SUMMARY OF RECENT SIGNIFICANT TA&R PROGRAM PROJECTS AND THEIR RESULTS

OSER Projects

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EXECUTIVE SUMMARY

This report provides a summary of activities and conclusions of the Minerals Management Service (MMS) Technology Assessment and Research Program (TA&R Program) recent Operational Safety and Engineering Research (OSER) projects. This program directly supports the MMS mission of promoting safe and sound operations in the Outer Continental Shelf (OCS) through leadership in research and standards development and in facilitating the use of science in making policy and leasing decisions.

The TA&R Program was established in the 1970's to assess offshore energy industry operations on the Outer Continental Shelf and promote development and incorporation of the Best Available and Safest Technologies (BAST) subsequently required through the 1978 Outer Continental Shelf Lands Act (OCSLA) amendments. As part of the TA&R Program initiative, the Operational Safety & Engineering Research (OSER) program is concerned with the evaluation of technological challenges associated with the entire life cycle of offshore energy operations, and has completed over one-hundred (100) projects since the start of 2005, of which ninety-one (91) are presented in this report.

Projects have been grouped into the following categories according to various categories that define the type of offshore research disciplines:

- Post-event Hurricane Damage Assessment;
- Deepwater;
- Drilling;
- Hindcast Data;
- Mooring & Anchors;
- Structures;
- Geotechnical;
- Pipelines;
- Production Measurements;
- Additional projects representative of TA&R Program's comprehensive approach to safety.

Many of the hurricanes, including Lili (2002), Ivan (2004), Katrina and Rita (2005), and Gustav and Ike (2008) resulted in significant damage and/or destruction to the Gulf of Mexico (GOM) offshore oil and gas facilities and pipelines. Based on hundreds of industry damage assessment reports resulting from each storm, MMS recognized the need to analyze damage assessment reports in order to determine the type, cause and extent of damage and to provide guidance for improving facility and pipeline integrity/design to reduce potential damage from future GOM hurricanes.

The reviewed deepwater research projects considered topics related to subsea riser designs, subsea integrity management, and corrosion. Steel Catenary Risers (SCR) are relatively inexpensive solution to deepwater oil and gas production. Fatigue stresses associated with extreme storms, vessel motions, and Vortex Induced Vibrations (VIV) are critical to SCR performance.

The focus of drilling research has been of paramount importance for maintaining system integrity to prevent catastrophic blowout, through techniques to prevent kicks and assessment of component risk and reliability. TA&R projects into drilling applications involved investigation of challenges of high temperature and high pressure well operations and identifying limitations of subsea Blow Out Preventer (BOP) equipment in HPHT drilling conditions.

The Moorings and Anchors research projects investigated related challenges and associated technologies. Ultra-deep water exploration and production has led to new challenges for operators, and new technology, such as the use of polyester ropes, to meet these challenges. Mooring failures during hurricanes Ivan, Katrina, and Rita caused a number of mobile drilling units to go adrift, dragging anchors and causing damage to pipelines. Advances in the development of Wave and Current Energy Generating Devices have led to the growth of new technologies, highlighting gaps in the regulatory standards, which are also covered in this section of the program.

The Structures Research projects investigated the technologies associated with platform structures, such as jackets, TLPs, Spars, and Jack-up rigs. The main thrust of the research was the effects of hurricanes in the Gulf of Mexico, the response of the producing platforms to the hurricanes and design recommendations for improvement of the designs in the events of sudden hurricanes and storms. Another emphasis of the research projects was the innovative use of blast charge materials for explosive removal of offshore structures (EROS), in a safe and environmentally friendly manner. In addition, an intensive experimental and theoretical study was carried out to assess the highly complex and nonlinear phenomena of sloshing and green water effects onto the offshore structures.

The Geotechnical Research Projects investigated geotechnical related issues, to assess offshore energy industry applications of geotechnical innovations, and to promote that governing MMS regulations, rules and operational guidelines encompass the use of the best available and safest technologies. The review study summarizes overall results and conclusions of recent significant geotechnical research projects to collate the findings to allow users easy and accurate access to obtain the necessary information.

The Pipeline Research Projects investigated the technologies associated with subsea pipelines. Pipelines are one of the most important and prominent feature of any subsea system, and their

integrity and management cannot be overestimated. The TA&R research projects presented and demonstrated the use of advanced technology for the pipeline damage detection and monitoring through advanced intelligent systems. The research projects also addressed the use of composite coatings for repairing the risers, as well as identified corrosion as a major damage mechanism for the risers. The extent of damage to the pipeline systems through several hurricanes, specifically near platforms, is well recorded and organized to highlight the importance of damage preventive mechanisms and removal technologies.

Production Measurement (i.e. measuring and monitoring properties of fluids associated with offshore oil and gas operations) is fundamental for assessing the operating environment of offshore assets. The Production Measurements Research Projects have focused on review of state-of-the-art technology and acceptable criteria for assessing natural gas quality and multiphase flow behavior. Particular challenges for the offshore environment have also been investigated.

The Arctic Research Projects investigated the technologies associated with arctic structures, exploration, production, and pipelines. Ice formation on one hand is a load and obstacle that needs to be mitigated effectively; on the other hand, man-made ice islands are an exciting prospect for drilling and production activities. Pipelines are yet another important consideration in arctic environment due to high technical challenges associated with ice gouging, strudel scouring, and upheaval buckling.

The TA&R Other OSER Research Projects have addressed the offshore equipment standard & capability, flow assurance, well integrity, and risk assessment etc. The Other OSER research projects have focused on the assessment of current design codes and industry practice, integrity management, and risk assessment.

ACRONYMS

Client	United States Department of the Interior, Mineral Management Services
DOI	United States Department of the Interior
ERB	Engineering & Research Branch
MCS	Marine Computation Services
MMS	Mineral Management Services
OSER	MMS TA&R Program Operational Safety and Engineering Research
TA&R Program	Technology Assessment & Research Program
US	United States of America
GOM	Gulf of Mexico
API	American Petroleum Institute

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1 INTRODUCTION

1.1 GENERAL

The offshore energy industry is increasingly building interest in exploring the more technologically challenging areas leading to the development of new technologies and encountering new risks. As a part of this endeavor, the MMS has actively been involved with the offshore energy industry in significant Technology Assessment and Research Program (TA&R Program) Operational Safety and Engineering Research (OSER) projects that will enable further development of new safe and environmentally conscious technologies. The TA&R Program projects also enable a "lesson learned" approach that benefits the national and international energy industry as a whole, while facilitating development of newer and better technologies for challenges in the offshore environment.

In order to maximize the value of the results from the research projects, it is imperative to collate the findings to allow users easy and accurate access to obtain the necessary information. The MMS TA&R Program has requested MCS Kenny to summarize key results and identify trends in ninety-one (91) projects completed since the start of 2005, in accordance with the categories listed on the MMS TA&R Program website.

1.2 STUDY OBJECTIVE

The objective of this study is to issue an engineering report that summarizes the overall results and conclusions of recent significant Operational Safety and Engineering Research (OSER) projects of the Technology Assessment and Research Program (TA&R Program).

1.3 DOCUMENT SCOPE

This document summarizes key results and trends in ninety-one (91) projects completed since the start of 2005. All the projects that have been reviewed in this report are list in Annex I.

1.4 OSER OBJECTIVES

The TA&R Program is a research element encompassed by the MMS Office of Offshore Regulatory Programs. The TA&R Program supports research associated with operational

safety and pollution prevention as well as oil spill response and cleanup capabilities. The TA&R Program was established in the 1970's to assess offshore energy industry operations on the Outer Continental Shelf and promote development and incorporation of the Best Available and Safest Technologies (BAST) subsequently required through the 1978 OCSLA amendments.

As part of the TA&R Program initiative, the Operational Safety & Engineering Research (OSER) program is concerned with the evaluation of technological challenges associated with the entire life cycle of offshore energy operations. This mission encompasses:

- Independent verification of emerging technologies (e.g. new materials and practices) in terms of reliability, operational safety and environmental protection;
- Investigation of techniques to best assess, retain or restore the integrity of aging offshore assets;
- Addressing numerous safety and long-term environmental concerns related to decommissioning and removal of assets.

1.5 RESEARCH METHODOLOGY

The research methodology has employed experimental data collection, literature reviews, surveys of state-of-the-art and emerging technology, analytical modeling and advanced finite element modeling. Some projects were conducted by using in-house database, interviewing with industry exporters, organizing workshop and direct comparison etc. The risk assessment in several projects focuses on HSE issues and human factors. The overall objective of those projects is to examine the relevant issues and to quantify them in the context of reliability assessment using state-of-practice methodology. In general the projects summarized in this report are descriptive in nature, outlining lessons learned and provide key recommendations for future technology development and use. In instances where experimental or environmental data was collated and reported, suitable statistical methods have been employed and appropriate mathematical models were developed or used.

1.6 REVISION HISTORY

This is Rev. 02 of the final report for client use.

2 TA&R PROGRAM POST-EVENT HURRICANE DAMAGE ASSESSMENT PROJECTS

2.1 CATEGORY OBJECTIVES

Over the past decade, the U.S. Gulf of Mexico (GOM) has experienced a heightened level of major hurricane activity (Category 4+) crossing the central and western portion of the GOM's offshore Oil and Gas developed region. Many of the hurricanes, including Lili (2002), Ivan (2004), Katrina and Rita (2005), and Gustav and Ike (2008) resulted in significant damage and/or destruction to offshore oil and gas facilities and pipeline. Based on hundreds of offshore energy industry damage assessment reports resulting from each storm, MMS recognized the need to analyze damage assessment reports in order to determine the type, cause and extent of damage and to provide guidance for improving facility and pipeline integrity/design to reduce potential damage from future GOM hurricanes.

2.2 PROJECTS WITHIN SCOPE

TA&R Program funded research following all six of the aforementioned major hurricane events. A total number of 26 studies were performed, some with focus on pre-determined topics to allow MMS comparison between the storms while other topics were chosen to address a particular and unexpected storm-specific event. This report does not capture the work performed for Hurricanes Gustav and Ike since the work was ongoing at the time of this report.

Table 2.1 is a list of all the projects that have been reviewed for this research topic area.

Table 2.1: Post-Event Hurricane Damage Projects in Scope of Work

TA&R Project No.	Project Name
593	Jackup MODUs: Assessment Checksheet for Hurricane Season
591	Evaluate Accuracy of Polyester Subrope Damage Detection Performed by ROVs Following Hurricanes and Other Events
581	Pipeline Damage Assessment from Hurricane Katrina/Rita
580	Hindcast Data on Winds, Waves and Currents During Hurricane Katrina and Rita
578	Assessment of Fixed Offshore Platform Performance in Hurricanes Katrina and Rita

TA&R Project No.	Project Name
559	Offshore Hurricane Readiness & Recovery Conference
553	Pipeline Damage Assessment from Hurricane Ivan
552	Mudslides during Hurricane Ivan and an Assessment of the Potential for Future Mudslides in the Gulf of Mexico
551	Assessment of Drilling and Workover Rig Storm Sea Fastenings on Offshore Floating Platforms During Hurricane Ivan
549	Assessment of Fixed Offshore Platforms in Hurricane Ivan, Andrew and Lili
548	Examination and Review of Mobile Offshore Drilling Unit (MODU) Loss of Station-keeping Ability During Hurricane Ivan and Assessment of Current Mooring Standards and Criteria to Prevent Similar Failures
503	Evaluate and Compare Hurricane-Induced Damage to Offshore Pipelines for Hurricane Lili
469	Post Mortem Failure Assessment of Drilling Rigs During Hurricane Lili
467	Hindcast Study of Winds, Waves and Currents in N. GOM in Hurricane Lili (2002)
466	Validation and Calibration of API-RP-2A Using Hurricane Lili to Update the Hurricane Andrew JIP Results

2.3 STUDY AREA AND ANALYSIS

2.3.1 Hurricane Hindcast Data

In order for MMS to understand the characteristics of each individual hurricane, under TA&R Projects No. 467 and 580, MMS captured the Metocean Data across the GOM region and provided site specific Metocean data to the contractors performing the MMS funded individual studies to allow greater consistency in comparing the results between studies. Study projects covered surface wind field, wave, salinity, sea surface temperature and current field in the GOM during the approach and passage of Hurricane Lili, Katrina and Rita. The results presented in those studies provide a comprehensive, validated and reliable hindcast database which will enable greater accuracy in the design of structures for hurricane loadings.

2.3.2 Hurricane Effects on Mooring Capabilities

Appropriate verification of standards for Mobile Offshore Drilling Unit's (MODUs) in the Gulf of Mexico is an ongoing issue given that the events, against which they are calibrated, such as hurricanes, are rare. In the aftermath of a hurricane there is a unique opportunity to reflect on the events that took place, to chronicle them, and give industry an understanding

of their impact on the standards that the industry considers appropriate in maintaining an envelope of safety for MODUs. Projects. No. 548 and 469 studied the failures associated with the Mobile Drilling Units during Hurricane Ivan and Lili, respectively.

When hurricane Lili passed through a region of fixed oil platforms in September 2003, it provided an opportunity to better understand the performance of fixed based platforms in extreme hurricanes. While a large majority of fixed platforms performed adequately during Lili with no damage reported, a smaller set were damaged significantly and in several cases the platforms collapsed. Extreme hurricanes, such as Lili, that pass through an area of densely populated offshore platforms are rare. The last such event was Hurricane Andrew in 1992, which resulted in the damage of several platforms. Based on the background of hurricane events, the performance of fixed jackets during Hurricane Lili was investigated in Project No. 466.

In addition, Project No. 591 evaluated the accuracy and effectiveness of polyester subrope damage detection processes following hurricanes for offshore structures. ROV inspections are used by the offshore industry to detect damage to polyester mooring systems and estimate remaining fatigue life if damage is found. This work was to address permanently moored floating production systems, rather than Mobile Offshore Drilling Units (MODUs).

2.3.3 Structures

MMS performed TA&R Projects No. 549, 551, and 578 to assess offshore structures damage due to Hurricanes; Ivan, Katrina and Rita. The need for this research study is to address the reasons of why some platforms performed satisfactorily while some others failed during the hurricanes. This research sheds light on the usefulness and recommendations into API RP 2A, which is an industry-wide and accepted offshore platform structural design code.

2.3.4 Geotechnical

Submarine mudslides can be triggered by significant wave-induced pressures on the ocean floor in shallow water (up to about 400 ft) during large hurricanes in the Mississippi Delta region of the Gulf of Mexico. Based on the observation of mudslides caused by Hurricane Camille in 1969, a number research was devoted to developing model to predict the mudslides. The mudslide activities caused by Hurricanes Ivan and Katrina has been

reported in the Mississippi Delta that provided a good opportunity to evaluate the existing models to predict mudslides and to re-examine the Mississippi Delta region that are expected to be vulnerable to mudslides. Project No. 552 aimed to investigate the potential risks of future mudslides in the Mississippi Delta region of the Gulf of Mexico by analyzing the mudslides activities during Hurricanes Ivan and Katrina. In addition, the MMS performed another study, Project No. 559, aimed to assess the performance of the Gulf of Mexico oil and gas infrastructure (MODUs, fixed and floating production systems, and pipelines) during Hurricane Ivan and to evaluate the present design and operational standards, practices, and technology to identify needs and opportunities for improvement. Wave conditions in Hurricane Ivan significantly exceeded those specified in API RP 2A design code.

2.3.5 Pipeline Damage Assessment

In almost all the hurricane events the majority of pipeline failures were near platforms and in mudflow areas. While increased number of instances where pipeline damage resulted by drill rigs that lost station-keeping had been a characteristic of Hurricanes Rita and Katrina, hurricane events crossing the Mississippi Delta region, for example Hurricanes Andrew and Ivan, resulted in a high number of pipeline failures due to soil movement and mudflows. MMS performed TA&R Projects No. 503, 553, and 581 to analyze pipeline damage caused by hurricanes Lili, Ivan, and Katrina/Rita, respectively.

2.4 CONCLUSIONS

The key conclusions of the reports are summarized below for each of the research topic area.

2.4.1 Hurricane Hindcast Data

Hurricane hindcast data is a key input into the design of offshore structures by providing a comprehensive, validated and reliable database of wind, sea state, and currents associated with various weather conditions. To maintain an up to date and accurate record of metocean conditions, it is important to perform hindcast analysis for the major weather events which occur in the Gulf of Mexico, therefore hindcast analysis was performed for Hurricanes Lili, Katrina and Rita.

2.4.2 Hurricane Effects on Mooring Capabilities

Hurricane events in the Gulf of Mexico result in the damage of offshore structures and vessels due to the severity of the metocean conditions. The reports examining mooring and station-keeping failures provided key lessons learned from these events by investigating the failure modes, and aimed to develop the associated standards to reflect these lessons learned. Moreover, the accuracy of subrope damage detection using ROV was found to be sufficient to detect rope jacket damage.

2.4.3 Structures

The structures research projects highlighted the effectiveness and some shortcomings, followed by design recommendations for offshore platforms. The on-site collected data showed that the there are several factors to be considered for the structures that were damaged or destroyed during the hurricanes. There was no loss of lives observed in any of the hurricanes, due to evacuation from the structures. The structures that were found to be damaged or destroyed most often were the low consequence, low rating structures. Overall, the study finding showed that the API RP 2A is a reliable design code for offshore structures of higher ratings.

Figure 2.1: Nabors Dolphin 105 Pre and Post Hurricane Lili Event

2.4.4 Geotechnical

Project No. 552 developed an approach in the framework of probability analyses to evaluate return period of future mudslide occurring by using a simple limit equilibrium model to analyze bathymetric data, soil strength data, and metocean data associated with the reported wave-induced mudslides during Hurricane Ivan and Katrina.

Project No. 559 held an Offshore Hurricane Readiness & Recovery Conference to assess the performance of the Gulf of Mexico oil and gas infrastructure (MODUs, fixed and floating production systems, and pipelines) during Hurricane Ivan and to evaluate the present design and operational standards, practices, and technology to identify needs and opportunities for improvement.

2.4.5 Pipeline Damage Assessment

Studies concluded that at that time of the hurricanes, offshore pipe design approaches in GOM and the industry practices related to human and environmental safety were satisfactory. Major negative impact of Hurricanes was the disruption in oil and gas production due to pipelines and infrastructure damage. In nearly all hurricane events, the major cause of damage occurred at or near the platform and was due to platform movement and/or toppling. For hurricane events crossing the Mississippi Delta region a high number of pipeline failures were impacted by soil movement and mudflows. Localized failures at pipe crossings and excessive pipe movement in shallow waters had been identified as a concern after Hurricane Ivan. During Hurricane Lili small diameter risers in shallow waters were mostly damaged due to bending fatigue as they were not able to span longer distances.

3 TA&R PROGRAM DEEPWATER RESEARCH PROJECTS

3.1 CATEGORY OBJECTIVES

As oil and gas exploration moves into deeper waters, new ideas and technologies are required to meet the challenges associated with exploration and production at these new water depths. The complex geological and logistical challenges associated with deepwater development projects are further complicated by equally complex safety concerns.

Through these research projects, the MMS strives to explore the technologies that can be applied to address the beneficial and detrimental facets of deepwater exploration, and utilize the resources in the best possible way.

Through the TA&R Program Deepwater Research Projects, the MMS strives to:

- Promote safety of operations and protection of the environment and personnel through research and technical assessment of existing and proposed deepwater production systems;
- Identify the need for new technologies and contract with offshore energy industry, government and academic researchers to assist in developing new ideas and solutions.

3.2 PROJECTS WITHIN SCOPE

Table 3.1 is a list of all the projects that have been reviewed for deepwater projects.

Each project report is grouped into specific research areas, which are: Subsea Riser Design, Riser Integrity Management, and Corrosion.

Table 3.1: Deepwater Projects in Scope of Work

TA&R Project No.	Project Name
622	Impact of Marine Growth on Pipeline Risers for Floating Facilities JIP
572	Deepwater Riser Fatigue Life, Modeling & Standard Study
536	Vertical Access Riser Comparative Risk Assessment
531	SCR Integrity Management JIP

TA&R Project No.	Project Name
522	Methodologies for Measuring and Monitoring Hydrogen for Safety in Advanced High Strength Linepipe Steel Applications
510	Seafloor Interaction with Steel Catenary Risers
509	Interstitially Insulated Pipe
500	Risk Comparison of Subsea vs. Surface Processing
497	Probabilistic Reliability and Integrity Assessment of Large-Diameter Compliant Risers for Ultra-Deepwater Operations
496	Design of Cathodic Protection Systems for Deep Water Compliant Petroleum Production Risers
494	New Touch-Down Zone Solutions for Steel Catenary Risers (SCRs)
490	CRA for Composite Drilling and Production Risers
487	An Assessment of Magnetization Effects on Hydrogen Cracking for Thick Walled Pipelines
481	Deepwater Riser VIV Project – Computational Fluid Dynamics (CFD) Simulation of Riser VIV
471	Assessment of Performance of Deepwater Floating Production Facilities

3.3 KEY CONCLUSIONS

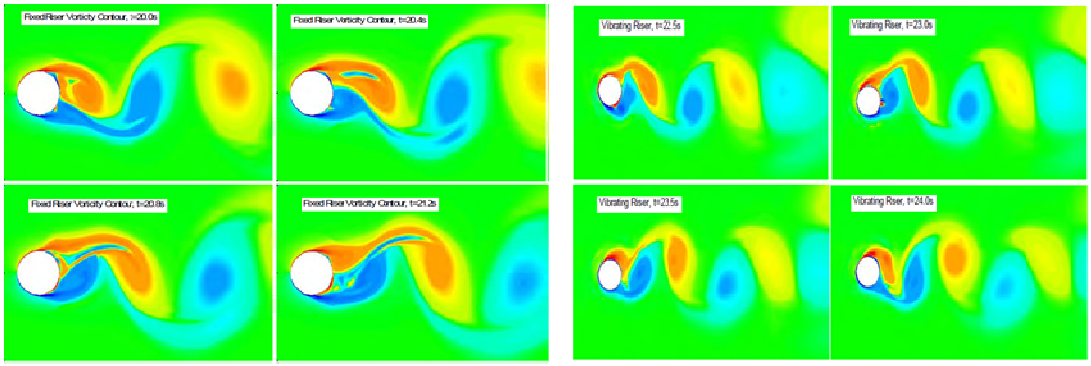
The TA&R Deepwater Research Projects have addressed several deepwater challenges and technologies which may be applied to them. Topics under the deepwater research project have looked at the impact of marine growth on pipeline risers for floating facilities, deepwater riser fatigue life, comparative risk assessment of subsea technologies and assessment of performance of deepwater floating production facilities during extreme events.

The key conclusions of the reports are summarized below for each of the research topic areas.

3.3.1 Subsea Riser Design

The research projects under subsea riser design examined current practices for riser analysis, design criteria, design philosophies, analysis methodologies and alternative riser designs. From the riser fatigue design studies, it was recommended that the practice of designing solutions based on higher level API recommended practices (RP) and Code of Federal Regulations (CFR) be continued. Some Alternative SCR designs such as titanium section for the touch down zone (TDZ) were also successfully brought to a technological

readiness level (TRL). Attempt to predict VIV response of risers in deepwater using advanced Computational Fluid Dynamics (CFD) techniques was also successful although further studies were recommended.



Fixed Riser b) Vibrating Riser

Figure 3.1: Vorticity Contours for Computational Riser Models

3.3.2 Integrity Management (IM)

Deepwater IM projects included Joint Industry Projects (JIPs) for riser IM studies and Comparative Risk Assessment (CRA) studies. The SCR integrity management JIP was an industry sponsored project that produced an easily implemented, transparent risk assessment methodology that is applicable to any engineered system and capable of being adapted to any corporate or regulatory standard. The comparative risk assessment carried out for subsea processing versus topsides processing and Compliant Vertical Access Riser (CVAR) versus conventional Direct Vertical Access Risers (DVAR) showed that overall, these new designs do not present any new risks The identified risks were found in many cases to be similar or less than those experienced in the industry.

3.3.3 Corrosion

The corrosion study carried out was aimed at developing a Cathodic Protection (CP) design protocol for deepwater compliant petroleum production risers. This was accomplished by focusing on existing and newly developed pipeline CP principles and concepts upon the specific geometric and operational aspects of subsea risers.

4 TA&R PROGRAM DRILLING RESEARCH PROJECTS

4.1 CATEGORY OBJECTIVES

Drilling research projects look at a varied range of issues associated with offshore drilling operations, but the primary focus is on the research that relates directly to the regulation of drilling operations. The program seeks out research that helps MMS engineers and supervisors with their day-to-day regulatory responsibilities as well as with understanding the safety issues associated with deepwater operations and new drilling technology. Research topics include the performance and reliability of safety equipment; new and evolving technology and its application to offshore drilling; assessment of various operational problems; and advanced well control techniques.

4.2 PROJECTS WITHIN SCOPE

The projects reviewed for this section are presented in Table 4.1.

Each project report is grouped into specific research areas, which are: High Pressure High Temperature (HPHT), Riser Configuration, Dynamic Well Control, Conductor Casing Integrity, and Blow Out Preventer (BOP) Components and Secondary Intervention Systems.

Table 4.1: Drilling Research Projects in Scope of Work

TA&R Project No.	Project Name
621	High Pressure High Temperature (HPHT) Elastomer Evaluation
606	Hybrid Well Riser Risk of Failure and Prevention
583	Characterizing Material Performance for Design of Sour Service HPHT Equipment in Accordance with API RP 6HP Practices
582	A Probabilistic Approach to Risk Assessment of Managed Pressure Drilling in Offshore Drilling Applications
566	Assessment of the Acceptability and safety of Using Equipment, Particularly BOP and Wellhead Components at Pressures in Excess of the Rated Working Pressure
541	Application of Dual Gradient Technology to Top Hole Drilling
540	Risk Assessment of Surface vs. Subsurface BOP's on Mobile Offshore Drilling Units
519	Drilling and Completion Gaps for High Temperature and High Pressure In Deep Water

TA&R Project No.	Project Name
495	Risk Assessment and Evaluation of the Conductor Pipe Setting Depth On Shallow Water Depths
474	Evaluation of Safety Concerns during Well Testing from OCS Drilling Rigs
463	Evaluation of Shear Ram Capabilities
455	Review of Shear Ram Capabilities
440	Development and Assessment of Well Control Procedures for Extended Reach and Multilateral Wells Utilizing Computer Simulation
431	Evaluation of Secondary Intervention Methods in Well Control
426	Long Term Integrity of Deep-Water Cement Systems

4.3 KEY CONCLUSIONS

The key conclusions of the reports are summarized below for each of the research topic areas.

4.3.1 High Pressure High Temperature Projects

The projects outline the requirements needed for the updating of the standards for HPHT drilling applications, highlighting the need for greater specificity with regard to High Temperature testing definitions. Given the advancement in technologies associated with these applications it was recommended that the MMS supplement the offshore energy industry standards to keep regulations current with best available technologies. The projects also highlight advancements in material development for use in these applications.

4.3.2 Risk Comparison of Riser Configuration

The projects examined the common use and risks associated with riser configurations utilizing surface BOPs. Figure 4.1 shows an illustration of the different BOP systems assessed. These projects draw on operational experience, both in the GOM and in other world locations, from which risk of failure and integrity of the riser system could be assessed. The projects emphasized that a strict eye to safety and maintenance procedures and conservative design parameters should be adopted.

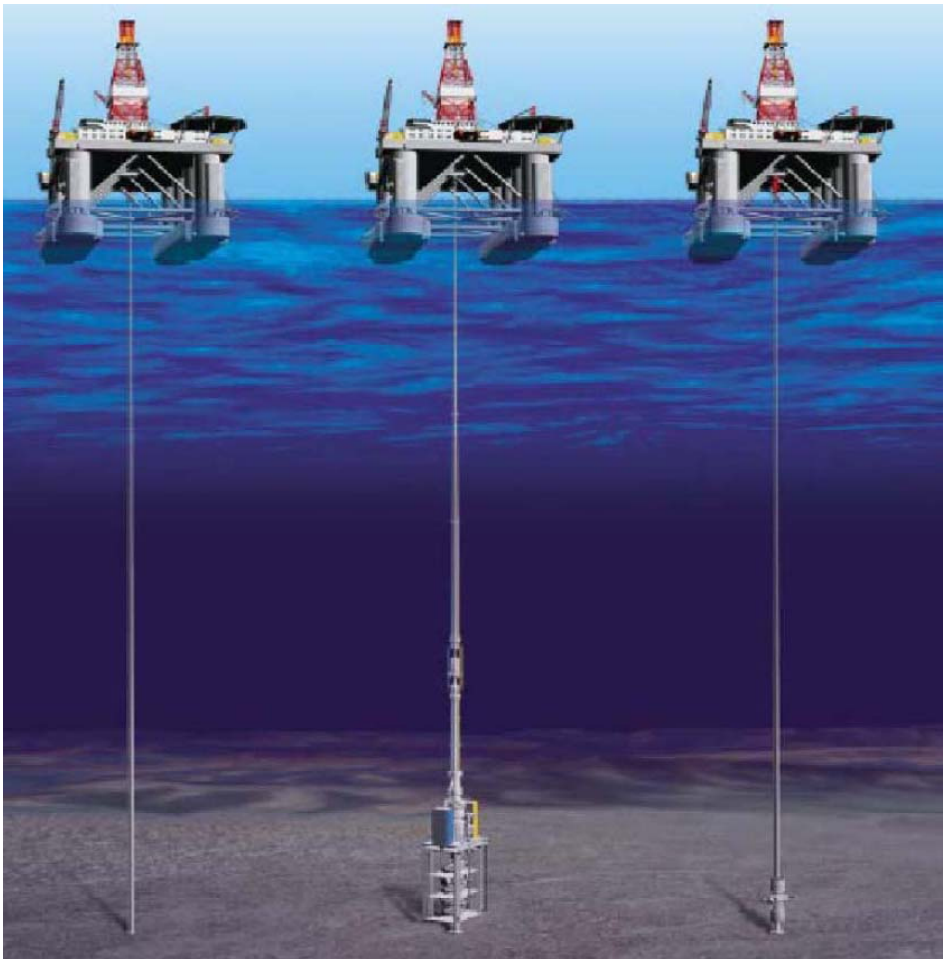


Figure 4.1: Illustration of deepwater drilling with Surface Blow Out Preventer (SBOP), Subsea Blow Out Preventer (BOP), and SBOP with Shut-In Device (SID)

4.3.3 Dynamic Well Control

Given the development of wells with less than favorable conditions, the control of drilling and certainty of well control is becoming more pronounced. The projects show developments in drilling practice to utilize Managed Pressure and Extended Reach Drilling practices, and highlight the probabilistic risks associated with each. Recommended Practices are outlined for the evaluation of safety of well testing from OCS drilling rigs.

4.3.4 Conductor Casing Integrity

Reports on conductor casing integrity outlined the risk assessment and evaluation of conductor pipe setting depth on shallow water wells, giving guidelines as to how to select conductor setting depths. It is recommended that casing depth for conductor casing cannot

be based on tradition, but must be determined for each individual well/platform. The cement compositions to provide well integrity were also determined.

4.3.5 BOP Components and Secondary Intervention Systems

These projects provide a better understanding of the factors governing shear ram capabilities. Equations have been developed to provide a better model of the available shear data than those used by BOP manufacturers. It was found that greater specificity was required in the guidelines to ensure a more uniform testing and results which are more reflective of actual shear values. Recommendations for secondary shear circuits on riser systems are added to mitigate against accidental unlatching at the LMRP.

5 TA&R PROGRAM MOORING AND ANCHORS RESEARCH PROJECTS

5.1 CATEGORY OBJECTIVES

Mooring lines and the associated anchors attach floating offshore oil and gas facilities to the seabed. They could be exposed to strong dynamic forces due to surface conditions and loop currents. To perform under normal and hurricane conditions, certain safety factors require specific attention during the design and construction phases. Ultra-deep water exploration and production has led to new challenges for operators, and new technology, such as the use of polyester ropes, to meet these challenges.

MMS has focused the recent research activities on:

- Safety concepts;
- Possible wear and tear of synthetic ropes;
- Damage survivability;
- Rope fatigue due to repetitive movements;
- Environmental impacts;
- Stress joint concepts (anchoring and upper attachments).

5.2 PROJECTS WITHIN SCOPE

The projects reviewed for this document are presented in Table 5.1.

Each project report is grouped into specific research areas, which are: Wave and Current Energy Generating Devices, Hurricane Hindcast Data, and Anchors.

Table 5.1 Moorings and Anchors Projects in Scope of Work

TA&R Project No.	Project Name
629	Assess the Design and Inspection Criteria and Standards for Wave and Current Energy Generating Devices
628	Assess the Design/Inspection Criteria/Standards for Wave and/or Current Energy Generating Devices
575	Torpedo Piles for Gulf of Mexico Applications
437	Reliability Analysis of Deepwater Anchors

5.3 KEY CONCLUSIONS

The key conclusions of the reports are summarized below for each of the project groupings.

5.3.1 Wave and Current Energy Generating Devices

The conversion of wave and current energy is a new and rapidly developing industry, and as such a greater understanding of this new industry is required as well as the development of suitable standards. The aims of the projects examining these issues are to provide the MMS with an indication of the current level of development of this industry, and the requirements needed to develop a suitable set of standards.

5.3.2 Anchors

Anchors are a central part in maintaining the station-keeping of offshore vessels. Therefore, it is of importance that the understanding and development of anchoring systems is ongoing. The aims of the projects examining these issues are to provide the MMS with an ongoing understanding of developing anchor technology and related standards. Figure 5.1 shows a typical torpedo pile geometry that has been successfully deployed by Petrobras in the Campos Basin in offshore Brazil.

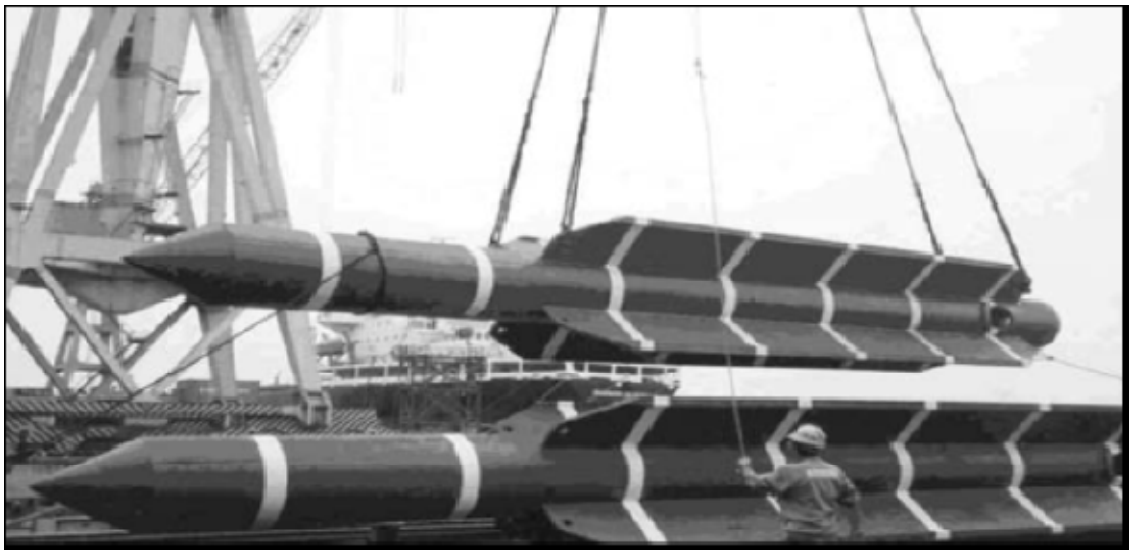


Figure 5.1: Typical Torpedo Pile Geometries as used by Petrobras in the Campos Basin

6 TA&R PROGRAM STRUCTURES RESEARCH PROJECTS

6.1 CATEGORY OBJECTIVES

Oil and gas exploration has evolved rapidly in the last 70 years. There is a vast growth of technology, and engineering innovations are ever expanding. The level of multi-disciplinary engineering sophistication in designing and analyzing the subsea components and structures has faced a high level of demand since the inception of oil and gas exploration under water. Subsea oil and gas revenues amount to about $1/4^{th}$ of the total yearly revenues generated by the United States in the oil and gas industry. Of the subsea infrastructures, the production, drilling and storage platforms play a central role. Their value to the overall success of the infrastructure and service cannot be overestimated.

There are several types of subsea production platforms. The platforms carry the working machinery, riser connections, drilling rigs, crew housing, umbilical connections, controls, and (in few types) storage and handling equipment that is necessary and required for oil and gas production.

Broadly speaking, the offshore platform structures can be classified into: (1) Fixed and (2) Floating. Of the fixed offshore platform structures are the gravity based, jacket, and compliance piled towers. The latter two are constructed of structural members and are installed by piles driven or suctioned into the seabed. The gravity based structures are installed by their heavy weight of concrete, and do not need any other stabilizing support.

On the other hand, the floating structures are supported by inter-balance between the buoyancy and their own weight, together with mooring support. The familiar examples are the tension leg platforms (TLP), spar structures, the semi-submersibles, the floating production and storage (FPS) and the floating production, storage and offloading (FPSO) systems.

The main distinction and decision to use one type of platform over the other is a function of water depth: The gravity based structures are typically used in shallow water (0-1000 ft. of water depth), whereas the floating structures are used in medium to deep water range (1,000 ft. to 5,000 ft. for semi-submersible, TLP, FPSO, whereas from 5,000 ft to 10,000 ft, usually semi-submersible, spars and FPS are the only feasible options).

Through the TA&R Program research projects, the MMS has conducted detailed studies on various platforms and structures, besides other components of the subsea infrastructure. The aim of the research projects is to increase the integrity of the existing and future platforms, as well as innovative technology use to develop space in the subsea for the structures that are no longer productive and have to be decommissioned.

Through TA&R Program Structures Research Projects, the MMS strives to:

- Promote continued safety of operations and protection of the environment and personnel through research and technical assessment of existing and potential offshore production platforms;
- Identify the need for new technologies and contract with offshore energy industry, government and academic researchers to assist in developing new ideas and solutions.

6.2 PROJECTS WITHIN SCOPE

The projects reviewed for this document are presented in Table 6.1.

Each project report is grouped into specific project groupings, which are: Explosive Removal of Offshore Structures (EROS), Assessment of Offshore Structures in Hurricanes, and Integrity Management of Offshore Structures.

Table 6.1: Structures Research Projects in Scope of Work

TA&R Project No.	Project Name
429	Oil Platform Removal Using Engineered Charges: In-Situ Comparison of Engineered and Bulk Explosive Charges
441	Mitigating Green Water Damage Through Design
482	Spar Vortex Induced Motions
488	Global Analysis of FPSO and Shuttle Tanker During Offloading
502	Assessment of New Repair Techniques for Ageing or Damaged Structures
543	Recommended Practice for the Structural Integrity Management of Fixed Offshore Platforms
570	Measurement of the Effect of Depth Below Mudline of Charge Placement During EROS
571	Loads Due to Extreme Wave Crests
609	Reliability vs. Consequence of Failure for API RP 2A Platforms Using API Bulletin 2INT-MET

6.3 KEY CONCLUSIONS

The TA&R Structural Research Projects have addressed several offshore platforms structural design, evaluation and removal challenges and technologies which may be applied to these effects. The projects have also assessed the use of engineered charges for efficient removal of fixed offshore platforms and outlined their advantages over traditional, more massive traditional bulk charges. The projects have studied highly nonlinear and complex wave-structure interactions to understand the mechanics of these phenomena for better design of offshore structures.

The key conclusions of the reports are summarized below for each of the project groupings:

6.3.1 Explosive Removal of Offshore Structures (EROS)

The research projects involved with the removal of fixed offshore platforms through the use of engineered explosive charges discussed the extensive field testing and some quantitative modeling for efficient removal of offshore structures. The experimental research demonstrated the effectiveness of modern engineered charges, their effectiveness in terms of weight to overpressure generated and the environmental friendliness of these charges and associated technology for use in future removal projects.

Figure 6.1: Removal of a Fixed Structure after Explosive Severing onto the Pile

6.3.2 Integrity Management of Offshore Structures

These research projects outline detailed modeling, simulation and experimental verification of complex, nonlinear wave behaviors on offshore structures, as well as the integrity management strategies. The repair materials and procedures for the offshore platforms with respect to integrity assessment are also discussed. The potential application of the research projects in this category is in the safe design, maintenance, and monitoring of offshore structures.

7 TA&R PROGRAM GEOTECHNICAL RESEARCH PROJECTS

7.1 CATEGORY OBJECTIVES

The MMS performs Geotechnical research to improve the techniques and equipment to characterize soil geological, geotechnical, and geophysical properties.

Soil properties are an important factor when determining the placement of offshore energy equipment and facilities. Extensive site investigation and assessment is performed to understand the behavior of soils in terms of:

- Surface and subsurface conditions;
- Physical, mechanical, and chemical properties;
- Associated risks.

Choosing a suitable location is often challenged by limited or outdated geological, geotechnical, and geophysical data. The high cost of obtaining new data limits how much can be obtained and then it requires costly methods for integration of data to optimize its usefulness.

Geohazards, such as submarine mudslides and gas hydrate deposits, present an important risk to cause problems related to offshore drilling and production of oil and gas. A successful design of offshore structures and associated facilities would not be achieved without taking the impact of such geohazards into consideration. Recently, the offshore energy industry has been becoming increasingly aware of the importance of understanding the geohazards and their impact on the offshore structures and associated facilities. The MMS performed a series of geotechnical research projects to characterize and better understand the geohazards of mudslides, gas hydrate deposits, and deep sediment temperature related to thermo-chemical sulfate reduction process. The assessments on these geohazards will help the geological, geotechnical, and geophysical engineers to improve the present techniques and equipments to avoid, reduce and mitigate the risks induced by the geohazards in future offshore oil and gas drilling operations and production.

7.2 PROJECTS WITHIN SCOPE

The projects reviewed for this document are presented in Table 7.1.

Each project report is grouped into two specific research areas, which are: Integrity Management and Reliability, and Verification of Methodology and/or Technology.

Table 7.1: Geotechnical Projects in Scope of Work

TA&R Project No.	Project Name
556	Risk Assessment of Submarine Slope Stability - Hydroplaning
550	A Pilot Study for Regionally-Consistent Hazard Susceptibility Mapping of Submarine Mudslides, Offshore Gulf of Mexico
491	Risk Assessment for Submarine Slope Stability
472	Project Offshore Deep Slope, Phase II, Progress Report
461	Characterizing Natural Gas Hydrates in the Deepwater Gulf of Mexico
432	Regional Synthesis of the Sedimentary Thermal History and Hydrocarbon Maturation in the Deepwater Gulf of Mexico

7.3 KEY CONCLUSIONS

Mudslides, as an important risk, impacted the offshore submarine structure and facilities such as pipelines. A series of TA&R projects (including Projects No. 472, 491, 550, 552 and 556) aimed to obtain better understanding of the mechanics of mudslides and to estimate the potential risks of future mudslides.

The key conclusions of the reports are summarized below for each of the research areas.

7.3.1 Integrity Management and Reliability

In Project No 550, a mudflow susceptibility mapping for Mississippi Delta of Gulf of Mexico (GOM) were developed to delineate mudflow failures, sediments susceptible to future slope failure, and areas of relative stability based on a geomorphic-based approach in which the characteristics of geologic map and mudflow inventory, slope inclination, soil properties, and sediment accumulation rate were taken into consideration. The mechanism of slide hydroplaning were studied in Project No. 491 by successfully constructing a 2-D numerical model to simulate fluid surrounding slide soil mass during hydroplaning. Project No. 556, continued from TA&R Project No. 491, simplified the evaluation results from the 2-D numerical model in Project No. 491 and incorporated them into a developed computer program to simulate the movement of a slide through water. Project No. 472 undertook a series of centrifuge tests to provide experimental comparison and calibration of existing

slope stability analytical methods. Based on the slope failure mechanism verified by the centrifuge tests, a risk-based methodology for determining the probability of submarine slope failure was developed by integrating soil conditions, slope angles, and recurrence of triggering events such as earthquakes.

7.3.2 Verification of Methodology and/or Technology

In Project No. 432, continuous maps of sedimentary temperature at 5 km sub-seafloor and thermal gradient at deep sedimentary interval (2 to 7 km sub-seafloor) were generated for Texas-Louisiana Continental Shelf, Gulf of Mexico, which may be used to estimate the potential risks of the occurrence of hydrogen sulfide (H2S) gas by the thermo-chemical sulfate reduction (TSR) processes in deep reservoirs. The TSR is a series of chemical reactions partly controlled by the reservoir formation temperature. Mapping out or estimating the sediment temperature at depths prior to drilling is an important component in the risk assessment.

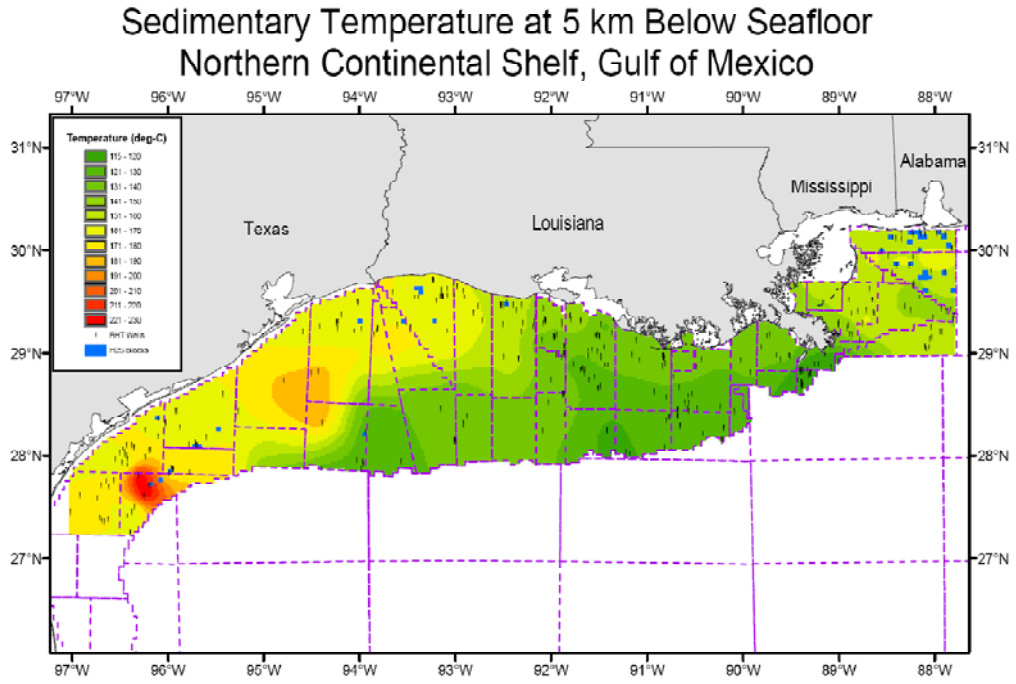


Figure 7.1: Geographically interpolated estimates of sedimentary temperature

Project No. 461 developed the technology and data to assist in the characterization of naturally occurring gas hydrates in the deepwater GOM and investigated the potential impact of gas hydrates on offshore drilling operations and production of oil and gas. The

recent study in this project indicated that the risks associated with drilling through typical GOM hydrate occurrence in fine grained sediments was minimal.

8 TA&R PROGRAM PIPELINE RESEARCH PROJECTS

8.1 CATEGORY OBJECTIVES

As energy developments move into deeper water depths and into new areas (such as arctic environments), pipeline networks for gas and oil transport must follow and overcome new challenges with state-of-the art riser systems and extended capability to handle distant subsea completions and tie-backs. The business climate is demanding innovative pipeline design, installation, and repair options.

Additionally, MMS remains attentive to the needs of existing pipeline operations. There is growing concern for the integrity of pipelines in offshore Federal waters in the wake of the nation's growing dependency of hydrocarbon-based energy and the economic disruptions that often result from disruptions (i.e., hurricane damage) to the steady stream of oil and gas from the Federal offshore. There is also concern over the susceptibility of pipelines to corrosion and third-party damage. Improved inspection, monitoring, and repair systems remain a focus for both existing and proposed pipelines systems.

Through TA&R Program Pipeline Research, the MMS strives to:

- Promote safety of operations and protection of the environment and personnel through research and technical assessment of existing and proposed pipeline systems;
- Identify the need for new technologies and contract with offshore energy industry, government and academic researchers to assist in developing new ideas and solutions.

8.2 PROJECTS WITHIN SCOPE

The projects reviewed for this section are presented in

Table 8.1.

Each project report is grouped into specific research areas, which are: Integrity management and reliability, damage detection and repair methods, and pipeline design methods.

Table 8.1: Pipelines Projects in Scope of Work

TA&R Project No.	Project Name
565	Guidelines for the Integrity Assessment methods of Piggable and Unpiggable Pipelines in the Gulf of Mexico
558	Composite Repair Methods for Steel Pipes
532	Deepwater GOM Pipeline Damage Characteristics and Repair Options
480	An Assessment of Safety, Risks and Costs Associated with Pipeline Removals
454	Safe Design of Hot On-Bottom Pipelines with Lateral Buckling (SAFEBUCK)
442	Intelligent Systems for Pipeline Infrastructure Reliability (ISPIR)
434	Strain-Based Design of Pipelines
433	Evaluation of Methods of Detecting and Monitoring of Corrosion Damage in Risers

8.3 KEY CONCLUSIONS

The key conclusions of the reports are summarized below for each of the research areas.

8.3.1 Integrity Management and Reliability

The projects outline different pipeline systems across the world where the need for guidelines related to integrity management and reliability of pipelines exist. The projects summarize the data collection of over 20,000 miles of subsea pipelines in the GOM, and outline the need for stronger infrastructure for integrity and risk assessment of the existing and abandoned pipeline systems. The projects also address the effective pipeline removal systems and evaluate different novel ideas using subsea structures to remove the abandoned pipelines. The risk assessment and cost related with the pipeline removal systems are also addressed from various leading offshore energy industry contractors and operators.

8.3.2 Damage Detection and Repair Methods

The projects address several damage detection and repair technologies for subsea pipelines and risers. The use of composite coatings for riser repair is discussed with significant testing and theoretical studies encouraging the use of composite coatings under complex loadings imposed on a steel catenary riser. The use of technology to develop advanced computer-based damage detection and monitoring is demonstrated. The intelligent system is capable of performing decisions for operators to diagnose the problems based on data output.

A major factor for riser damage has been identified as corrosion. In general, the research projects conclude that the integrity monitoring and damage detection, as well as insight into understanding the mechanisms of damage, is a key to long service and safety.

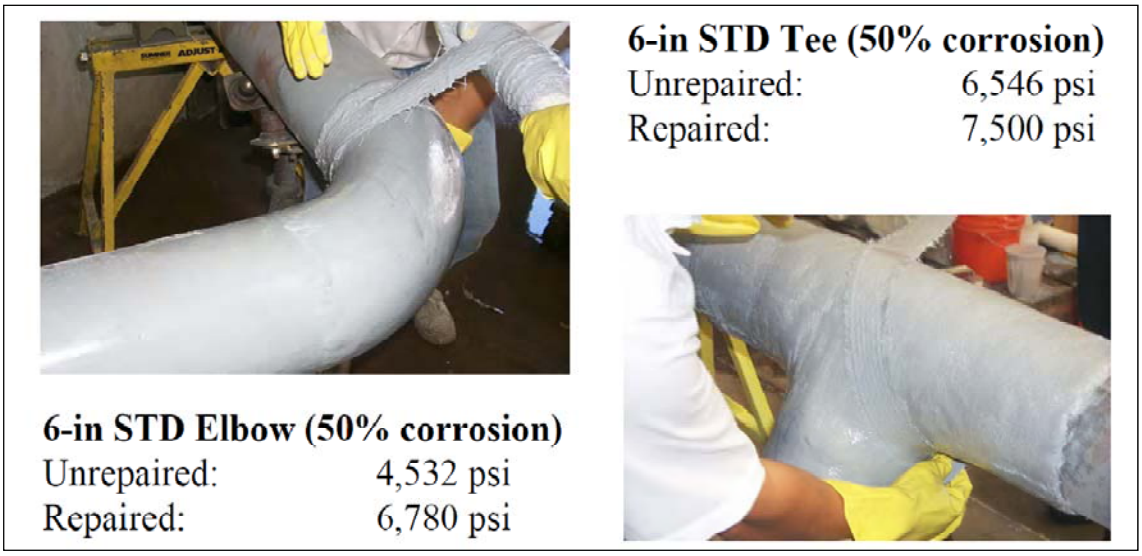


Figure 8.1: Application of Composite Coating on Test Elbows

8.3.3 Pipeline Design Methods

Extensive theoretical and experimental studies of the pipelines show that the strain-based design approach needs to be exercised with deep insight into the critical parts of the pipeline, which are mostly the girth welds and heat affected zones. The pipelines can perform satisfactorily under external hydrostatic pressure, but the account of internal pressure and cyclic loadings due to shut-off and start-up cycles is also critical. In addition, the SAFEBUCK JIP study demonstrates that the pipeline lateral buckling can be mitigated through the use of well-designed mitigation techniques, and has developed design

guidelines for lateral buckling of high temperature pipelines. SAFEBUCK JIP recommends these design guidelines to be appended to API standards for pipeline designs, with the limitations of pipeline sizes and other parameters clearly specified as its scope.

9 TA&R PROGRAM PRODUCTION MEASUREMENT RESEARCH PROJECTS

9.1 CATEGORY OBJECTIVES

The accurate measuring and monitoring of fluid properties is fundamental for assessing the operating environment of offshore assets. Production measurement covers a broad range of applications, such as assessing natural gas quality in terms of water vapor content and hydrocarbon dew point and determining sloshing loads from liquid levels in platform tanks. The information collected from production measurement methods dictate pipe corrosion prevention regimes, confirm compliance with transportation tariffs, detect fluid leakage, and may identify long-term fatigue issues.

Through TA&R Program Production Measurement Projects, the MMS strives to:

- Promote protection of the environment and personnel through research and technical assessment of existing and proposed measuring and monitoring techniques;
- Identify the need for new technologies and contract with offshore energy industry, government and academic researchers to assist in developing new techniques.

9.2 PROJECTS WITHIN SCOPE

The projects reviewed for this section are presented in Table 9.1.

Table 9.1: Production Measurement Projects in Scope of Work

TA&R Project No.	Project Name
533	Development of Accurate Sampling Systems and Methods for Monitoring Water Vapor in Natural Gas Streams
534	Development of Accurate Methods for Predicting Hydrocarbon Dew Points
535	Accuracy of Liquid Level Sensors

9.3 KEY CONCLUSIONS

The TA&R Production Measurement Projects have addressed several fluid measuring and monitoring challenges and technologies which may be applied to them. The key conclusions of the reports are summarized below for each of the projects:

9.3.1 Monitoring Water Vapor in Natural Gas

This research assessed the performance level of existing moisture sampling methods and equipment, such as filters, tubing and heating equipment, which are (1) commonly used by the natural gas industry and (2) recommended by manufacturers for use with moisture analyzers. The research will provide guidance for the possible preparation of an industry standard for moisture determination as a tool to avoid pipeline corrosion.

9.3.2 Predicting Hydrocarbon Dew Points

Evaluate the accuracy of heavy hydrocarbon characterization methods for calculating hydrocarbon dew points (HDP) from compositional data and provide guidance for the preparation of an API standard for calculating HDP.

9.3.3 Accuracy of Liquid Level Sensors

Improve the accuracy of liquid level measurements by providing guidance on selecting the right location for sensors and the appropriate sampling interval; provide practical solutions for analyzing liquid level measurements.

10 TA&R PROGRAM ARCTIC RESEARCH PROJECTS

10.1 CATEGORY OBJECTIVES

As energy developments are moving toward Arctic regions, design considerations for the Arctic unique conditions become important. Estimates of recoverable hydrocarbon indicate that these regions hold approximately 15% and 25% of the world oil and gas reserves, respectively. These resources are typically located in remote areas with limited infrastructure, and there exist significant challenges to progress developments safely while limiting environmental impact. There is also a need to develop schemes which are economically viable and technically reliable.

The arctic conditions have some contrasting features. On one hand, the ice formation on the subsea structures is a source of undesirable externally imposed loads and obstacles that need to be mitigated; on the other hand, artificial ice formation is being explored in the form of man-made ice islands to develop them into drilling and exploration structures in some offshore areas of the world. The problems to the arctic pipelines due to ice gouging, strudel scour, and global buckling have also attracted a large body of research for design recommendations.

Through these research projects, the MMS strives to explore the technology that can be applied to address the beneficial and detrimental facets of the arctic environments, and utilize the resources to the best possible way.

Through TA&R Program Arctic Research Projects, the MMS strives to:

- Promote safety of operations and protection of the environment and personnel through research and technical assessment of existing and proposed arctic production systems;
- Identify the need for new technologies and contract with offshore energy industry, government and academic researchers to assist in developing new ideas and solutions.

10.2 PROJECTS WITHIN SCOPE

The projects reviewed for this section are presented in Table 10.1.

Each project report is grouped into specific research area, which are: Ice formation on structures, arctic pipelines, and exploration and production platforms.

Table 10.1: Arctic Research Projects in Scope of Work

TA&R Project No.	Project Name
601	Seabed Scour and Buried-Pipeline Deformation due to Ice Ridges
597	Assessment of Superstructure Ice Protection as Applied to Offshore Oil Operations Safety: Problems, Hazards, Needs and Potential Transfer Technologies
596	Sea-Spray Icing of Drilling and Production Platforms
584	Exploration and Production Options for Cold Regions of the US Outer Continental Shelf
577	Design Options for Offshore Pipelines in the US Beaufort and Chukchi Seas
538	Controlling Underwater Noise from Offshore Gravel Islands During Production Activities
468	Ice Island Study

10.3 KEY CONCLUSIONS

The TA&R Arctic Research Projects have addressed several challenges and outlined technologies that could be applied to arctic environments. The projects have addressed the ice formation problem which causes icing loads and obstacles on arctic production platforms, the quantitative models to predict ice accretion so as to minimize the ice formation, technologies from various onshore industries that can be applied for ice formation control on offshore structures, the sensitive nature of arctic pipelines to ice gouging, and upheaval buckling problems, as well as design recommendations.

The key conclusions of the reports are summarized below for each of the research areas.

10.3.1 Ice formation on structures

There was an emphasis on and recognition of problems encountered due to ice formation on the drilling and production structures on arctic platforms. The research projects provided practical methods and ways through which ice formation and the associated risks can be minimized. The basic idea is to use de-icing technology from aviation, railroad, and transportation industries, to apply to the offshore arctic environment. The estimate of accretion of ice on various types of structures is developed through quantitative modeling based on sound theoretical principles as well as data collection over a number of years.

10.3.2 Arctic pipelines

The research projects have discussed at length the qualitative and quantitative research on the potential damages to the arctic pipelines due to seabed ice gouging, strudel scouring, and upheaval buckling. The research emphasized the need for development of design guidelines for arctic pipelines against the listed damage mechanisms. This is supported by a number of statistical data collections over the Beaufort and Canadian Arctic Seas. The research also showed CFD-based modeling techniques for ice gouging, which could reduce the simulation time and can be used to obtain preliminary estimate of safe burial depth of the pipeline to minimize damage due to ice gouging.

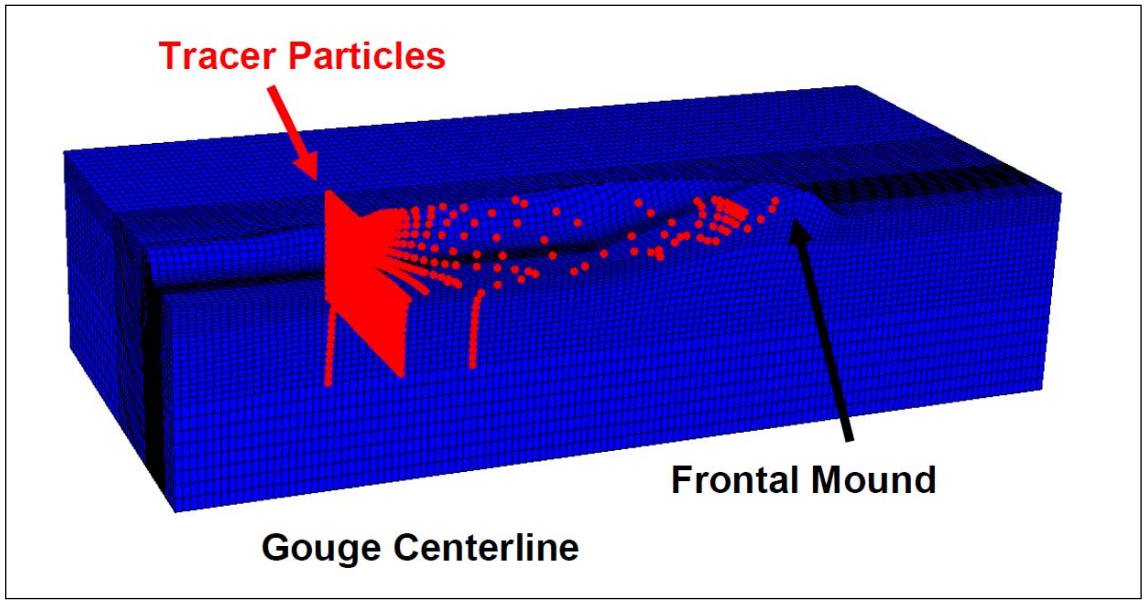


Figure 10.1: Finite Element Ice Gouging Model

10.3.3 Exploration and production structures

Various aspects of exploration and production structures in the arctic regions are discussed. These include the artificial formation of man-made islands, the noise control through underwater structures, and production options for US OCS. The research showed the positive prospects of current technology, as well as the success of current technology towards implementation of already installed structures in Beaufort Sea and Canadian Arctic Seas.

11 TA&R PROGRAM OTHER OSER RESEARCH PROJECTS

11.1 CATEGORY OBJECTIVES

As the offshore energy industry is developing interest in deepwater, the offshore equipment standard & capability, flow assurance, well integrity, risk assessment/risk-based studies become important. Through these research projects, the MMS strives to explore the technologies and methodologies that can be applied to address the protection of offshore facilities, standards and capabilities of offshore equipment, decommissioning options of large platforms etc.

Through TA&R Program Other OSER Research Projects, the MMS strives to:

- Promote continued safety of operations and protection of the environment and personnel through risk based methodologies of existing and proposed offshore production systems;
- Identify the need for new technologies and contract with offshore energy industry, government and academic researchers to assist in extending capabilities of offshore equipment.

11.2 PROJECTS WITHIN SCOPE

The projects reviewed for this section are presented in Table 11.1.

Each project report is grouped into specific research areas, which are: offshore equipment standard and capability, flow assurance and well integrity, and integrity management and risk assessment.

Table 11.1: Other OSER Research Projects in Scope of Work

TA&R Project No.	Project Name
618	Comparative Study of Offshore Wind Turbine Generators (OWTG) Standards
602	Cement Fatigue and HPHT Well Integrity with Application to Life of Well Prediction
579	Joint Industry Project to Study Risk-Based Restarts of Untreated Subsea Oil and Gas Flowlines in the GOMR

TA&R Project No.	Project Name
473	Integration of Human factors within Safety Assessment and Management with Specific Reference to Human Limitations in Response to Automated data inputs from Control Room Management & Monitoring Systems
470	International Workshop on Advances in Research and Development of Coatings for Corrosion Protection of Offshore Oil and Gas Facilities
464	Development of Integrity Methodologies for the Topsides of Offshore Production Facilities
459	Comparative Risk Assessment of the Decommissioning Options for Large Platforms in the POCSR
446	ROV/AUV Capabilities

11.3 KEY CONCLUSIONS

The TA&R Other OSER Research Projects have addressed the offshore equipment standard & capability, flow assurance, well integrity, and risk assessment etc. The key conclusions of the reports are summarized below for each of the research areas.

11.3.1 Offshore Equipment Standard and Capability

The No 618 project was to address design standards needed for the development of offshore wind turbine generator (OWTG) in the United States. The study compared the standards in terms of structural reliability for extreme storm conditions. The comparison started with a generic assessment of each guideline and ended with site specific case studies. The results of the study showed that the IEC and API design methodologies generate similar levels of structural reliability for the conditions included in this study.

The No 446 project was to develop a technical assessment of present and future AUV/ROV capabilities relevant to subsea deepwater oil and gas developments. Improvements that would enhance the reliability and uptime for AUV's and ROV's were identified. The project also identified technology gaps.

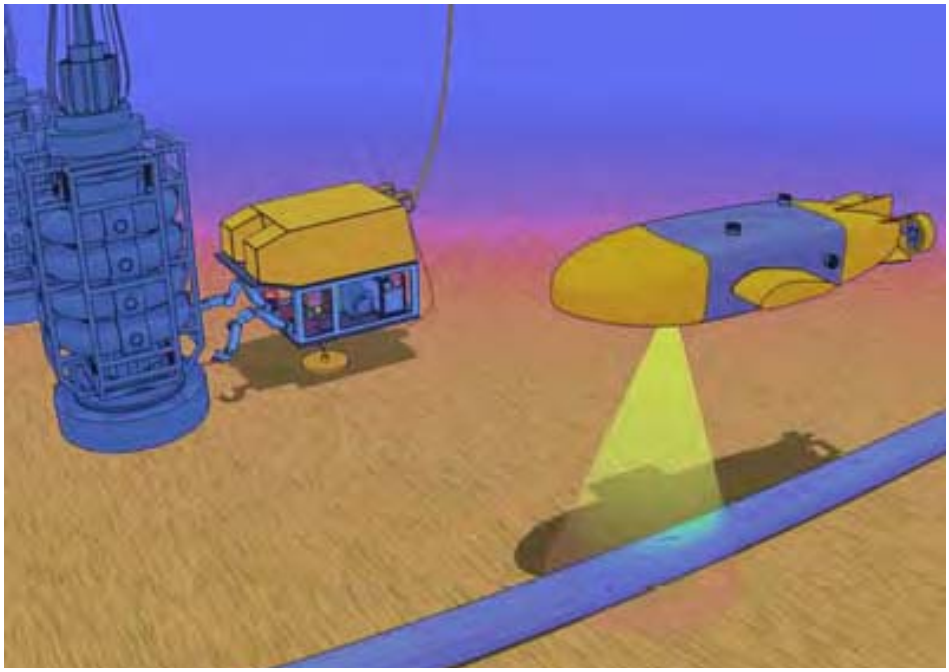


Figure 11.1: Examples of offshore equipment: subsea systems

11.3.2 Flow Assurance and Well Integrity

No. 602 project was to develop a better understanding of the performance of the casing-cement bond under HPHT well conditions, leading to a model to predict well life. This study focused on the effect of both static loading and fatigue behavior of well cement based on analytical and finite element models. The study found that the mechanical properties of cement play a very important role in the static and fatigue performance of cement.

In No. 579 project, experiments were conducted to investigate the effect of restart rate, water cut, liquid loading and oil-water distribution on the plugging tendency of crude oil–water systems upon restarts. This project highlighted some of the key factors involved in hydrate plug formation during production restarts.

11.3.3 Integrity Management and Risk Assessment

Project No. 464 was to develop an engineering methodology for topsides structures, plant and piping integrity management and to integrate the survey/inspection process with existing defect assessment procedures. The consequence of topsides damage or degradation was assessed with respect to safety, the environment, business disruption and reputation.

Topsides structural components and other items that are typically inspected were classified according to the consequence of their failure (A being the highest consequence and E the lowest). These classes have been assigned on the basis of personnel safety and loss of hydrocarbon inventory but not on economic grounds.

Project No. 459 project was to compare the safety risks associated with completely removing three representative platforms from the POCSR. This study provides a Comparative Risk Assessment of the decommissioning options for removing three specific platforms, as directed by MMS. Review of the accident rate data presented in the study and the analysis results point to underwater work with divers as the major risk area.

Project No. 473 was to improve the way in which human factors is integrated within safety management in offshore energy industry. This was achieved through development and validation of the Influence Network (IN) technique.

Project No. 470 undertook a complete assessment of opportunities for research and development of coating practice, coating materials, coating application, repair, non-destructive evaluation, and extended coating life prediction. The recommendations from the workshop offer a clear identification of the research and development issues necessary to create a roadmap for achieving them.