 – of IEC vs. API standards
- Task 3 – IEC vs. ANSI/UL standards
- Task 4 – Other gap analysis assessments
- Task 6 – United States vs International Accreditation Practices

This report presents the results of Task 6, United States vs International Accreditation Practices, the comparative assessment to determine the similarities of and differences between how the U.S. Occupational Safety and Health Administration (OSHA) accredits Nationally Recognized Testing Laboratories (NRTL, such as Underwriters Laboratories (UL) and Factory Mutual (FM)) and how international authorities accredit independent testing laboratories. The following independent testing laboratories, all within the EU, were specifically noted for inclusion into the analysis.

- SGS British Approval Service for Electrical Equipment in Flammable Atmospheres (BASEEFA),
- Physikalisch-Technische Bundesanstalt (PTB),
- Laboratoire Central des Industries Electriques (LCIE).

BSEE will use the results of this gap analysis to make BSEE electrical-related regulations easier to follow by industry, more robust, and easier to enforce. The ultimate goal of improved regulations is safer operations on the OCS, resulting in better protection of the environment and a reduction in the loss of life and property.

The aim of this report is to provide an overview of the Conformity Assessment Body (CAB) accreditation arrangements, in detail for the US and EU with an overview across the rest of the world (RoW). The report specifically focuses on the accreditation of CABs intending to certify electrical products for use in potentially explosive atmospheres otherwise known as Hazardous (Classified) Locations.

The report gives a description of the arrangements within each of the 3 geographical divisions (US, EU & RoW), makes comparisons where meaningful and useful, and gives an analysis of the differences to assist BSEE in the review of electrical systems from around the world.

2. Accreditation Body Structure

Accreditation is defined as the third-party attestation relating to a conformity assessment body (CAB) conveying formal demonstration of its competence to carry out specific conformity assessment tasks.[1]

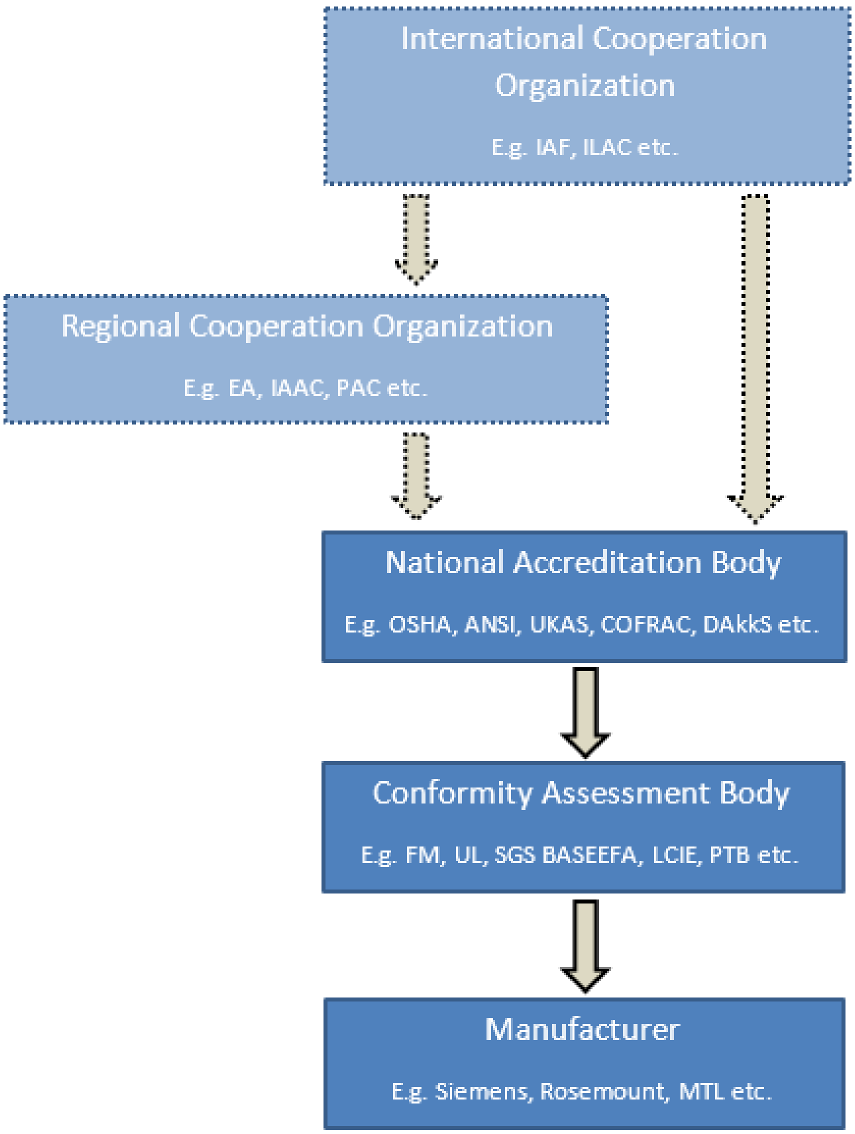

Figure 1: Accreditation Body Structure

[1] ISO/IEC 17011:2004(E) Conformity assessment – General requirements for accreditation bodies accrediting conformity assessment bodies

Figure 1 illustrates the accreditation body structure. Around the world various countries require products to be tested and certified before being used or sold, typically those that could be harmful if poorly designed or constructed. CABs provide the testing and certification services to product manufacturers and importers to allow for their products to be used and sold. To ensure that CABs are sufficiently capable, they are required to be accredited by a National Accreditation Body (NAB) through an assessment of their processes and procedures. Regional and International cooperation organizations aim to ensure that accreditation is of a high standard within a region or internationally in order to allow easier trade of products certified by accredited CABs. Regional and International cooperation organizations have various tiers of membership but at the highest level require their member NABs to adhere to a unified set of standards and be subject to peer review. NABs, CABs and cooperation organizations are examined in each of the following sections.

3. National Accreditation Bodies

3.1 Accreditation Bodies in the United States

The United States has a number of NABs covering different products and services that are required to have accreditation. This report specifically covers the Occupational Safety & Health Administration (OSHA) requirements that products for use in potentially explosive atmospheres be tested and certified for safety by an OSHA-recognized organization. OSHA's Nationally Recognized Testing Laboratory (NRTL) Program fulfils this responsibility by recognizing the capabilities of CABs to test and certify such products for manufacturers. OSHA uses the word 'recognition' as a synonym for 'accreditation'. OSHA is effectively the NAB for CABs accrediting and certifying equipment for installation in potentially explosive atmospheres.

3.2 Accreditation Bodies in the European Union

In 2008, the European Parliament and the Council of the European Union adopted Regulation (EC) No 765/2008[2] that provides a legal framework for the provision of accreditation services across Europe.[3] The Regulation covers the operation of accreditation in support of testing, examination, verification, inspection, calibration and certification activities (collectively known as conformity assessment) including conformity assessment required by legislation.

In the EU accreditation means an attestation by a NAB that a CAB meets the requirements set by harmonized (across the EU) standards to carry out conformity assessment activities. CABs that meet

[2] REGULATION (EC) No 765/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products

[3] Decision No 768/2008/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 on a common framework for the marketing of products

these requirements are known as Notified Bodies (NB). Harmonized standards are created by one of the European Standardization bodies (CEN, CENELEC or ETSI) at the request of the European Commission.

Under the Regulation, accreditation, when carried out against the recognized harmonized standards, is regarded as a public authority activity. EU Member States are required to appoint a single national accreditation body for these activities. Some examples of national accreditation bodies are:

- UKAS the UK Accreditation Service
- COFRAC Comité français d'accréditation – the French accreditation service
- DAkkS Deutsche Akkreditierungsstelle GmbH – the German accreditation service

3.3 Other International Accreditation Bodies

Many countries have their own accreditation bodies to regulate product conformity within their own country. A significant number are also members of regional and international cooperation organizations which aim to ensure that accreditation standards remain high in order to facilitate trade. Some examples of national accreditation bodies from around the world are:

- CNAS China National Accreditation Service for Conformity Assessment
- SCC Standards Council of Canada
- EMA Entidad Mexicana de Acreditación – the Mexican accreditation service

4. Conformity Assessment Bodies

4.1 CABs in the United States

The acknowledgment by OSHA that an organization meets the requirements for a NRTL is specified in 29 CFR 1910.7(b)[4]. In granting recognition, OSHA has determined that the organization has the capability, control programs, independence and effective procedures to perform safety testing and certification of the types of products covered under the test standards included in its scope of recognition. An organization must have the necessary capability both as a testing laboratory and as a product certification body to receive OSHA recognition as a NRTL. Two example NRTLs responsible for a large volume of manufactured products in the US are UL and FM.

As well as being recognized by OSHA FM is also accredited by UKAS under the ATEX equipment directive[5] and is thus a NB (NB 1725) for ATEX certified equipment. UL are also a NB for ATEX (NB 0539) and are accredited by DANAK, the Danish accreditation authority.

[4] Title 29 Code of Federal Regulations, Part 1910.7 Definition and requirements for a nationally recognized testing laboratory.

[5] DIRECTIVE 2014/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast).

4.2 CABs in the European Union

CABs in the EU are accredited by a NAB to a defined scope which includes the overall conformity testing standards and any specific testing standards that they use (typically chosen from recognized national and international standards). Depending on the type of product this level of accreditation may be sufficient.

A range of product types require CE Marking before being placed on the market or put into service in the EU. CE Marking identifies that a product has been subject to conformity assessment and has met all of the requirements of the relevant harmonization legislation for that type of product. The general requirements for placing a product onto the market in the EU is outlined in EU legislation:

- Decision No 768/2008/EC (on a common framework for the marketing of products)[6]

Conformity assessment of equipment for explosive atmospheres (ATEX) has further requirements as defined under ATEX legislation. Under ATEX, CABs are required to be accredited as a NB:

- Directive 2014/34/EU (equipment and protective systems intended for use in potentially explosive atmospheres)[7]

NB accreditation has additional requirements as noted in:

- *EA-2/17 M: 2016 - EA Document on Accreditation for Notification Purposes*
- *EN ISO/IEC 17011 - Conformity assessment -- General requirements for accreditation bodies accrediting conformity assessment bodies*
- *EN ISO/IEC 17020 Conformity assessment—Requirements for the operation of various types of bodies performing inspection*
- *EN ISO/IEC 17021 Conformity assessment—Requirements for bodies providing audit and certification of management systems*
- *EN ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories.*
- *EN ISO/IEC 17065 Conformity assessment—Requirements for bodies certifying products, processes and services*.

Existing accreditation to the above standards is typically taken into account to support accreditation as a NB. CABs in the EU who are ATEX NBs include SGS BASEEFA (NB 1180), LCIE (NB 0081) and PTB (NB 0102).

[6] Decision No 768/2008/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 on a common framework for the marketing of products

[7] DIRECTIVE 2014/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast).

4.3 Other International CABS

The requirements to become a CAB around the world are set by the NAB(s) for each country. NABs that are members of regional and international cooperation organizations aim to have consistent accreditation processes for CABs to enable easier trade of certified products, similar to that detailed for the EU. A significant proportion of NABs, and thus the CABs that they accredit, therefore accredit to relevant international standards such as the ISO/IEC 17000 series. A list of accredited CABs can typically be found on NAB websites.

4.4 Analysis

OSHA has its own set of CAB accreditation requirements whereas the EU and RoW, typically adhere to the recognized international ISO/IEC 17000 series standards. Later sections in this report go into this in detail, however, it's worth noting that an updated draft version of the NRTL program requirements is available that brings them more into line with international standards such as the ISO/IEC 17000 series.

NRTLs in the US show a similar mixed focus to US NABs with some NRTLs also developing standards. NRTLs UL and FM write standards for equipment in potentially explosive atmospheres and use those same standards for product testing and certification activities that they perform. It is likely that CABs in the EU and RoW are involved as stakeholders in standards development but not to the extent of the US where some national standards were almost entirely developed by a single NRTL. Examples of the standards produced by NRTLs are:

- *FM 3610 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II & III, Division 1, Hazardous (Classified) Locations.*
- *UL 913 Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations*.

In the EU applicable accreditation standards come from the set of European harmonized standards published by one of the three standards bodies, CEN (European Committee for Standardization), CENLEC (European Committee for Electrotechnical Standardization) and ETSI (European Telecommunications Standards Institute), which together form the European Standards Organization (ESO). CEN, CENELEC and ETSI are regional mirror bodies to their international counterparts ISO (International Organization for Standardization), IEC (International Electrotechnical Commission) and ITU-T (International Telecommunication Union, telecommunication standardization sector) resulting in international standards being adopted wherever possible.

The issue raised by having dual function CABs and standards developers is that conflicts of interest between the two functions must be managed. The key point here is that standards development in the US has robust regulation predicated on the principle of consensus. The guiding principles are outlined in the document ANSI Essential Requirements: Due process requirements for American National Standards (ANS). This document notes that the standards approval, change and withdrawal process is open with a balance of interests and without dominance by any single party. Final approval of an ANS is through a consensus vote. This process ensures that standards are developed fairly and to meet a recognized need thus mitigating any possible conflict of interest in dual CABs and standards developers. To reinforce this ANSI provides accreditation to organizations wishing to engage in standards development, which UL and FM both hold.

Analysis of the differences between NRTL approved standards and those used internationally is part of the overall project and covered by Tasks 1-3.

5. Cooperation Organizations

5.1 Regional Cooperation Organizations

Regional cooperation organizations promote cooperation between national accreditation bodies in a region at multiple levels. At the highest level of cooperation are Multilateral Recognition Agreements (MLAs) or Mutual Recognition Agreements (MRAs). Conformity assessment results provided by CABs accredited by a MRA/MLA signatory are typically accepted by other MRA/MLA signatories. Goods and services requiring conformity assessment can therefore be traded through all of the countries represented in the MRA/MLA with no need for re-testing or re-assessment in every country.

Regional cooperation organizations are responsible for ensuring accreditation quality standards are being met, typically through regular peer evaluations. Regional Cooperation Organizations include:

- AFRAC – African Accreditation Cooperation
- APLAC – Asia Pacific Laboratory Accreditation Cooperation
    - Includes SCC, CNAS, EMA and ANAB as full MRA signatories
- ARAC – Arab Accreditation Cooperation
- IAAC – Inter-American Accreditation Cooperation
    - Includes SCC, EMA and ANAB as full MLA signatories
- EA – European co-operation for Accreditation
    - Includes UKAS, COFRAC and DAkks as full MLA signatories
- PAC – Pacific Accreditation Cooperation
    - Includes CNAS, EMA and ANSI as full MLA signatories
- SADCA – Southern African Development Community Cooperation in Accreditation

5.2 European co-operation for Accreditation (EA)

The EA (http://www.european-accreditation.org) has a special role in providing the cooperative accreditation infrastructure across the EU in accordance with the requirements of Regulation (EC) No

765/2008.[8] The EA MLA is an agreement signed between EA members to recognize the equivalence, reliability and therefore increased acceptance of results provided by accredited testing, examination, and verification, inspection, and calibration and certification organizations across Europe. It provides a framework that delivers equal, comparable and reliable accreditation services. NABs are admitted to the MLA only after stringent evaluation of their operations by a peer evaluation team to determine continued compliance with ISO/IEC 17011,[9] the internationally recognized standard for accreditation bodies. The MLA process is observed by personnel from the European Commission, national authorities and an EA Advisory Board, which consists of stakeholders and other interested parties in the business and regulatory community.

5.3 International Cooperation Organizations

International cooperation organizations operate on a global scale and fulfil a similar role to the regional cooperation organizations. Although individual countries can sign up to global MRA/MLAs it is more typical for a regional cooperation organization to sign on its members behalf and to confer the global MRA/MLA on to all signatories of its regional MRA/MLA. International cooperation organizations typically perform peer evaluation (such as to ISO/IEC 17011) of regional cooperation organizations on a regular basis (e.g. every four years for the IAF) but leave the majority of peer evaluation to the regional cooperation organizations.

5.4 International Laboratory Accreditation Cooperation (ILAC)

ILAC (https://ilac.org/) is the international organization for accreditation bodies operating in accordance with ISO/IEC 17011[10] and involved in the accreditation of conformity assessment bodies including calibration and testing laboratories using ISO/IEC 17025.[11] Its MLA has regional signatories IAAC, EA and APLAC.

[8] REGULATION (EC) No 765/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products.
[9] ISO/IEC 17011:2004(E) Conformity assessment – General requirements for accreditation bodies accrediting conformity assessment bodies.
[10] ISO/IEC 17011:2004(E) Conformity assessment – General requirements for accreditation bodies accrediting conformity assessment bodies.
[11] ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories.

5.5 International Accreditation Forum (IAF)

The IAF (http://iaf.nu/) is the world association of Conformity Assessment Accreditation Bodies and other bodies interested in conformity assessment in the fields of management systems, products, services, personnel and other similar programs of conformity assessment. Its primary function is to develop a single worldwide program of conformity assessment which reduces risk for business and its customers by assuring them that accredited certificates may be relied upon. Accreditation assures users of the competence and impartiality of the body accredited. Its MRA includes ISO/IEC 17065[12] and has regional signatories IAAC, EA and PAC.

6. IECEx Accreditation

IECEx was set up by the IEC Conformity Assessment Body and is overseen by the IECEx Management Committee (ExMC) with a number of supporting groups and committees. The ExMC is made up of a number of non-voting positions and up to 3 delegates from each member body. Any country with a full or associate member national committee of the IEC may apply for membership of the IECEx system and appoint a member body. Non-members may also apply subject to additional requirements. Member bodies are responsible for overseeing the application process for IECEx accreditation as an IECEx Certification Body (ExCB) or testing lab (ExTL) in their country. IECEx encompasses four global certification schemes:

- The IECEx Certified Equipment Scheme
- The IECEx Certified Service Facilities Scheme
- The IECEx Certificate of Personnel Competence Scheme
- The IECEx Conformity Mark Licensing System

The Certified Equipment Scheme (with some consideration of the Conformity Mark Licensing Scheme) offers a single, international certificate of conformity and a fast track process to meeting national requirements using IECEx equipment test and assessment reports. The IECEx certified equipment scheme ensures confidence through the use of international IEC standards (with additional provision for any national modifications that are applicable) as well as requiring independent certification and testing (i.e. manufacturers cannot self-certify). Organizations holding IECEx accreditation include:

- SGS BASEEFA – ExCB (Equipment, Servicing, Personnel and Conformity Mark)
- LCIE – ExCB (Equipment, Personnel and Conformity Mark)
- PTB – ExCB (Equipment, Servicing and Conformity Mark)
- FM – ExCB (Equipment)
- UL – ExCB (Equipment, Servicing, Personnel and Conformity Mark)

[12] ISO/IEC 17065:2012 Conformity assessment – Requirements for bodies certifying products, processes and services

7. Accreditation Applications

7.1 How OSHA Processes a NRTL Application

The regulations for the NRTL Program require that organizations applying for an initial recognition by OSHA as a NRTL, or for an expansion, or a renewal of its recognition, provide sufficient information and detail in its application to demonstrate that it meets the requirements and criteria for recognition, expansion, or renewal. The CAB must define the product safety test standards for which recognition is being sought. OSHA shall as necessary, conduct an on-site review of the testing facilities of the applicant, as well as the applicant's administrative and technical practices.

The recognition by OSHA of a NRTL is evidenced by a letter of recognition from OSHA. The letter will provide specific details of the scope of the OSHA recognition, including the specific equipment or materials for which OSHA recognition has been granted, as well as any specific conditions imposed by OSHA. The recognition by OSHA of any NRTL will be valid for 5 years. The recognized NRTL shall continue to satisfy all the requirements or limitations in the letter of recognition during the period of recognition.

7.2 How an application to be a Notified Body is processed in the EU

Accreditation for the purposes of certifying products for sale or use in the EU is similar in structure to that used for NRTLs. A CAB applies for accreditation to a notifying authority in an EU member state. The CAB is required to submit information demonstrating that it meets the requirements for accreditation before going through the notifying authority's assessment process. The requirements of the assessment process are derived from multiple sources including EU legislation, relevant standards and guidance documents from the regional cooperation organization, EA. As with NRTLs the CAB must select which test standards it's applying for, chosen from EU harmonized standards, and the area of conformity assessment (such as ATEX).

Recognition as a NB will be confirmed by the notifying authority and published on the list of NBs by the EU. Unlike NRTLs NB status has no end date, instead NBs are subject to regular surveillance by the notifying authority (an independent review and audit) to ensure requirements continue to be met.

7.3 How IECEx Applications are Processed

IECEx applications are processed in a largely similar way to NRTLs and NBs. An application is made to the secretary of the ExMC through the member body of an IECEx participating country. The prospective ExCB or ExTL is required to submit information demonstrating that it meets the requirements for accreditation before going through the IECEx assessment process for the relevant scheme (the NRTL equivalents are the IECEx Certified Equipment Scheme and the IECEx Conformity Mark Licensing Scheme). As with NRTLs and the EU the prospective ExCB or ExTL must select which test standards it's applying for from the approved list of IEC standards.

Recognition as an ExCB or ExTL will be confirmed by the ExMC with ExCBs added to the list published on the IECEx website (ExTLs are required to be associated with an ExCB so only ExCBs are listed). ExCBs and ExTLs are subject to regular surveillance and re-assessment every 5 years by an IECEx assessment team (an independent review and audit).

8. Comparative Assessment

The comparative assessment examined accreditation procedures and the general requirements that NRTLs or NBs must meet. NRTL accreditation and supplementary procedures have been examined and compared to EU legislation using the following documents:

- *OSHA Regulations, Standards 29 CFR, 1910.7 Definition and requirements for a nationally recognized testing laboratory.* (including Appendix A)
- *OSHA Instruction (Directive) CPL 01-00-003 (1999) NRTL Program Policies, Procedures, and Guidelines*
- *Regulation (EC) No 765/2008 Accreditation*[13]
- *Regulation (EC) No 768/2008 marketing of products*[14]

EU regulations apply to all countries across Europe. The EU comparison is therefore applicable to independent testing laboratories SGS BASEEFA, PTB and LCIE who are all based in the EU and have ATEX accreditation. UK specific procedures from UKAS have also been examined as an example of how the EU regulations have been implemented (SGS BASEEFA is accredited by UKAS).

- *LAB3 - The Conduct of UKAS Laboratory Assessments*[15]
- *C1 - General Principles for the Assessment of Management System, Product and Persons Certification Bodies*[16]
- *Department for Business, Energy and Industrial Strategy - Guidelines for the Appointment of UK Notified Bodies*[17]

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[13] REGULATION (EC) No 765/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products.

[14] Decision No 768/2008/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 on a common framework for the marketing of products.

[15] UKAS Publication – LAB3, Edition 4, August 2009 – The Conduct of UKAS Laboratory Assessments

[16] UKAS Publication – C1, Edition 4, September 2014 – General Principles for the Assessment of Management System, Product and Persons Certification Bodies.

[17] UK Government – Department for Business, Energy and Industrial Strategy – Guidelines for the Appointment of UK Notified Bodies, August 2016.

NRTL evaluation criteria have been examined and compared to EU legislation and international standards using the following documents:

- *OSHA NRTL Program - Application Guidelines* (specifically the section on evaluation criteria)[18]
- *EN ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories.*
- *EN ISO/IEC 17065 Conformity assessment — Requirements for bodies certifying products, processes and services.*
- *Directive 2014/34/EU equipment and protective systems intended for use in potentially explosive atmospheres*[19]
- *Decision No 768/2008/EC marketing of products*[20]

The following IECEx documents have also been examined and compared to the NRTL documents (both OSHA regulations and application guidelines):

- *IECEx 01 - IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System) - Basic Rules.*
- *IECEx 01B - Guidance for the use of the IECEx Logo.*
- *IECEx 02 - IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System) - Rules of Procedure.*
- *IECEx 04 - IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres - IECEx Conformity Mark Licensing System – Regulations.*
- *IECEx OD 003 - IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System) - Assessment Procedures for IECEx acceptance of Candidate Accepted Certification Bodies (ExCBs) and Ex Testing Laboratories (ExTLs) – Parts 1 & 2.*
- *IECEx OD 010-2 - Operational Document - Guidance for the development, compilation, issuing and receipt of ExTRs - Part 2: Procedures and guidance.*
- *IECEx OD 011-2 - Guidance on Use of the IECEx Internet based "On-Line" Certificate of Conformity System - Part 2: Creating IECEx Equipment Certificates of Conformity CoCs.*
- *IECEx OD 024 - IECEx Rules of Procedure covering testing, or witnessing testing at a manufacturer's or user's facility.*
- *IECEx OD 032 - IECEx Assessor's Guide.*

[18] OSHA NRTL Program - Application Guidelines, October 2000.

[19] DIRECTIVE 2014/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast).

[20] Decision No 768/2008/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 on a common framework for the marketing of products.

The IECEx comparison is applicable to independent testing laboratories SGS BASEEFA, PTB and LCIE who all have IECEx accreditation for equipment. In the US, NRTLs FM, UL and Intertek are also approved to operate under the IECEx Certified Equipment Scheme.

8.1 Accreditation Procedures

The accreditation procedures for the EU, UK and the IECEx were compared to the NRTL accreditation procedures as described in 29cfr1940.7 Appendix A. Each of the sections was compared against the EU, UK and IECEx procedures. Table 1 lists the accreditation procedures, sections and the number of topics in each section. The topics that are met or not met by EU, UK and IECEx procedures are discussed below the table. For example the 'Acceptance and on-site review' section has three topics. The EU does not meet the requirements in any of the topics but the UK and IECEx meet all three.

Table 1: Summary of Accreditation Procedures Comparison

Section	Topics	EU Comparison	UK Comparison	IECEx Comparison
Accreditation Procedure		**Met / Not Met**	**Met / Not Met**	**Met / Not Met**
Applications				
Eligibility	2	2 / 0	2 / 0	1 / 0 (1 N/A)
Content of Application	3	3 / 0	3 / 0	3 / 0
Filing Office Location	1	1 / 0	1 / 0	1 / 0
Amendments and Withdrawals	2	0 / 2	1 / 1	0 / 2
Review and Decision Process				
Acceptance and on-site review	3	0 / 3	3 / 0	3 / 0
Positive Finding by Staff	1	1 / 0	1 / 0	1 / 0
Negative Finding by Staff	2	0 / 2	2 / 0	2 / 0
Preliminary Finding by Assistant Secretary	3	0 / 3	2 / 1	1 / 1 (1 NA)
Public Review and Comment Period	2	0 / 2	0 / 2	0 / 2
Action after Public Comment (Note 1)	3	1 / 2	2 / 1	2 / 1
Action after Public Objection (Note 1)	5	1 / 4	2 / 3	1 / 4
Terms and Conditions of Recognition				
Terms and Conditions of Recognition	1	0 / 1	1 / 0	1 / 0
Temporary Recognition of Certain NRTLS	2	0 / 2	0 / 2	0 / 2
Supplementary Procedures				

Section	Topics	EU Comparison	UK Comparison	IECEx Comparison
Accreditation Procedure		**Met / Not Met**	**Met / Not Met**	**Met / Not Met**
Test Standard Changes	1	0 / 1	1 / 0	1 / 0
Expansion of Current Recognition	1	0 / 1	0 / 1	0 / 1
Renewal of OSHA Recognition	1	0 / 1	0 / 1	0 / 1
Voluntary Termination of Recognition	1	0 / 1	1 / 0	1 / 0
Revocation of Recognition by OSHA	1	1 / 1	1 / 1	1 / 1

Note 1 – The EU, UK and IECEx do not have a public review comment period during the review and decision process. However, a number of the activities contained within the NRTL Action after Public Comment/Objection sections are performed during EU, UK or IECEx accreditation such as making a final decision and public announcement. These activities have been judged independently of the prior NRTL requirement for a public review and comment period.

The following subsections provide more detail on the differences (primarily 'not met' topics) between NRTL, EU, UK and IECEx accreditation procedures as summarized in Table 1 above.

8.1.1 Applications

The initial application process is broadly similar between the US and EU. Both are primarily focused on internal accreditation but with provision for foreign applications, the US through an included process and the EU through MRAs. In this case an MRA allows a non-EU country to accredit their own NBs under the same regulations as the EU. The list of countries who have signed an MRA is small but does include the US, although only Switzerland has been accepted to provide ATEX certification (the US MRA covers EMC and telecommunication equipment). The IECEx application process is also similar but with a global outlook.

Two areas are missing from the EU legislation and IECEx system, revising an application before completion and voluntary withdrawal. UK procedures do include provision for application revision but also don't have a voluntary withdrawal process. As there will be a working relationship between the applicant and accreditation body or IECEx assessors during the application it is considered that revision or withdrawal could be accommodated without issue despite a lack of written processes. The missing areas are therefore not considered to be significant.

8.1.2 Review and Decision Process

8.1.2.1 *Acceptance and on-site review*

The NRTL documentation provides an overview of the review process and requirements. In comparison, EU legislation specifies that a CAB may request assessment but places no specific requirements on the process. The EU also requires accreditation bodies to have sufficient competent personnel to perform its assigned tasks, the same as for NRTL, but there is no defined review protocol or requirements for a site visit. UK documentation goes into more detail and meets all of the NRTL requirements whilst the IECEx system has the most robust approach. IECEx requires a site visit conducted by approved assessors with sufficient experience and IECEx assessor training.

8.1.2.2 *Positive Finding by Staff*

The broad requirements for a positive finding and request for the NRTL application to be approved are matched by EU, UK and IECEx procedures.

8.1.2.3 *Negative Finding by Staff*

As the EU does not perform accreditations, which are handled by national accreditation authorities in each member state, there are no requirements on reporting negative findings to the applicant or allowing for revisions to address the reasons for failure. UK and IECEx procedures are broadly similar to a NRTLs with options for correcting non-conformances or appeals.

8.1.2.4 *Preliminary Finding by Assistant Secretary*

Preliminary findings are produced for NRTLs outlining whether they meet the requirements for recognition based upon a range of factors. They are supplied to the applicant and published in the Federal Register but are not considered to be an official decision. The EU has no equivalent requirements to produce preliminary findings. The UK accreditation authority UKAS provides interim findings on a regular basis throughout the review process to allow for non-conformances to be addressed but these are not published. IECEx is similar in that the applicant is made of aware of findings during the application process but there are no published preliminary findings.

Key Point 1 – Public preliminary findings are not required for the EU, UK or IECEx

8.1.2.5 *Public Review and Comment Period*

The EU, UK and IECEx do not have a public review during the accreditation process. Accredited organizations may be challenged as to their competence once accredited.

Key Point 2 – A public review is not required for the EU, UK or IECEx

8.1.2.6 *Action after Public Comment*

NRTL, EU, UK and IECEx documentation all contain requirements to inform the applicant of the final decision and make a copy of the decision public. There are two main differences between the requirements. Length of recognition is stated for NRTLs (5 years), UK accreditation (4 years) and IECEx (5 years) but there is no limit specified for EU NBs. The EU, UK and IECEx also don’t have a specified stop work cut-off following the final decision. As a procedural matter this is not considered significant to the integrity of the accreditation process.

8.1.2.7 *Action after Public Objection*

The same comments noted for Public Review and Comment Period and Action after Public Comment apply here for the EU, UK and IECEx.

8.1.3 Terms and Conditions of Recognition

The terms and conditions of recognition encompass five topics:

8.1.3.1 *Letter of recognition*

A NRTLs letter of recognition specifies the scope of OSHA recognition, specific details of equipment or materials covered and whether there are any special conditions. An open access database is used across the EU to record a similar set of information. Following accreditation as a NB the notifying authority provides the requisite information the EU for storage on the NANDO (New Approach Notified and Designated Organizations) Information System. IECEx provides a list of ExCBs and their scope on its website.

8.1.3.2 *Period of recognition*

NRTL requirements specify a 5 year period before re-assessment is required. The EU specifies no similar limit for a NB but they are subject to surveillance activities. In the UK this takes the form of annual surveillance activities with a full re-assessment every 4 years. IECEx also carries out surveillance activities but with a full re-assessment every 5 years.

8.1.3.3 *Constancy in operations*

NRTLs are required to satisfy all of the requirements listed in the letter of recognition during the period of recognition. An OSHA audit schedule is developed each year to check various aspects of each NRTL to ensure that terms of recognition are being met. EU legislation requires NABs to monitor CABs to ensure that terms of accreditation are being met. Surveillance activities and requirements are stated in the UK documentation. IECEx has a similar surveillance program.

8.1.3.4 *Accurate publicity*

NRTLs are not allowed to misrepresent the scope or conditions of their recognition. The EU has similar requirements regarding use of accreditation marking but in general it falls under general surveillance activities and complaints procedures. UK documentation includes a requirement for NBs to control use of their certificates and identification number including guidelines on actions to be taken in the event of misuse. IECEx has a document outlining certification mark regulations and licensing requirements which together with other documents serve to ensure accurate use of IECEx related information.

8.1.3.5 *Temporary Recognition*

Provision is included for temporary recognition of certain NRTLS (UL and FM) for five years between 1988 and 1993. None of the examined documentation allows for temporary recognition in the EU or in the IECEx system but as this is historical and no longer applies it is not considered significant.

8.1.4 Supplementary Procedures

8.1.4.1 *Test standard changes*

Recognized NRTLs may change a testing standard or elements within one by notifying the Assistant Secretary (of OSHA), certifying that the revised standard is at least as effective and providing data to support its conclusions. The revised standard is then reviewed and judged acceptable if it is substantially equivalent to the previous version. Changes to standards made through standards bodies are accepted directly.

EU legislation doesn't provide detail on how to change testing standards, however there is information in the UK documentation. The UK implements formal conformity assessment and accreditation standards (e.g. ISO/IEC 17025) changes in accordance with transition schedules produced by IAF or ILAC. Changes to other standards requires either reevaluation by UKAS to the new standard through surveillance or an extension to scope or by using a flexible scope of accreditation. Flexible scopes of accreditation narrowly define what a laboratory can and cannot do based upon its competence and may be mixed with fixed scopes as required. Flexible scope activities are in line with the requirements of ISO/IEC 17025 and include modifying existing methods, developing new methods, using technically equivalent standard methods and using revised standard methods.

IECEx is based upon recognized international standards and deviation from those would require an extension of scope. Changes to accepted standards are addressed through surveillance activities as the standard is introduced with both the current and previous revisions of a standard accepted.

8.1.4.2 *Expansion of Recognition*

NRTL expansion of scope follows the standard application review process but with a shorter public review period and the site visit may not be required. It is expected that the process will be shorter as a lot of the information will have already been reviewed. The EU legislation has no equivalent information on expansion of scope but it is covered in the UK. UKAS requires a similar process with effectively a shortened version of a full review focusing on the additional scope items which may be combined with already planned surveillance activities. Similarly to the full review the UK does not include a public review.

IECEx extensions of scope are reviewed by the assessment team that completed the last assessment and in conjunction with the ExMC secretary decide on whether a full or limited re-assessment is necessary. Again there is no public consultation as part of this process.

8.1.4.3 *Renewal of Recognition*

NRTLs apply for renewal of recognition on a five yearly basis which is processed and accepted or rejected by OSHA. A public review period is included and recognition does not end until OSHA makes a final decision. An alternative method is also noted whereby OSHA may authorize a NRTL to self-certify instead of applying for a renewal. Again there are no equivalent requirements in EU legislation but it is covered in the UK. UKAS conducts annual surveillance activities to ensure accreditation requirements are being met with every fourth year being a full re-assessment. IECEx follows a similar process with annual surveillance activities and a full re-assessment every fifth year. As previously noted the EU, UK and IECEx do not offer a public consultation period nor do they have an option for self-certification.

Key Point 3 – OSHA may allow NRTLs to self-certify against their letter of recognition

8.1.4.4 *Termination and Revocation of Recognition*

NRTLs may request voluntary termination of recognition by giving written notice to OSHA. There is no provision in EU legislation for something similar but UKAS allows for both temporary suspension and withdrawal of accreditation (in full or in part). Withdrawal of an ExCB form the IECEx scheme is allowed but requires advance notice of one year.

The NRTL revocation procedure may be enacted by OSHA if the NRTL fails to meet requirements stated in its letter of recognition or misrepresents itself (what it can do, scope of recognition etc.). Information provided by third parties may be used to initiate revocation procedures. Both the EU and UK have equivalent revocation procedures that may be applied to similar failures of an accredited organization. In terms of the process itself EU legislation requires an appeals process but does not specify what it should entail. The appeals process in the UK is broadly similar to that used by OSHA with the exception that the appeals process is not public and only records of suspension or withdrawal of accreditation are publicly available.

IECEx has an equivalent suspension and withdrawals process for ExCBs and ExTLs failing to meet IECEx requirements or breaking IECEx rules as well as an overall appeals process. Typically a six-month period to address any issues is given prior to suspension/withdrawal proceedings which require a four fifths majority vote of the ExMC. Similarly to the EU and UK, IECEx does not publish details of suspension/withdrawal proceedings or the appeals process but the results are replicated to the IECEx website list of ExCBs.

Key Point 4 – EU, UK and IECEx suspension, withdrawal and appeals processes are internal to the relevant organization with only the outcome made public

8.1.5 Other Features

There are some additional features of EU accreditation that are worth noting. EU legislation and UK guidelines allow for non-accredited NBs. These are organizations without an accreditation certificate but can demonstrate that they meet all of the NB requirements for product conformity assessments. The route to becoming a NB without accreditation is significantly longer and limited in scope to NB conformity assessment activities (i.e. they're still not accredited and there is limited recognition outside of the EU).

There are number of clauses in EU legislation relating to cooperation between EU member states. These include exchanging information (such as suspensions and revocations, as well as information on conformity assessment activities) and participating in NB joint activities. These are not applicable to NRTLs but do reinforce the equivalence of conformity assessment activities across the EU.

8.2 Evaluation Criteria

The evaluation procedures for the EU, UK and the IECEx were compared to the NRTL evaluation criteria described *in OSHA NRTL Program Application Guidelines*. Table 2 lists the evaluation criteria sections and the number of topics in each section. The topics that are met or not met by EU, UK and IECEx procedures are then listed. The EU and UK have been combined as the majority of topics relate to ISO/IEC standards which are the same for the EU and UK. IECEx also uses the same standards but has some additional requirements necessitating a separate column. For example the 'Testing Facilities' section has seven topics. Both the EU & UK and IECEx meet six topics in full but do not meet one topic.

Table 2: Summary of Evaluation Procedures Comparison

Section	Topics	EU & UK Comparison	IECEx Comparison
Evaluation Criteria		**Met / Not Met**	**Met / Not Met**
Capability			
Testing Facilities	7	6 / 1	6 / 1
Testing Equipment	5	5 / 0	5 / 0
Testing Evaluation and Processing Procedures	9	7 / 2	7 / 2
Calibration Program	8	8 / 0	8 / 0
Quality Assurance	4	4 / 0	4 / 0
Records	3	3 / 0	3 / 0
Personnel	6	5 / 1	5 / 1
Control Programs			
Listing and Labelling	4	3 / 1	3 / 1
Follow-up and Field Inspections	10	2 / 8	5 / 5
Independence	6	0 / 6	1 / 5
Report and Complaint Procedures			
Reports	3	3 / 0	3 / 0
Complaints	3	3 / 0	3 / 0

The following subsections provide more detail on the differences (primarily 'not met' topics) between NRTL, EU, UK and IECEx evaluation criteria as summarized in Table 2 above.

8.2.1 Capability

8.2.1.1 *Testing Facilities*

NRTL and ISO/IEC 17025 requirements for testing facilities are broadly the same with six out of seven points fully covered. However, a significant proportion of the last point is not covered by any of the standards, legislation or guidance documents for the EU, UK or IECEx (as all derive from the same international standards). The missing areas relate to general security, off-site storage, security personnel, confidentiality and security policies and fire protection.

Key Point 5 – EU, UK and IECEx test facility requirements do not completely match NRTL requirements, particularly activities such as general security and fire protection

8.2.1.2 *Test Equipment*

All NRTL and ISO/IEC 17025 requirements for test equipment are broadly similar with no identified gaps.

8.2.1.3 *Testing Evaluation and Processing Procedures*

Regarding testing evaluation and processing procedures there are some differences in several areas.

NRTLs are required to include the following topics in their procedures: selection of standards, responsible persons for decision making, resolving disagreements on standards applicability and products covered by multiple standards. ISO/IEC 17000 series standards include requirements on responsibilities and authorizations which includes responsible persons in general terms but there are no equivalent requirements for the others in any of the standards, legislation or guideline documents examined. The missing requirements are not considered significant as both ATEX and IECEx are using a significantly smaller set of approved standards that should be interoperable without issue.

Testing procedures need to be developed, maintained and reviewed over time. NRTLs are required to identify personnel responsible for these activities, frequency of reviews and who verifies that procedures are being followed. Specific detail is missing from ISO/IEC 17025 and standards supporting IECEx but the documentation control requirements contained within are considered to meet the same overall objective. This point is therefore not considered significant.

8.2.1.4 *Calibration Program*

NRTL and ISO/IEC 17025 requirements for calibration are broadly similar with no identified gaps but there are a few points worth considering. ISO/IEC 17025 includes calibration information on the list of equipment records but does not otherwise detail calibration procedures. Calibration is therefore required to obtain and maintain that information but it is implicit rather than explicit like for NRTLs. ISO/IEC 17025 also goes further than the NRTL requirements with requirements on the use and update of correction factors and safeguards against equipment adjustments that would invalidate equipment calibration.

8.2.1.5 *Quality Assurance*

All NRTL requirements for quality assurance are broadly similar with no identified gaps when compared to ISO/IEC 17025 and ISO/IEC 17065.

8.2.1.6 *Records*

All NRTL requirements for records are broadly similar with no identified gaps when compared to ISO/IEC 17025 and ISO/IEC 17065.

8.2.1.7 *Personnel*

The majority of NRTL requirements for personnel are broadly similar to those in ISO/IEC 17025 and ISO/IEC 17065. The exception is the requirement for an employee safety program to identify, evaluate and control or prevent laboratory hazards which is not covered by any of the documents examined although ISO/IEC 17025 does require development of non-standard test methods to include any necessary safety measures. ISO/IEC 17025 also states that regulatory and safety requirements on the operation of laboratories is not covered by the standard. In general, the IEC requires measurements and test methods incorporated into IEC standards to carry prominent health, safety or environmental warnings where needed either at the beginning of a test method (for general warnings) or within the text (for specific warnings). Employee safety in the EU is governed by a number of EU Directives which are enacted into national law by EU member countries as well as national laws such as the Health and Safety at Work Act 1974 in the UK. The European Agency for Safety and Health at Work (EU-OSHA) oversees the EU approach with a competent authority acting as a focal point in each member state.

Key Point 6 – Requirements for general safety of employees are not covered by EU, UK or IECEx accreditation procedures or ISO/IEC standards

8.2.2 Control Programs

8.2.2.1 *Listing and Labelling*

NRTL programs have a range of protected certification marks depending on the issuing company. In contrast the EU has a more limited set of certification marks such as the CE mark for conformity in general and several ATEX markings for different aspects of that scheme. The markings are protected in both cases. IECEx has equivalent protection through a trademark on the IEC part of the logo/marking and the word “IECEx”.

The main differences for listing and labelling is that NRTLs are required to list the test standards used on the certification mark which is not required in the EU or by IECEx. EU and IECEx list test standards on the certificate of conformance and place “Ex” markings on the product label in accordance with the relevant test standards (IEC 60079 series). This is not considered significant as the full set of test standards used are available and ATEX and IECEx indicate the main test standards used on the product label through "Ex" markings.

8.2.2.2 *Follow-up and Field Inspections*

NRTLs are required to perform surveillance on a manufacturer's products, processes and quality management system with the processes involved and frequency of inspections specified. ISO/IEC 17065, EU legislation and the IECEx system require ongoing surveillance activities of certified products but only IECEx specifies a frequency of inspection. This is not considered significant in the EU as surveillance is still required which is expected to be scheduled by CABs.

The most significant difference in this section between NRTL requirements and requirements in the ATEX certification scheme is the tiered approach to conformity assessments. Most of the NRTL requirements for follow-up and inspection are included in the ATEX certification scheme but only under certain modules (see Appendices A&B for a summary of conformity modules required for each equipment type and a list of conformity modules). The modules applicable to ATEX are examined in Table 3.

Table 3: ATEX Conformity Assessment Module Summary

Module	Summary
A	Conformity to type based on internal production control The manufacturer (without oversight of a NB) controls its own internal production through any controls, procedures and monitoring activities deemed necessary. There is no module specific NB oversight
B	EU Type Examination A design review to confirm that the technical design meets the ATEX requirements and that the product has been produced in accordance with the design.
C1	Conformity to type based on internal production control plus supervised product testing This is similar to Module A with the addition of supervised testing of every product conducted under the supervision of the NB.
D	Conformity to type based on quality assurance of the production process In this module the manufacturer declares that the product conforms to type based upon an approved quality system for production, final product inspection and testing. The NB assesses the quality system, which must ensure that the manufactured products conform to type, and is responsible for regular surveillance including audits and unexpected visits (which may include random product testing).
E	Conformity to type based on product quality assurance This module is similar to Module D with the exception that the approved quality system is not required to cover the production process, only final product inspection and testing.
F	Conformity to type based on product verification Conformity to type is ensured through examination and testing of every product by a NB.

Module A is applicable only to ATEX equipment in group II, category III (the lowest category) which effectively amounts to self-certification by the manufacturer and is not allowed under NRTL requirements.

Key Point 7 – ATEX allows for a limited amount of self-certification by manufacturers (ATEX equipment in group II, category III)

None of the NRTL inspection and follow up inspection requirements are met for equipment in this category. The other ATEX equipment groups and categories have to include module B, which establishes the EU type certificate, plus one other module that ensures conformity with the EU type certificate. The highest risk category is group II category I which requires either module D or F whilst group II, category II equipment requires either module C1 or E. The choice of module in both cases broadly breaks down into the NB either assessing quality assurance or performing product testing. The result of this is that the minimum requirements of ATEX conformity assessments do not meet NRTL requirements. Unless additional measures are taken in addition to the ATEX requirements there will be a gap with regard to a manufacturer's quality assurance system or independent product testing as ATEX doesn't require both.

Key Point 8 – ATEX only requires product testing or manufacturer quality management system assessment but not both

A number of issues relate to the detail given in EU and IECEx documents where the activities are performed but the specific points included in the NRTL requirements are not explicitly required. These issues are not considered to be significant as noted below:

- ATEX modules D and E don't explicitly cover the specific points of a NRTL assessment of a manufacturer's evaluations and tests
- ISO/IEC 17065, as used by the EU, and ATEX requirements don't explicitly cover the specific points of NRTL follow-up inspections and surveillance
- The EU and IECEx only cover NRTL requirements for agents carrying out surveillance activities at a general subcontractor level
- IECEx system contractual requirements do not fully match the NRTLs
- Actions following a manufacturing non-conformance are not specified in detail for the EU (except for recalls which are covered) and the IECEx.

The first four points are not considered significant as the broader activities are required. For the last point NRTLs require manufacturers to have procedures or agreements in place to cover recalls, removal of conformity marks, product rebuild to meet required standards and scrapping or replacement of returned parts if removal of conformity mark or product rebuild cannot be done. EU and IECEx procedures require provision for product recalls and equivalency for the other procedures. Manufacturers may work with NBs or ExCBs to address non-conformities (product rebuild and/or replacements) and withdrawal of a certificate of conformity requires removal of conformity marks from products and documentation.

One other issue remains relating to confirmation that manufacturers have separation of the head of QA from production. This is not considered significant within the wider context of the manufacturer quality system assessment procedures, which for IECEx and applicable ATEX modules, are based upon the internationally recognized standard ISO 9001.

8.2.2.3 *Independence*

ISO/IEC 17000 series standards and EU legislation is significantly less prescriptive than the NRTL requirements with authority given to NBs to judge the acceptability of independence provisions. CABs are required to be independent organizations in all cases but in the EU some degree of organizational affiliations are allowed. The EU does go a little further in some areas with specific provisions covering consultancies, subcontractors and subsidiaries. IECEx prohibits ExCBs and ExTLs from being part of or under the influence of manufacturing interests associated with “Ex” services.

The areas of financing (both to and from), ownership and personal interests are not specifically covered by ISO/IEC 17000 series standards, IECEx requirements or EU legislation. Independence and impartiality are required to be maintained and there are provisions to achieve this but it is not possible to state in general that the specific NRTL requirements would be met.

Key Point 9 – EU NBs and IECEx ExCBs and ExTLs are required to be sufficiently independent of the organizations they are assessing but may not fully meet all of the NRTL ownership and financing requirements

Conflicts of interest are required to be disclosed and managed for NRTLs, IECEx (via ISO/IEC 17025 or 17065) and in the EU. Although not specifically named as conflict of interest policies, the impartiality and disclosure requirements for the EU and IECEx fulfil the same role.

8.2.3 Report and Complaint Procedures

8.2.3.1 *Reports*

NRTLs require test reports to contain a number of different pieces of information. ISO/IEC 17025 contains a similar list but together with ISO/IEC 17065 go a little further with additional information requirements for test reports as well as calibration certificates and other certification documents. IECEx additionally provides templates to ensure consistency of reporting.

The ISO/IEC standards, EU legislation and IECEx requirements don't match up to the NTRL requirements particularly well with regard to preparing technical reports. However, the general principles of a clear and accurate report with sufficient controls in place are the same, hence it was not considered an issue. Distribution and confidentiality are considered in all cases.

8.2.3.2 *Complaints*

The NRTL complaints procedure requirements are met in full by ISO/IEC 17025 and 17065 requirements. The EU has an additional requirement for CABs to hold liability insurance or state backing in order to become accredited.

9. Summary of Key Points

The following is a summary of the key points identified in the comparative assessment.

1. Public preliminary findings published for NRTL applications but are not required for the EU, UK or IECEx.
2. A public review is held as part of a NRTL application but is not required for the EU, UK or IECEx.
3. OSHA may allow NRTLs to self-certify against their letter of recognition which is not an option for the EU, UK or IECEx.
4. The NRTL suspension, withdrawal and appeals processes are carried out in public compared to the EU, UK and IECEx which carry them out internally with only the outcome made public.
5. NRTL requirements for test facility requirements include areas such as general security and fire protection which are not covered by the EU, UK and IECEx procedures.
6. Requirements for general safety of employees are not covered by EU, UK or IECEx accreditation procedures or ISO/IEC standards.
7. NRTLs do not allow manufacturers to self-certify their own products but ATEX (EU & UK) allows for a limited amount of self-certification by manufacturers (ATEX equipment in group II, category III).
8. NRTLs and IECEx require both product testing and manufacturer quality management system assessment but ATEX (EU & UK) only requires one of the two.
9. NRTLs have strict ownership and financing requirements that may not be fully met by the organizational independence requirements for EU NBs and IECEx ExCBs and ExTLs.

10. Draft NRTL Procedures

The review and analysis of NRTL procedures used OSHA Instruction CPL 1.0.3 NRTL Program Policies, Procedures, and Guidelines with an effective date of December 1999. An updated draft version (June 2016) has been developed that has not yet come into force with no guidance on when that is likely to happen. This section briefly looks at the changes that this draft document makes and how they affect the analysis.

10.1 Independence

The NRTL independence clauses have been removed from the updated draft in favor of the ISO/IEC 17025 approach to maintain independence by identifying, eliminating and controlling risks to impartiality. This makes the requirements across the EU, UK and IECEx effectively the same.

10.2 Renewals

The information provided in the CPL 1.0.3 document didn’t expand on the alternative renewal procedure that was noted during the review as a NRTL self-certification against its letter of acceptance. The updated draft makes it clear that the renewal request and self-certification follow the same procedure with regard to the information a NRTL has to supply and that a site assessment is required if one hasn't been completed in the previous 18 months.

10.3 Minimum Performance

The updated draft adopts ISO/IEC 17025 and ISO/IEC 17065 with some supplementary requirements as the baseline for a NRTLs performance. The requirements noted to not be covered during the review are typically listed as supplementary requirements in the draft. Significant changes are noted in the following subsections.

10.3.1 Subcontracting of tests and calibrations

The draft, In line with ISO/IEC 17025, allows for subcontracting of tests and calibrations with some additional requirements to ensure that subcontractors are suitably qualified and regularly assessed.

10.3.2 Acceptance of Inspection and Test Reports

The draft allows for acceptance of inspection and test reports from various organizations subject to meeting a number of requirements. The key point here is that these reports are accepted when issued by an accredited organization. This includes organizations holding the following accreditations:

- ISO/IEC 17020 accreditation plus the relevant scope through an ILAC signatory
- Part of the IEC Certification Body scheme
- IECEx

10.3.3 Surveillance

The draft outlines that under some circumstances a minimum of 4 factory surveillance visits per year are required. Most notably this includes manufacturers producing products intended for use in hazardous locations. This requirement is more stringent than the surveillance requirements noted in the review.

11. Conclusions

The following conclusions are applicable to independent testing laboratories SGS BASEEFA, PTB and LCIE who are all accredited through EU legislation for ATEX as well as through the IECEx system for equipment. Based upon the key points identified in the analysis section, the following conclusions can be drawn:

1. NRTL applications and appeals processes involve the public at an early stage in contrast to both the EU and IECEx whose processes are all internal until the final decision. For established NB, ExCBs and ExTLs this difference will not affect the quality of conformity assessments or accredited products.

2. Renewal of NRTL recognition by self-certification against their letter of recognition is a weakness of the OSHA NRTL program in comparison to the EU and IECEx. This issue has been clarified in the draft NRTL directive and thus will close the perceived gap.
3. NRTL requirements for test facilities are not fully met for the EU and IECEx, specifically general security, fire protection and personnel safety. These aspects are typically covered by national (or regional (e.g. EU)) regulations but this difference has no significant effect on quality of conformity assessments or accredited products.
4. Independence of assessors is required in all cases but the EU and IECEx may not meet all of the NRTL requirements. The level of independence required is currently considered sufficient to ensure integrity of testing and assessment is maintained but the NRTL, EU and IECEx requirements will become fully aligned when the draft NRTL directive is enacted.
5. ATEX does not provide a sufficient framework to be considered equivalent to the NRTL program for the following major reasons:
    a. Manufacturers are allowed to self-certify some low risk products
    b. ATEX requires products to be either tested or made under an assessed quality management system but not both
6. The IECEx Certified Equipment Scheme is broadly comparable[21] to the NRTL program. ExCBs and ExTLs can therefore be considered to be equivalent to the corresponding parts of a NRTL (ExCB for certification and ExTL for testing). However, there remain some differences which are likely to prohibit use of IECEx certification directly in the US without changes to the law (particularly labelling and markings).
    a. As a number of NRTLs hold multiple accreditations, including IECEx, an interim solution for manufacturers is to use those NRTLs to provide a fast track service to NRTL certification based upon existing IECEx documentation. This is supported by the draft NRTL directive allowing for use of test reports from IECEx and other accredited organizations

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[21] Accreditation to ISO/IEC 17025 for testing and ISO/IEC 17065 for certification are also largely comparable to the corresponding parts of a NRTL, particularly if endorsed by a regional or international cooperation body (such as IAF and ILAC). However within the context of this analysis it is unlikely to see either of these separately from a certification scheme such as ATEX or IECEx.

Appendix A – ATEX Required Conformity Assessment Modules

- Equipment Group 1, Category M.1 – Mining equipment required to remain functional in the presence of explosive atmospheres
  - Module B and either Module D or F
- Equipment Group 1, Category M.2 – Mining equipment intended to de-energize in the presence of explosive atmospheres
  - Internal Combustion Engines and Electrical Equipment - Module B and either Module C1 or E
  - Other Equipment – Module A
- Equipment Group II, Category I – Equipment for use in explosive atmospheres present continuously, for long periods or frequently
  - Module B and either Module D or F
- Equipment Group II, Category II – Equipment for use in explosive atmospheres that occur occasionally
  - Internal Combustion Engines and Electrical Equipment - Module B and either Module C1 or E
  - Other Equipment – Module A
- Equipment Group II, Category III – Equipment for use in explosive atmospheres that are unlikely to occur or if they do only for a short period or infrequently
  - Module A
- Any of the above may also use Module G in addition to the required modules.

Appendix B – EU Conformity Assessment Modules

Modules applicable to EU ATEX Directive 2014/34/EU in **bold**

Module B – EU Type Examination

Module C – Conformity to type based on internal production control

Module C1 – Conformity to type based on internal production control plus supervised product testing

Module C2 – Conformity to type based on internal production control plus supervised product checks at random intervals

Module D – Conformity to type based on quality assurance of the production process

Module D1 – Quality assurance of the production process

Module E – Conformity to type based on product quality assurance

Module E1 – Quality assurance of final product inspection and testing

Module F – Conformity to type based on product verification

Module F1 – Conformity based on product verification

Module G – Conformity based on unit verification

Module H – Conformity based on full quality assurance

Module H1 – Conformity based on full quality assurance plus design examination

Appendix C – Regulations and Standards Reviewed

[1] ISO/IEC 17011:2004(E) Conformity assessment – General requirements for accreditation bodies accrediting conformity assessment bodies

[2] REGULATION (EC) No 765/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products

[3] Decision No 768/2008/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 on a common framework for the marketing of products

[4] CFR 29: Labor, Part 1910.7 Definition and requirements for a nationally recognized testing laboratory

[5] DIRECTIVE 2014/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast)

[6] EA-2/17 M: 2016 - EA Document on Accreditation for Notification Purposes

[7] EN ISO/IEC 17011:2004 - Conformity assessment -- General requirements for accreditation bodies accrediting conformity assessment bodies

[8] EN ISO/IEC 17020:2012 Conformity assessment—Requirements for the operation of various types of bodies performing inspection

[9] EN ISO/IEC 17021:2011 Conformity assessment—Requirements for bodies providing audit and certification of management systems

[10] ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories

[11] ISO/IEC 17065:2012 Conformity assessment – Requirements for bodies certifying products, processes and services

[12] FM 3610 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II & III, Division 1, Hazardous (Classified) Locations

[13] UL 913 Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations

[14] CFR 29: Labor, Part 1910.7 Appendix A OSHA Recognition Process for Nationally Recognized Testing Laboratories

[15] Directive Number: CPL 1-0.3 NRTL Program Policies, Procedures, and Guidelines, Effective Date: December 2, 1999

[16] UKAS Publication – LAB3, Edition 4, August 2009 – The Conduct of UKAS Laboratory Assessments

[17] UKAS Publication – C1, Edition 4, September 2014 – General Principles for the Assessment of Management System, Product and Persons Certification Bodies

[18] UK Government – Department for Business, Energy and Industrial Strategy – Guidelines for the Appointment of UK Notified Bodies, August 2016

[19] OSHA NRTL Program - Application Guidelines, October 2000

[20] IECEx 01 - IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System) - Basic Rules

[21] IECEx 01B - Guidance for the use of the IECEx Logo

[22] IECEx 02 - IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System) - Rules of Procedure

[23] IECEx 04 - IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres - IECEx Conformity Mark Licensing System – Regulations

[24] IECEx OD 003 - IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System) - Assessment Procedures for IECEx acceptance of Candidate Accepted Certification Bodies (ExCBs) and Ex Testing Laboratories (ExTLs) – Parts 1 & 2

[25] IECEx OD 010-2 - Operational Document - Guidance for the development, compilation, issuing and receipt of ExTRs - Part 2: Procedures and guidance

[26] IECEx OD 011-2 - Guidance on Use of the IECEx Internet based “On-Line” Certificate of Conformity System - Part 2: Creating IECEx Equipment Certificates of Conformity CoCs

[27] IECEx OD 024 - IECEx Rules of Procedure covering testing, or witnessing testing at a manufacturer’s or user’s facility

[28] IECEx OD 032 - IECEx Assessor's Guide