BUREAU OF SAFETY AND ENVIRONMENTAL ENFORCEMENT

Wireline Operations Research Final Report

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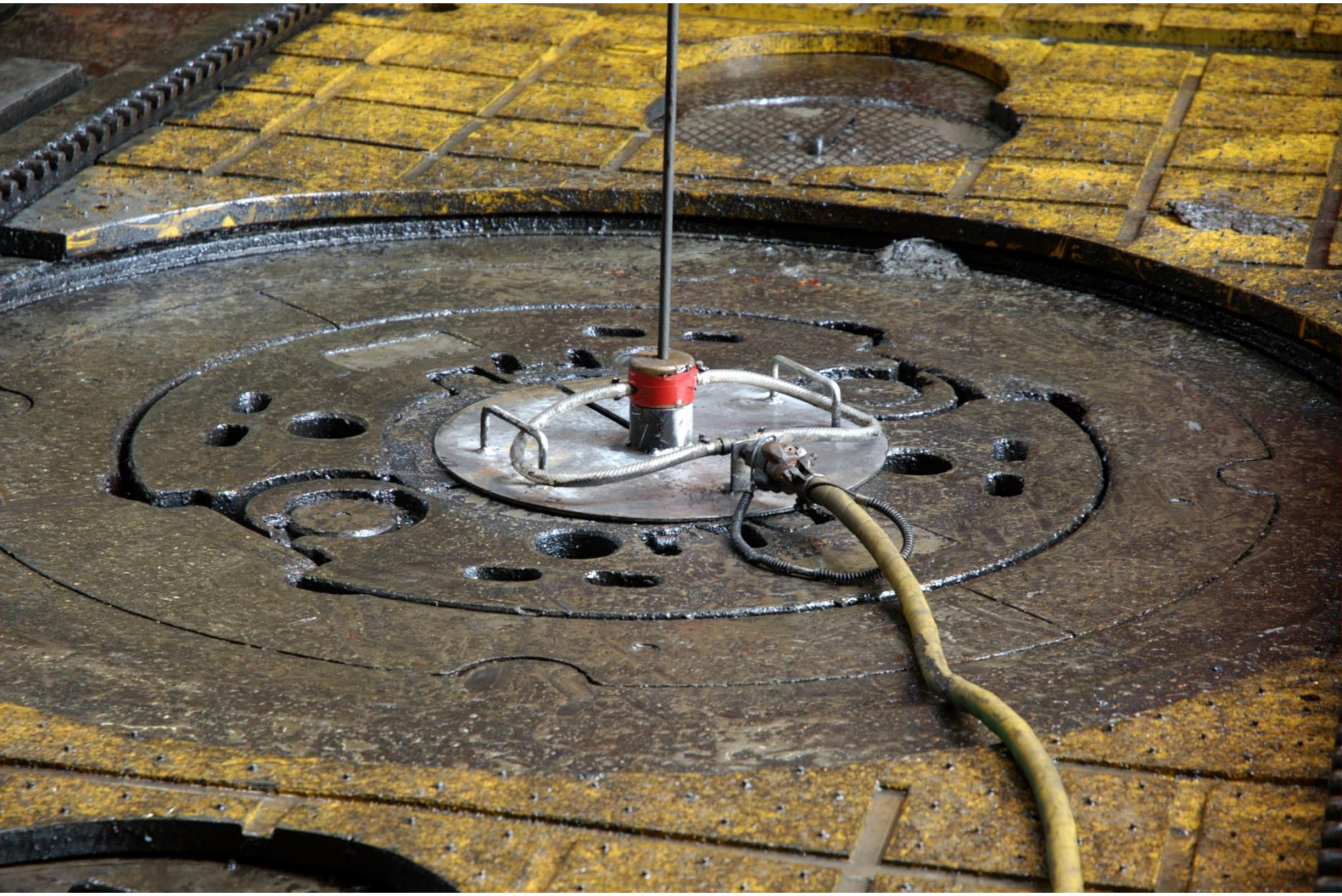

BSEE Bureau of Safety and Environmental Enforcement

Booz | Allen | Hamilton

RPS

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ACRONYMS AND ABBREVIATIONS

AAC	Alaska Administrative Code
ALARP	As Low As Reasonably Practicable
ANP	National Agency of Petroleum (Brazil)
API	American Petroleum Institute
BOP	Blowout Preventer
BSEE	Bureau of Safety and Environmental Enforcement
CFR	Code of Federal Regulations
CNH	National Hydrocarbons Commission (Mexico)
C-NLOPB	Canada-Newfoundland Labrador Offshore Petroleum Board
C-NSOPB	Canada-Nova Scotia Offshore Petroleum Board
DIS	Draft International Standard
DNV	Det Norske Veritas
DNVGL	Det Norske Veritas Germanischer Lloyd
GIT	Grease Injector Tube
HSE	Health and Safety Executive (United Kingdom)
IADC	International Association of Drilling Contractors
IEEE	Institute of Electrical and Electronics Engineers
IRF	International Regulators' Forum
ISO	International Standards Organization
kPa	Kilopascals
MASP	Maximum Anticipated Surface Pressure
MPa	Megapascals
MWP	Maximum Working Pressure
NEB	National Energy Board (Canada)
nm	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Emergency Management Authority
NORSOK	Norsk Sokkels Konkuranseposisjon
NOV	National Oilwell Varco
NZPM	New Zealand Petroleum and Minerals
OD	Outer Diameter
OEM	Original Equipment Manufacturer
PSA	Petroleum Safety Authority (Norway)
psi	pounds per square inch
RP	Recommended Practice
RWP	Rated Working Pressure
SOW	Statement of Work
UK	United Kingdom
UPO	Unintentional Pull-Off
WBE	Well Barrier Elements
WEA	Working Environment Authority (Denmark)
WHE	Wellhead Equipment
WOMP	Well Operations Management Plan

EXECUTIVE SUMMARY

The Bureau of Safety and Environmental Enforcement (BSEE) has a mission to promote safety, protect the environment, and conserve resources offshore. Offshore well blowouts, which are uncontrolled releases of hydrocarbons to the environment, pose a threat to both the safety of offshore workers and the environment. To support BSEE's ongoing mission, this report evaluates best practices for maintaining well control and preventing well blowouts during wireline operations and includes recommendations for updating BSEE's current wireline pressure testing regulations.

Wireline operations are a common method of well operations that involve lowering tools into a well using a wire or braided cable. These tools are used to conduct a variety of functions throughout the various phases of exploration and production activities, including well diagnostics, well perforation, completions, and abandonment. When wireline operations are performed on wells under pressure, pressure control devices, such as wireline rams and wireline lubricators, are used to maintain well control and prevent well blowouts.

To ensure that pressure control devices are capable of maintaining well control and functioning as intended, wireline operators conduct pressure tests on these devices to ensure that they can withstand expected pressures within the well bore. BSEE regulations in Title 30 of the Code of Federal Regulations (CFR) §250.620 require offshore wireline operators to use a lubricator and at least one set of wireline rams for wireline operations where there is communication between the hydrocarbon bearing zone and the well bore, and that the lubricator, once installed on the well, must be pressure tested at the expected surface shut-in pressure. BSEE's regulations are as follows.

> *"Wireline operations*
>
> *The lessee shall comply with the following requirements during routine, as defined in §250.601 of this part, and nonroutine wireline workover operations:*
>
> *(a) Wireline operations shall be conducted so as to minimize leakage of well fluids. Any leakage that does occur shall be contained to prevent pollution.*
>
> *(b) All wireline perforating operations and all other wireline operations where communication exists between the completed hydrocarbon-bearing zone(s) and the well bore shall use a lubricator assembly containing at least one wireline valve.*
>
> *(c) When the lubricator is initially installed on the well, it shall be successfully pressure tested to the expected shut-in surface pressure."*

For this study, the research team (1) conducted a survey of industry wireline operators, service companies, and pressure control equipment manufacturers; (2) researched and conducted a gap analysis of the wireline operations regulations of U.S. states and the member countries of the International Regulators' Forum (IRF) and; (3) recommend updates or revisions to BSEE requirements to ensure safe and consistent pressure testing procedures among wireline operators. This report presents the findings of the industry survey and regulations gap analysis, as well as our final recommendations to BSEE for updating and revising the wireline operations regulations in 30 CFR §250.620.

INDUSTRY SURVEY

A voluntary survey of industry wireline operators was conducted to collect information on current industry standards, procedures, and criteria for successful pressure testing during wireline operations. The surveys were composed of approximately 60 survey questions, with minor differences depending on the specific expertise and operations of the companies.

The survey questions developed and distributed to industry participants were based on the following set of five core questions that were provided by BSEE. The full set of about 60 survey questions was developed to provide additional background and context for these core questions.

1. What pressures are used for both routine[1] and non-routine operations to test the wireline lubricator and wireline rams? Are these well bore pressures or pump pressures? Is it acceptable to test with well bore pressure? If well bore pressure is allowed for testing, when will it be allowed and what safety precautions and barriers need to be in place?
2. Are the lubricator tests being charted? The current regulations do not state that lubricator tests need to be charted. How are operators verifying that the test is successful if the test is not being charted?
3. When are wireline rams used? If wireline rams are used, are the pressure tests being charted?
4. What criteria do operators currently use as a successful pressure test of the wireline rams and lubricator?
5. Most operators are requesting to lower their test pressure to 1,000 pounds per square inch (psi) when wireline pressure control equipment is rigged above a rig blowout preventer (BOP). This is a departure from 30 CFR §250.620(c) to not test to expected shut-in surface pressure when the lubricator is initially installed. The reason operators are requesting this departure is because they say testing to a high pressure will damage their blind shear rams. Is this reason accurate? Is granting this departure a safe practice? Will the blind shear ram of the rig BOP shear and seal on the wireline cable? Compare available original equipment manufacture's (OEM) make, model, and size of blind shear rams for shear and seal. Are the OEM's claims based on physical testing or modelling? What type of damage do operators expect of the blind shear rams due to high-pressure testing?

An example set of survey questions is included in this report in Appendix A.

Nine oil and gas companies were invited to participate in the survey of wireline operations, standards, and practices, particularly those related to pressure testing. This included seven wireline operators, one wireline service company, and one BOP manufacturer. Five companies responded to the survey – four wireline operators and one wireline service company. The other four companies declined to participate in this study.

[1] BSEE regulations in 30 CFR §250.601 define routine operations as follows: "*Routine operations mean any of the following operations conducted on a well with the tree installed: (a) Cutting paraffin; (b) Removing and setting pump-through-type tubing plugs, gas-lift valves, and subsurface safety valves which can be removed by wireline operations; (c) Bailing sand; (d) Pressure surveys; (e) Swabbing; (f) Scale or corrosion treatment; (g) Caliper and gauge surveys; (h) Corrosion inhibitor treatment; (i) Removing or replacing subsurface pumps; (j) Through-tubing logging (diagnostics); (k) Wireline fishing; and (l) Setting and retrieving other subsurface flow-control devices.*"

GAP ANALYSIS OF U.S. STATE AND IRF REGULATIONS METHODS

Oil and gas regulations related to wireline operations of 13 U.S. states with significant oil and gas activity and 9 IRF countries were researched.

U.S. Oil and Gas States

1. Alabama
2. Alaska
3. California
4. Colorado
5. Florida
6. Louisiana
7. Mississippi
8. North Dakota
9. New York
10. Oklahoma
11. Pennsylvania
12. Texas
13. West Virginia

IRF Member Counties

1. Australia
2. Brazil
3. Canada
4. Denmark
5. Mexico
6. Netherlands
7. New Zealand
8. Norway
9. United Kingdom

Relevant laws and regulations were accessed through official government websites of each state or country and searched for rules, regulations, legislation, guidance, or policies related to oil and gas activities applicable to wireline operations. For the IRF countries, BSEE provided contact information to the research team for conducting telephone interviews to validate and expand upon the online research of regulations and policies. Each country contact was sent an email invitation requesting a telephone interview. Interviews were conducted with representatives from Australia, Canada, New Zealand, Norway, and the United Kingdom. A representative from Denmark responded with detailed information via email. The research team was unable to interview regulators from Brazil, Mexico, and the Netherlands.

RESULTS AND DISCUSSION

This section provides a summary of the study findings and resulting recommendations for expanding BSEE's wireline pressure testing regulations in 30 CFR §250.620. Our recommendations are based on the three questions posed in the BSEE statement of work (SOW) under Task 2.

Specify Consistent Testing and Performance Criteria for a Successful Pressure Test

The study results indicate that pressure tests for wireline pressure control devices should be divided into two general categories: field tests, which are performed in the field when the wireline pressure control devices are installed on the wellhead, and shop tests, which occur in a testing facility and are performed periodically (e.g., annually).

The results from U.S. state and IRF country regulations, as well as reported industry practice from the industry survey, indicate that field pressure tests are most commonly performed with a low-pressure test between 200 psi and 350 psi and with a high-pressure test some margin above maximum anticipated surface pressure (MASP). The study results indicate field pressure tests are generally performed when the pressure control equipment is first installed, and after any disconnection and reconnection is made. Most entities researched (i.e., states, countries, companies, or voluntary standards) specified shop pressure tests that are performed periodically (either annually or once every five years) with a low-pressure test between 200 psi and 350 psi and a high-pressure test at or above the equipment rated working pressure (RWP).

For pressure testing when rigged above a drilling BOP, some companies appear to be testing their wireline pressure control equipment only up to 1,000 psi in the field. However, survey participants reported that field test pressure should be determined by the pressures expected in the well bore, *not* the limitations of the BOP blind shear rams. Further, industry participants reported that closing the drilling BOP blind shear rams and subjecting them to more than 1,000 psi from above is also not a safe practice. The blind shear rams are designed to withstand pressure from below, such that pressure forces the rams together, resulting in a tighter seal. Pressure from above will tend to pry the blind shear rams apart, potentially leading to leaks and damaging the sealing surface of the rams. Industry participants offered two potential solutions for testing to appropriate pressures when rigged above a BOP. A test plug can be placed in the well bore below the BOP to create a seal, or a set of inverted blind shear rams could be installed on the rig BOP and closed so that they are subject to pressure from the proper direction during pressure tests.

Determine What Should be Charted and How Long the Pressure Test Must Be Held

Charting is the process of making a record of a pressure recording over time during a pressure test. Charting of wireline pressure control equipment pressure tests can be done with circular, analog charts that make a paper record, or with digital devices whose results can be saved and viewed on a digital device (Recorders Charts & Pens, Inc, 2017). The study results indicate that charting is nearly always performed during shop tests because the equipment is readily available at testing facilities. Therefore, our discussion of charting focuses on whether charting is used during field pressure tests.

Industry survey participants reported using a mixture of digital charts and analog charts, which are typically circular paper charts. The study results show a wide variety of acceptance criteria for successful test pressure holding times and pressure drops. Holding times include 3, 5, 10, and 15-minute periods. Allowable pressure drops also varied and ranged from 0 psi, to a 1% drop, 5% drop, and a 10% drop. This range in practices and requirements suggests that updated BSEE regulations that specify testing procedures and acceptance criteria would be beneficial by creating more uniform practices among industry wireline operators.

Determine When it is Appropriate to Test with Well bore Pressure and What Barriers Needs to Be in Place When Testing

To conduct a pressure test in the field, pressure must be introduced to the bodies of the wireline pressure control equipment. This can be done by either using a surface pump or introducing the equipment to the pressure present in the well bore. While testing with well bore pressure may be technically less complex and less costly, it does not allow for testing above the pressure present in the well bore. Testing above well bore pressure can only be achieved by using a surface pump.

Most of the study results indicate that pressure testing is not performed with well bore pressure, rather it is performed using surface pump-in pressure. In some cases, well bore pressure is used for tests if the initial pressure test has already been conducted with surface pump-in pressure, or if the well bore pressure is particularly low (e.g., less than 5,000 psi). Most entities researched cited the use of wireline rams during any wireline operations under pressure. Wireline rams are not generally used in operations not under pressure, for example when the lubricator is rigged on top of a drilling BOP and kill-weight fluid[2] in present in the well bore.

RECOMMENDATIONS

Recommendations developed from this study are presented in Table ES-1 below. To make recommendations for updating BSEE wireline pressure testing regulations, the research team reviewed

[2] Kill-weight fluid is defined as an amount or density of drilling fluid that provides hydrostatic pressure to prevent the influx of formation fluids into the well bore (Schlumberger, 2017).

the results from the industry survey and the gap analysis of the regulations of U.S. states, IRF countries, and four voluntary consensus standards. In an iterative analysis of results from the survey and gap analysis, the research team considered what policies and requirements are common among regulators, what practices are already common in industry, and how industry can comply with new requirements without an unreasonable burden. We sought to recommend several new requirements for BSEE to consider, so there would be a 'menu' of options from which to choose when considering what new policies to codify in the regulations. We are not recommending that the new proposed procedures below be adopted simultaneously. Rather, we recommend that BSEE consider each change individually and determine which ones should be codified and, if so, on what schedule.

Although many of the recommendations would establish substantive new requirements for industry, it is unlikely that any of the proposed changes present a significant new burden because much of industry (based on the survey responses) is already carrying out most of the recommended policies and procedures presented in Table ES-1below. Overall, our recommendations would make wireline operations more consistent across the industry and bring all operators to a common, higher level of safety.

Table ES-1. Recommendations for Updated BSEE Wireline Pressure Testing Regulations

Category	No.	Recommendation
Pressure Testing	1	**Field pressure tests for wireline rams and lubricators** Conduct field low- and high-pressure tests of the wireline rams and lubricator when installed and after each time a connection is broken. ▪ Low-pressure test at any pressure from 250 psi to 350 psi ▪ High-pressure test 20% above MASP Departures from this requirement should not be granted to allow for testing to only 1,000 psi when rigged above a drilling BOP. When lubricators are rigged above drilling BOPs, operators should either use a test plug or install inverted blind rams in the BOP stack designed to hold pressure from above to allow pressure testing to 20% above MASP.
	2	**Maintenance shop pressure test for wireline rams and lubricators** Conduct low- and high-pressure tests periodically at a pressure test facility. ▪ Low-pressure test at any pressure from 250 psi to 350 psi ▪ High-pressure test at RWP
	3	**Recertification shop pressure test for wireline rams and lubricators** Conduct low- and high-pressure tests annually at a pressure test facility. ▪ Low-pressure test at 250 psi to 350 psi ▪ High-pressure test at 50% above RWP
Charting	4	**Pressure-test charting** All wireline ram and lubricator field pressure tests must be charted, and records of the test results maintained for the life of the well, with the following exception: ▪ For wells with pressure below 1,000 psi, charting is not required; however, operators must document their observation of the pressure tests in a formal record such as a well log ▪ Both analog and digital charts are acceptable records
	5	**Acceptance criteria for pressure tests.** All field pressure tests must be held for a minimum of 5 minutes. ▪ Maximum allowable pressure drop: 5%

Category	No.	Recommendation
Testing with Well Bore Pressure and Required Barriers	6	**Testing with well bore pressure** Lubricators and wireline rams must be tested with a surface pump to a safety margin above surface shut-in pressure for wells with more than 1,000 psi pressure. ▪ Well bore pressure testing is allowable only for wells with surface shut-in pressure of 1,000 psi or less. For these low-pressure wells, the lubricator and wireline rams may be tested to surface shut-in pressure.
	7	**Barriers required for wireline operations** When pressure is present in the well bore, all wireline operations must feature at least one set of wireline rams and one device capable of cutting the wireline cable (e.g., a wireline cutter or a blind shear ram).

1.0 INTRODUCTION

The Bureau of Safety and Environmental Enforcement (BSEE) has a mission to promote safety, protect the environment, and conserve resources offshore. Offshore well blowouts, which are uncontrolled releases of hydrocarbons to the environment, pose a threat to both the safety of offshore workers and the environment. To support BSEE's ongoing mission, this report reviews best practices for maintaining well control and preventing well blowouts during wireline operations and includes recommendations for updating BSEE's current wireline pressure testing regulations.

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For this study, the research team (1) conducted a survey of industry wireline operators, service companies, and pressure control equipment manufacturers; (2) researched and conducted a gap analysis of the wireline operations regulations of U.S. states and the member countries of the International Regulators' Forum (IRF) and; (3) recommend updates or revisions to BSEE requirements to ensure safe and consistent pressure testing procedures among wireline operators. This report presents the findings of the industry survey and regulations gap analysis, as well as our final recommendations to BSEE for updating and revising the wireline operations regulations in 30 CFR §250.620.

1.1 WIRELINE OPERATIONS BACKGROUND

Wireline operations are defined as any oil and gas exploration or production activity that involves lowering a tool into a well bore using a wire or braided cable. While some wireline cables are used only to lower and raise tools through the well bore, wireline cables can also be used to conduct electrical signals from these tools to the surface. Wireline cables can be a single strand or multiple, braided strands. Braided cables are often referred to as wireline, and single-strand cables are referred to as slicklines. This

distinction is often critical as it is a technical challenge to form a pressure seal around the rough, irregular surface of a braided cable and easier to form a seal around the smooth surface of a slickline. (RigZone, 2017)

Wirelines and slicklines are used for a wide variety of purposes throughout the various phases of exploration and production activities, including well diagnostics, well perforation, completions, abandonment, change zone operations, and other operations requiring permitting from BSEE. Slicklines are often used to place and retrieve well equipment such as plugs, gauges, and valves. These functions do not require the transmittal of electronic signals through the wire. Operations that use wireline tools to measure well characteristics and properties are referred to as wireline logging or well logging. Wireline logging tools are lowered into the well bore using a cable and collect data using a variety of methods including electromagnetic and acoustic wave measurements. Wireline logging can measure resistivity, conductivity, formation pressure, temperature, and well bore dimensions.

Wireline operations are also used to perforate wells. Perforation is the process that allows reservoir hydrocarbons to freely flow into the well bore, allowing for production. Perforations are also performed to allow fluid to flow from the pipe into an outer annulus, often for the setting of an abandonment plug. In typical operations, a wireline is used to lower a perforating gun into the well bore. The perforating gun features explosives that, when detonated, generate perforations in the well bore casing, creating a pathway for hydrocarbons to flow into the well bore. (RigZone, 2017)

In a typical configuration, the wireline cable is coiled onto a large drum, then routed through a series of pullies or sheaves into a vertical orientation before entry to the well (see Figure 1). The wireline operator rotates this drum to alternately lower (unspool) or raise (spool) the wireline tool. The cable is typically routed through a lubricator, which is a pressure control device used to initially house the tool string and create a seal between the outside environment and the pressurized environment in the well. The lubricator may be assembled on top of wireline rams (sometimes also referred to as a "wireline valve" or "wireline blowout preventer [BOP]"), which are designed to maintain well control (von Flatern, 2014).

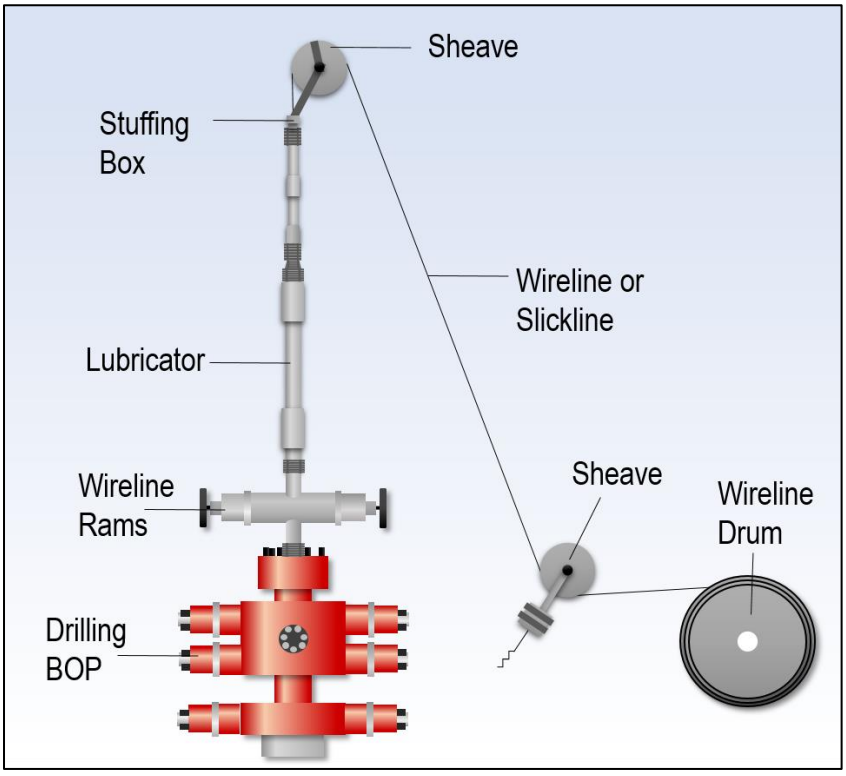

Figure 1. Diagram of typical wireline or slickline configuration

Wireline rams consist of a series of rams, similar to BOP rams; however, wireline rams are often operated manually under low well bore pressure conduction (e.g., 1,000 psi) and can be operated hydraulically for higher well bore pressures. As with BOP rams, there are a variety of designs of wireline rams. Wireline rams feature a small hole remaining when fully closed, which is designed to accommodate the wireline cable and create a seal around the cable (see Figure 2) (NOV, 2017a).

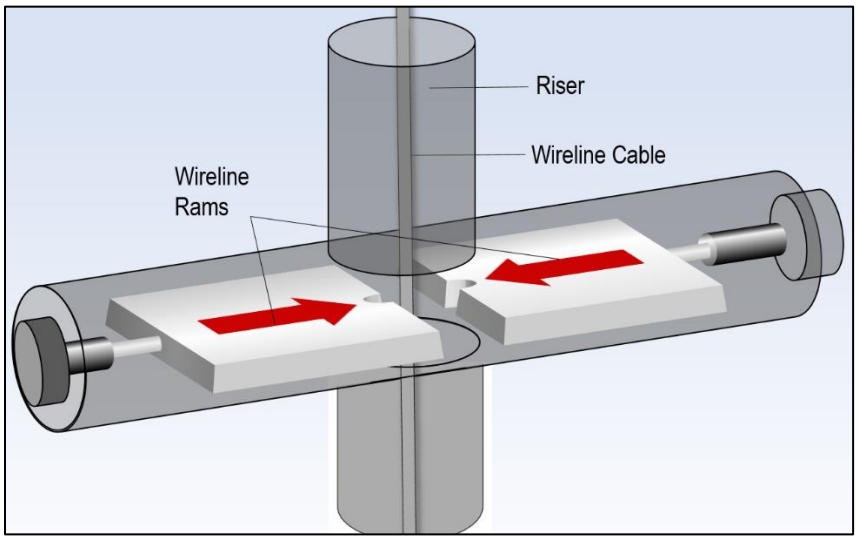

Figure 2. Diagram of wireline rams sealing around wireline. Arrows represents ram sealing motion.

Blind rams are designed to seal completely and cannot accommodate a wireline cable. Blind shear rams (also referred to as shear seal rams) are designed to cut the wireline cable as they close, then completely seal off the well bore (see Figure 3). If wireline blind rams are needed to fully seal off the well bore, some wireline operators use wireline cutters, which are devices designed to cut the wireline cable, allowing the cable and associated tools to fall down the well bore in case of an emergency. Cutting the wireline cable will allow the wireline blind shear rams, or possibly the drilling BOP (if one is present), to close, shutting in the well and preventing a blowout. Wireline pressure control equipment is typically rigged on top of a drilling BOP during the drilling phase and on top of a Christmas tree during the production phase.

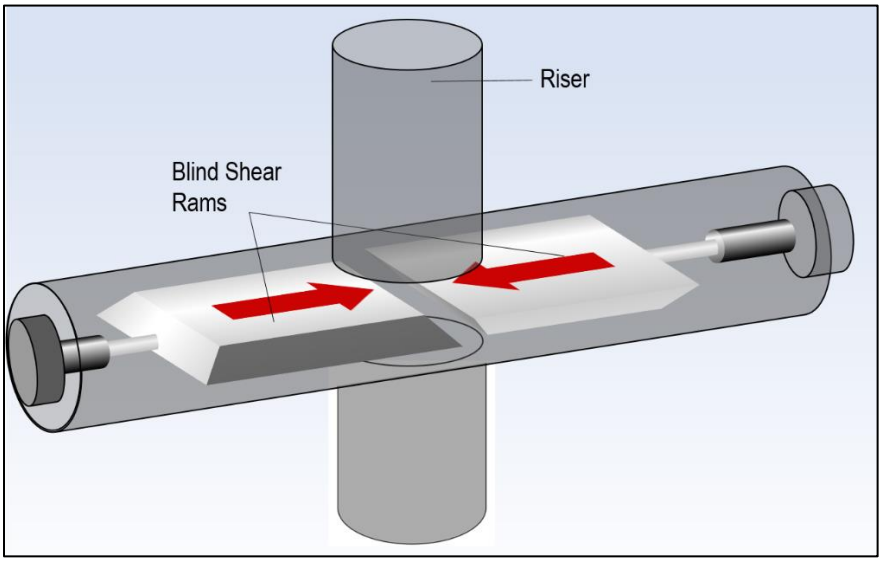

Figure 3. Diagram of blind shear rams. Arrows represent ram sealing motion.

2.0 METHODS

To inform the development of recommendations to BSEE, two separate research tasks were conducted. First, a survey was conducted of wireline operators, service companies, and pressure control device manufacturers. Next, research was conducted on the regulations related to wireline operations for U.S. states and countries of the IRF.

2.1 INDUSTRY SURVEY METHODS

Nine oil and gas companies were contacted to participate in a voluntary survey to collect information on their wireline operations standards and practices, especially related to pressure tests. This included seven operators, one wireline service company, and one BOP manufacturer. A common set of approximately 60 survey questions was distributed to all participants, with minor modifications to some of the surveys to tailor them to the specific expertise and operations of the companies. An example set of survey questions is included in this report in Appendix A. If responses to the surveys were incomplete or unclear to the research team, the industry representatives were contacted directly (by email and telephone) and asked clarifying questions. All industry participation was entirely voluntary.

The survey questions developed and distributed to industry participants were based on the following set of five core questions that were provided by BSEE. The full set of approximately 60 survey questions was developed to provide additional background and context for these core questions:

1. What pressures are used for both routine[3] and non-routine operations to test the wireline lubricator and wireline rams? Are these well bore pressures or pump pressures? Is it acceptable to test with well bore pressure? If well bore pressure is allowed for testing, when will it be allowed and what safety precautions and barriers need to be in place?
2. Are the lubricator tests being charted? The current regulations do not state that lubricator tests need to be charted. How are operators verifying that the test is successful if the test is not being charted?
3. When are wireline rams used? If wireline rams are used, are the pressure tests being charted?
4. What criteria do operators currently use as a successful pressure test of the wireline rams and lubricator?
5. Most operators are requesting to lower their test pressure to 1,000 pounds per square inch (psi) when wireline pressure control equipment is rigged above a rig BOP. This is a departure from 30 CFR §250.620(c) to not test to expected shut-in surface pressure when the lubricator is initially installed. The reason operators are requesting this departure is because they say testing to a high pressure will damage their blind shear rams. Is this reason accurate? Is granting this departure a safe practice? Will the blind shear ram of the rig BOP shear and seal on the wireline cable? Compare available original equipment manufacture's (OEM) make, model, and size of blind shear rams for shear and seal. Are the OEM's claims based on physical testing or modelling? What type of damage do operators expect of the blind shear rams due to high-pressure testing?

Five companies provided responses to the Wireline Operations Survey – four operators and one wireline service company. The other companies that were contacted declined to participate in this study.

[3] BSEE regulations in 30 CFR §250.601 define routine operations as follows: "*Routine operations mean any of the following operations conducted on a well with the tree installed: (a) Cutting paraffin; (b) Removing and setting pump-through-type tubing plugs, gas-lift valves, and subsurface safety valves which can be removed by wireline operations; (c) Bailing sand; (d) Pressure surveys; (e) Swabbing; (f) Scale or corrosion treatment; (g) Caliper and gauge surveys; (h) Corrosion inhibitor treatment; (i) Removing or replacing subsurface pumps; (j) Through-tubing logging (diagnostics); (k) Wireline fishing; and (l) Setting and retrieving other subsurface flow-control devices*."

2.2 GAP ANALYSIS OF U.S. STATES AND IRF COUNTRY REGULATIONS METHODS

Oil and gas regulations of 13 U.S. states with significant oil and gas activity and 9 IRF countries were researched.

U.S. Oil and Gas States

1. Alabama
2. Alaska
3. California
4. Colorado
5. Florida
6. Louisiana
7. Mississippi
8. North Dakota
9. New York
10. Oklahoma
11. Pennsylvania
12. Texas
13. West Virginia

IRF Member Counties

1. Australia
2. Brazil
3. Canada
4. Denmark
5. Mexico
6. Netherlands
7. New Zealand
8. Norway
9. United Kingdom

Both U.S. and foreign regulations were searched for any provisions related to wireline operations pressure testing. U.S. states with onshore operations were researched because BSEE is interested in examining whether policies and regulations from onshore activities, such as drilling for shale gas, could be considered and adopted for offshore operations. Louisiana and Texas were selected for research due the extensive oil and gas resource development in Gulf of Mexico coastal waters of these states. Mississippi, Alabama, and Florida have less offshore activity, compared to Louisiana and Texas, but do have some offshore activities in their state waters. California was selected because of its offshore activity in the Southern California Planning Area, and Alaska was selected for its current offshore activities in Cook Inlet and potential development in the Beaufort and Chukchi Seas. West Virginia, Pennsylvania, and New York were selected for their onshore oil and gas development activities related to the Marcellus Shale play, North Dakota for the Bakken Shale, and Colorado for the Niobara shale.

The IRF describes itself as "a group of 10 countries' regulators of health and safety in the offshore upstream oil and gas industry. It exists to drive forward improvements in health and safety in the sector through collaboration on joint programs and information sharing" (International Regulators' Forum, 2017). The nine IRF countries[4] selected for regulatory review for this project have substantial offshore oil and gas resource development and robust regulatory regimes with policies and standards that BSEE may consider adopting.

All potentially relevant laws and regulations were accessed from the official government websites of each state or country and searched for any regulations, legislation, guidance, or policies related to oil and gas activities generally, and wireline, slickline, well workover, and well intervention activities specifically. Regulations closely related to wireline operations were also reviewed, including some regulations that were not directly related to pressure testing but may be relevant to future BSEE rulemaking activities.

For the IRF countries, BSEE provided contact information to the research team for conducting phone interviews to validate and enhance the online research of regulations and policies. Each country was sent an email invitation for a phone interview, and phone interviews were conducted with representatives from Australia, Canada, New Zealand, Norway, and the United Kingdom. A representative from Denmark

[4] The U.S., represented by BSEE, is a 10th member of the IRF.

provided information via email. The research team was unable to interview regulators from Brazil, Mexico, and the Netherlands.

2.3 METHODS FOR MAKING RECOMMENDATIONS

To make recommendations for updating BSEE wireline pressure testing regulations, the research team reviewed the results from the Task 1 Industry Survey from 5 companies and the Task 3 Gap Analysis of the regulations of 13 states, 9 countries, and 4 voluntary consensus standards. In an iterative analysis of results from the two tasks, the research team considered what policies and requirements are common among regulators, what practices are already common in industry, and how industry can comply with new requirements without an unreasonable burden. We sought to recommend several new requirements for BSEE to consider, so there would be a 'menu' of options from which to choose when considering what new policies to codify in the regulations. We are not recommending that the new proposed procedures below be adopted simultaneously. Rather, we recommend that BSEE consider each change individually and determine which ones should be codified and, if so, on what schedule.

Although many of the recommendations would establish substantive new requirements for industry, it is unlikely that any of the proposed changes present a significant new burden because much of industry (based on the survey responses) is already carrying out most of the recommended policies and procedures presented in Section 3 below. Overall, our recommendations would make wireline operations more consistent across the industry and bring all operators to a common, higher level of safety.

3.0 RESULTS

3.1 INDUSTRY SURVEY RESULTS

This section describes the responses of four operators and one wireline service company to the Wireline Operations Survey. In this report, actual company names are not provided; rather, generic aliases (e.g., "Company A") are used for companies that responded.

3.1.1 SURVEY RESPONSES FROM COMPANY A

Company A is an operator in the Gulf of Mexico.

Lubricator Pressure Testing

In the field, Company A performs a low-pressure lubricator test at 250 psi to 350 psi, and a high-pressure test at 500 psi above the maximum anticipated surface pressure (MASP). The International Association of Drilling Contractors (IADC) defines MASP as:

> *"A design load that represents the maximum pressure that may occur in the well during the construction of the well. NOTE: As with land and shelf wells, the MASP is a surface pressure."* (IADC, 2017)

Lubricators also undergo annual certification tests. Company A does not test using well bore pressure, rather they conduct pressure tests via surface pump. If necessary, they route well bore fluids encountered during wireline operations through the Christmas tree (for wells in the production phase) to a flare or through the lubricator then through a 1502 connection to a gas buster. The operator often uses a quick test sub to facilitate pressure testing during wireline operations.

Wireline Ram Pressure Testing

Wireline rams are always used during wireline operations in which pressure is present. For slickline operations, three sets of rams are used with a shear seal ram on the bottom and two wireline rams above.

For wireline operations (with braided cables), four sets of rams are used. The bottom ram is a shear seal ram, above that is an inverted ram, followed by two wireline rams. Grease is pumped through the wireline rams to create a seal between the wireline rams and the braided cable.

During field pressure tests, the shear seal rams are pressure-tested from below to ensure that they are able to hold pressure. Field pressure tests involve a low-pressure test and a high-pressure test identical to the lubricator pressure testing. In the field, Company A function tests the wireline rams without pressure. The wireline rams are function tested under pressure in the annual certification tests. Pressure tests are considered successful if there is no pressure drop over the course of the test.

During shop tests, a smooth rod is placed between the wireline rams to simulate the presence of a wireline cable or slickline.

Charting

Lubricator pressure tests are charted using circular charts, and the charts are stored in a file dedicated to information on a particular well. These files are maintained and updated throughout the life of the well. Company A uses digital charts for pressure tests for drilling BOPs and coiled tubing BOPs, but uses analog charts for pressure tests for wireline lubricators.

Pressure tests for the wireline rams are charted on circular, analog charts, and are stored in the well file, just as the lubricator test charts are stored.

Use of Pack-Offs

Dual wireline pack-offs are also used, are subject to a low-pressure test of 250 psi to 350 psi and a high-pressure test of 1,000 psi in the field, and are pressure tested to their rated working pressure (RWP) during shop recertification tests.

Rigging Above a Drilling BOP

When wireline pressure control equipment is rigged on top of a drilling BOP, Company A closes the blind shear rams on the BOP in order to form a pressure seal below the lubricator and wireline rams for purposes of pressure testing via surface pump. Company A reports that they only pressure test to 1,000 psi in these circumstances because BOP manufacturer guidelines specify that the blind shear rams can only withstand 1,000 psi of pressure from above. BOP blind shear rams are manufactured and optimized to withstand pressure from below. Company A reported that they do not know what damage would be incurred to the blind shear rams if they are subject to more than 1,000 psi from above.

Company A has tested whether blind shear rams on rig BOPs are capable of severing wireline cables but did not provide the outcome of those test results. They use wireline cutters in every wireline operations configuration in case the cable must be severed to close the BOP rams.

Finally, Company A reports that they have been investigating the use of a plug that will allow pressure testing above 1,000 psi when rigging on top of a drill BOP. See Table 1 for a summary of survey responses for Company A.

Table 1. Summary of Company A Survey Responses

Equipment	Company Response
Testing with Well Bore Fluids	Does not test with well bore pressure
Lubricator Field Test	Low-pressure test at 250 psi to 350 psi High-pressure test at MASP + 500 psi

Equipment	Company Response
Lubricator Shop Test	Certified annually
Wireline Ram Field Test	Low-pressure test at 250 psi to 350 psi High-pressure test at MASP + 500 psi
Wireline Ram Shop Test	Certified annually
Charting	Lubricator and wireline ram tests recorded with circular, analog charts
Testing Above Rig BOP	BOP manufacturers recommend not exceeding 1,000 psi above blind shear rams

3.1.2 SURVEY RESPONSES FROM COMPANY B

Company B is an operator in the Gulf of Mexico.

Lubricator Pressure Testing

Company B reports that lubricators are subjected to a low-pressure test at 250 psi and a high-pressure test at 500 psi above MASP in the field when the lubricator is initially installed on the wellhead. For subsequent tests, when the connection is broken, a quick test sub is used to perform the pressure tests. Annual certification tests are the responsibility of the equipment vendor and are performed by a third-party at their own test facilities. Company B does not test using well bore pressure. They perform field pressure tests via surface pump. When a wireline run is finished and the well is shut-in, they bleed off any remaining pressure to a tank with a gas buster, which also features a flare stack.

Wireline Ram Pressure Testing

Wireline rams are always used during wireline operations, and the rams are typically only closed if there is a failure in the stuffing box or during fishing operations. The rams are pressure tested offshore in the field using a low-pressure test at 250 psi to 350 psi and a high-pressure test at 500 psi above MASP. The wireline rams are not function tested offshore. They are pressure tested onshore using an appropriate cable to seal the closed wireline rams. Annual certification tests are the responsibility of the equipment vendor and are performed by a third-party at their own test facilities.

Company B's standard wireline ram configuration features four rams, has an RWP of 15,000 psi, and has a 5 and 1/8th inch connection. The configuration has two sets of upright wireline rams, a set of inverted wireline rams, and a set of blind shear rams. Different configurations can be used depending upon local well conditions. The blind shear rams are typically only used if the wireline rams fail.

Charting

Company B uses both digital and circular, analog charts for lubricator pressure tests. These charts are stored at the well site so they can be accessed in case of a BSEE audit, and are also stored on a digital server.

Tests of the wireline rams are also charted. The BSEE regulations 30 CFR §250.737(c) are used as guidance for the charting methods:

> *"Duration of pressure test. Each test must hold the required pressure for 5 minutes, which must be recorded on a chart not exceeding 4 hours. However, for surface BOP systems and surface equipment of a subsea BOP system, a 3-minute test duration is acceptable if recorded on a chart not exceeding 4 hours, or on a digital recorder. The recorded test pressures must be within the middle half of the chart range, i.e., cannot be within the lower or upper one-fourth of the chart*

range. If the equipment does not hold the required pressure during a test, you must correct the problem and retest the affected component(s)"

Use of Pack-Offs

Wireline pack-offs are tested during the primary lubricator test.

Rigging Above a Drilling BOP

Company B reports that BOP blind shear rams are not designed to withstand pressure greater than 1,000 psi from above. If pressures more than 1,000 psi are exerted from above, the rams may leak but will not incur permanent damage. Company B also reports that it is not a safe practice to only test the wireline pressure control equipment to 1,000 psi. The equipment must be tested at 500 psi above MASP to ensure safe operations.

Company B reports that the blind shear ram of the BOP can successfully sever a wireline cable and then seal and shut-in a well, and this capability is supported by tested from the BOP manufacturer. Company B does not use wireline cutters. See Table 2 for a summary of survey responses from company B.

Table 2. Summary of Company B Survey Responses

Equipment	Company Response
Testing with Well Bore Fluids	Does not test with well bore pressure
Lubricator Field Test	Low-pressure test at 250 psi High-pressure test at MASP + 500 psi
Lubricator Shop Test	Annual shop tests are performed by a third party secured by the equipment vendor
Wireline Ram Field Test	Low-pressure test at 250 psi to 350 psi High-pressure test at MASP + 500 psi
Wireline Ram Shop Test	Annual certification tests are performed by a third party secured by the equipment vendor
Charting	Lubricator and wireline ram tests recorded with circular, analog charts
Testing Above Rig BOP	BOP blind shear rams are will leak if subjected to more than 1,000 psi from above. This is not a safe practice, as the high-pressure test should always be performed at MASP + 500 psi.

3.1.3 SURVEY RESPONSES FROM COMPANY C

Company C is an operator in the Gulf of Mexico.

Lubricator Pressure Testing

When lubricators are initially installed, Company C tests to 500 psi to 1,000 psi above surface shut-in pressure via surface pump. Subsequent pressure tests are performed any time the lubricator is disconnected and reinstalled, and these pressure tests are performed using well bore pressure.

When bleeding down lubricators after any operation, two possible procedures are used: (1) if possible, the lubricator and contents are bled down through a flowline to the vent system, or (2) if the vent system/flowline is not operational, a metal, grounded bucket is used to collect any liquid hydrocarbons

and gas is vented locally. The area around the lubricator is considered a classified area and any equipment in that area is required to meet the electrical classification standards.

Lubricators undergo annual certification tests by a third party using American Petroleum Institute (API) Recommended Practice (RP) 54. API RP 54 states that the wireline lubricator and wireline rams should be pressure tested every 12 months at a minimum to the equipment's RWP. (API, 1999)

Wireline Ram Pressure Testing

Wireline rams are always used during wireline operations. For RWPs greater than 10,000 psi, Company C typically uses two wireline rams at the base of the lubricator above a conventional tree swab valve. For equipment rated at 15,000 psi, three sets of wireline rams are used. The wireline rams are pressure tested along with the lubricator and are, therefore, tested at 500 psi to 1,000 psi above surface shut-in pressure via surface pump, then are tested at well bore pressure during subsequent tests when the lubricator is disconnected.

As with the lubricator, wireline rams undergo annual certified pressure tests by third parties using API RP 54. The certification test includes function testing of the wireline rams. Wireline rams are tested in the open and closed position. Pressure tests are held to the test pressure for three minutes, pressure is lowered to zero, then pressure is increased to the test pressure once again and held for three minutes.

The wireline rams are not function tested in the field, and Company C does not use a blind shear ram in their wireline ram configurations.

Charting

Lubricator pressure tests are not charted but are recorded on the daily activity report per the BSEE regulations in 30 CFR §250.743. To ensure that pressure tests are successful, a visual inspection of the pressure control equipment is done during the pressure tests, and a pressure gauge is monitored to ensure that tests pressures are maintained over the course of the test. Pressure tests of the wireline rams are not charted.

Rigging Above a Drilling BOP

When rigged on top of a BOP for wireline operations, Company C closes the blind shear rams and pressure tests to 1,000 psi because the blind shear rams cannot withstand pressure greater than 1,000 psi from above. Company C noted that when rigged above a BOP, it is not possible to test to MASP. To compensate for this, Company C uses kill-weight fluid in the well bore as an additional well control measure and has never had a well control incident while conducting wireline operations through a BOP. See Table 3 for a summary of results from Company C.

Table 3. Summary of Company C Survey Responses

Equipment	Company Response
Testing with Well Bore Fluids	Surface pump pressure is used for the initial field test. Subsequent field tests use well bore pressure.
Lubricator Field Test	500 psi to 1,000 psi above surface shut-in pressure.
Lubricator Shop Test	Annual certification tests are performed by a third party following API RP 54. Low-pressure test at 200 psi, high-pressure test at 1.5 × RWP
Wireline Rams Field Test	500 psi to 1,000 psi above surface shut-in pressure.
Wireline Rams Shop Test	Annual certification tests are performed by a third party following API RP 54

Equipment	Company Response
Charting	Lubricator and wireline ram tests are not charted
Testing Above Rig BOP	These pressure tests are performed at 1,000 psi, as testing to MASP is not possible. Kill-weight fluids are used in the well bore during these operations to compensate for this.

3.1.4 SURVEY RESPONSES FROM COMPANY D

Company D is an operator.

Lubricator Pressure Testing

Company D tests lubricators in the field to 20% above MASP using surface pump pressure. If there is a need to release well bore fluids, such as at the end of operations, they are released through a bleed sub or a pump-in sub. Well bore pressure is not used for tests. Shop tests are performed every six months in the shop, during which time the lubricator is subject to a low-pressure test at 250 psi to 350 psi, and a high-pressure test at the RWP. For these pressure tests, the target test pressure is held for 15 minutes, and the test is considered successful if the pressure drops less than 1% over the test period.

Wireline Ram Pressure Testing

Company D uses wireline rams for all wireline operations that are under pressure. The pressure tests conducted for wireline rams are the same as those performed for lubricators. Field pressure tests are performed at 20% above MASP using surface pump pressure. Shop tests are performed at least every six months with a low-pressure test at 250 psi to 350 psi and a high-pressure test at the equipment RWP. When pressure testing the wireline rams, a solid rod is used to seal the space between the slots in the wireline rams designed to accommodate the wireline cable.

Company D reports that testing with a solid rod has resulted in successful tests and safe operations in the field. Solid rods are used rather than braided cables because there is so much variation in the shape and structure of braided wirelines due to the wear and "seasoning" that is caused by repeated use. Unless shop tests could be conducted with the same wireline that would be used in the field (which is impractical), testing of a braided cable in the shop would not simulate field conditions. Function tests of the wireline rams are performed both in the field and in the shop and involve opening and closing the rams without pressure. For these pressure tests, the test pressure is held for 15 minutes, and the test is considered successful if the pressure drops less than 1% over the test period.

Charting

Both lubricator and wireline ram tests are charted during field tests and shop tests. Chart recorders are either electronic transducer driven (with a 12-month calibration cycle) or chart recorder/paper (with a 6-month calibration cycle). For field tests, a copy of the pressure test chart is saved to a dedicated file. For shop tests, hard copies are stored at the office and scans are made of the hard copy charts to create electronic copies, which are stored in a database. All charts are maintained for two years beyond the life of the equipment.

Rigging Above a Drilling BOP

Company D responded that they pressure test wireline equipment rigged on top of BOPs per the direction of their customers, and did not provide any typical pressure testing methods for this scenario. A summary of Company D's responses is presented in Table 4.

Table 4. Summary of Company D Survey Responses

Equipment	Company Response
Testing with Well Bore Fluids	Company D does not test with well bore pressure
Lubricator Field Test	Low-pressure test at 250 psi to 350 psi High-pressure test at 20% above MASP
Lubricator Shop Test	Low-pressure test at 250 psi to 350 psi High-pressure test at equipment RWP
Wireline Ram Field Test	Low-pressure test at 250 psi to 350 psi High-pressure test at 20% above MASP
Wireline Ram Shop Test	Low-pressure test at 250 psi to 350 psi High-pressure test at equipment RWP
Charting	Lubricator and wireline ram pressure test are charted in the field and in the shop with either electronic charts or circular, analog charts. Charts are saved for two years beyond the life of the equipment.
Testing Above Rig BOP	Test according to customer direction

3.1.5 SURVEY RESPONSES FROM COMPANY E

Company E is a wireline and slickline service company. Company E submitted significantly more detailed information than other industry survey participants. To present this information, this section features additional subheadings that are not present in other company response sections.

Lubricator Pressure Testing

Lubricators are tested both in the field and in the shop. Field pressure tests are performed when the lubricator is first installed on the wellhead and involve a high-pressure test 20% above MASP. No low-pressure test is performed in the field.

Shop test pressures vary depending upon the RWP of the equipment. For equipment with RWPs above 5,000 psi, pressure tests in the shop are performed at a pressure 50% above the RWP of the equipment. For equipment with RWPs of 5,000 psi or below, the high-pressure test is performed at double the RWP. There is no low-pressure test performed in the shop.

The pressure values shown in Table 5 below were provided by Company E and show the shop test pressures for typical RWPs. The middle column shows the highest allowable MASP for a given equipment RWP (based on the assumption that equipment must be tested to 20% over MASP, and the test pressure should not exceed the RWP). For example, if a well's MASP is 8,000 psi, equipment rated to 10,000 psi can be used. If the well's MASP is 9,000 psi, then equipment rated to 15,000 psi must be used. This middle column is particularly useful as pressure control equipment is typically only available from the manufacturer at the standard RWPs shown below.

Table 5. Test pressures and maximum acceptable MASP for example RWPs

Equipment RWP (psi)	Highest Acceptable MASP (psi)	Shop Test Pressure (psi)
20,000	16,666	30,000
15,000	12,500	22,500
10,000	8,333	15,000
5,000	4,166	10,000
3,000	2,500	6,000

Lubricator shop pressure tests are performed at the following times:

- When the lubricator is initially received from the manufacturer
- Annually in what is referred to as a "quality check"
- Every five years in what is referred to as a "major recertification," which is performed by the original lubricator manufacturer and a third-party certifier
- After replacement of major pressure-containing components

Shop Pressure Test Methods

Lubricator shop pressure tests are conducted as follows:

- The lubricator is filled with a non-compressible fluid (typically water or glycol) and all air is bled from the system
- Pressure is increased slowing until test pressure is reached and is stable
- The lubricator and pressure gauges are isolated from the pressure source and the pressure is held for five minutes
- Pressure is reduced to ambient pressure, then the pressure test is repeated using a pressure hold time of fifteen minutes

The shop pressure tests are considered successful if the following conditions are met:

- There is no visible leakage during the pressure holding period
- Pressure does not drop by more than 5% of the test pressure or 500 psi (whichever is lower) during the pressure holding period

Testing with Well Bore Pressure

Pressure testing using well bore pressure is only allowed under the following conditions:

- During a cased well production logging operation in a known developed field
- No hydrogen sulfide gas is present
- Actual wellhead pressure at rig up time has already reached MASP
- Wellhead pressure is less than 5,000 psi

Equalization testing must only be done by a hose bypassing the swab valve if possible. If well bore pressure can be introduced without passing through the swab valve, then pressure should be increased at a maximum rate of 1,000 psi per minute. Exceeding this value may result in cable damage and an unintentional pull-off (UPO).

When pressure testing is performed with well bore fluids, the pressure test cannot be performed to 20% above MASP (by definition, MASP is the greatest pressure available). To compensate for the additional

risk introduced by not testing above MASP, the equipment must have been shop tested to its RWP within the last three months.

Well Bore Pressure Testing Methods

Pressure tests with well bore pressure are conducted in the following order:

- If a tool trap is being used, the operator slacks off after the wireline tool string passes the tool trap, and rests the wireline tool string on the tool trap. This method prevents placement of the tool in the tool catcher.
- If there is no tool trap, or if the wireline tool string is longer than the lubricator, the operator bumps the cable until the top of the tool contacts the top of the riser.
- The operator bumps up one final time with very little force to ensure the tool string is caught.
- The operator counts the number of wraps on the cable drum.
- The operator slacks some cable to ensure the tool is in the tool catcher.
- After verifying that the entire tool string is within the lubricator, the operator verifies which valve is to be closed, and:
    - If manually operated, the operator closes the swab valve slowly and counts the number of turns;
    - If hydraulically operated, the operator verifies the closing method and confirms against gauge pressures, strokes pumped, or volumes returned.
- The operator bleeds off the pressure from the wellhead equipment (WHE) through the surface manifold with two pathways if applicable.
- The operator ensures that the well is closed and the pressure gauge on the wireline rams reads zero.
- The operator opens the bleed or dump port on the wireline rams manifold fully, and ensures that pressure is released.

Qualifications of Third-Party Certifiers

There are several levels of pressure control training. Shop tests must be performed under the supervision of a Maintenance Supervisor certified with the requirements below. Maintenance personnel must:

- Possess a Level 2 Wellhead Equipment 10K Pressure certification; and
- Satisfactorily complete an approved specific WHE maintenance course.

Wireline Ram Pressure Testing

Company E uses wireline rams any time there is pressure in the well bore. Company E provided Figure 4, which demonstrates various configurations of wireline rams and associated risk levels.

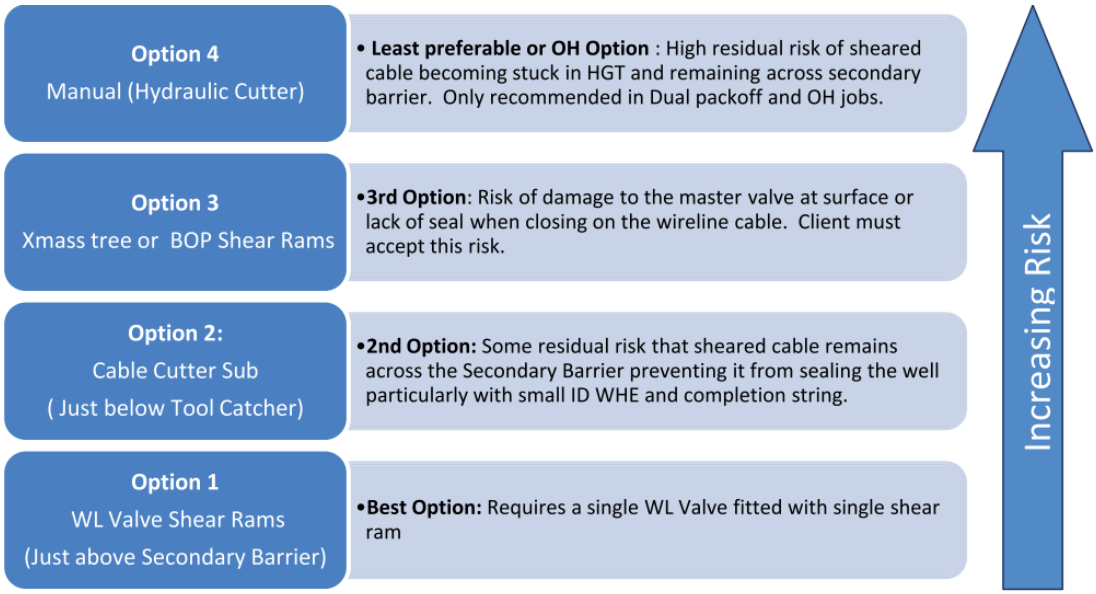

Figure 4. Wireline ram configurations and associated risk (provided by Company E)

Wireline rams are function tested without pressure. During shop tests of the wireline rams, a solid test rod is used to simulate a braided cable.

Charting

Company E does not require charting of pressure tests in the field, unless required by the customer. All shop pressure tests are charted. Hard copies of the pressure tests are recorded using a circular, analog chart or a printed copy of a digital chart. If a chart recorder is used, it is fitted with a clock rotation speed appropriate for the duration of the test. For shop tests, digital and hardcopy charts are required and are retained for the useful life of the equipment. If digital charts are used, a hard copy must be printed and saved.

Rigging Above a Drilling BOP

Company E reported that BOP blind shear rams should never be subject to pressure from above, and they are unsure why some companies believe that the blind shear rams can withstand up to 1,000 psi of pressure from above. Company E reported that the sealing surface of the blind shear rams could be damaged if subjected to pressure from above. Pressure from above the rams may also force the rams open, allowing fluid to leak through the sealed rams. Company E's position is that it is not safe practice to subject BOP blind shear rams from above pressure.

However, Company E noted that blind shear rams could be installed in an inverted configuration to allow pressure testing from above. Also, a test plug could be set to perform the pressure test to the MASP.

These shear rams have been designed and tested to the specifications in API Specification 16A, Specification for Drill-Through Equipment. The wirelines that have been successfully tested are 1/8-inch wireline, 7/16-inch braided logging cable, 0.108-inch slickline, 15/32-inch logging cable, 1/4-inch wireline cable, flat pack, 1/8th inch outer diameter (OD) slick pipe, and 0.49 inch OD E-Line.

Table 6. Summary of Company E Survey Responses

Equipment	Company Response
Testing with Well Bore Fluids	Pressure testing using well bore fluids is allowed only when all of the following conditions are met: During a cased well production logging operation in a known developed field No hydrogen sulfide gas is present Wellhead pressure at rig up time has already reached its MASP Wellhead pressure is less than 5,000 psi
Lubricator Field Test	High-pressure test 20% above MASP
Lubricator Shop Test	Annual high-pressure test For equipment with RWP above 5,000 psi, test pressure is 50% above RWP For equipment with RWP of 5,000 psi or below, test pressure is double RWP
Wireline Ram Field Test	High-pressure test 20% above MASP
Wireline Ram Shop Test	Annual high-pressure test For equipment with RWP above 5,000 psi, test pressure is 50% above RWP For equipment with RWP of 5,000 psi or below, test pressure is double RWP
Charting	Charting not required in field tests (but can be requested by customers) Charting is done in shop certification tests
Testing Above Rig BOP	BOP blind shear rams should never be subject to pressure from above BOP blind shear rams could be installed in an inverted configuration to allow for pressure testing from above

3.2 GAP ANALYSIS OF U.S. STATES AND IRF COUNTRIES RESULTS

This section summarizes the oil and gas well wireline operations and pressure testing regulations from the 13 states and 9 countries researched for this project. While the focus of research was on pressure testing for wireline pressure control equipment, other state and country requirements found to be potentially relevant for BSEE policymaking are also presented.

3.2.1 U.S. STATES

Thirteen states were researched for regulations related to testing of wireline operations pressure control equipment, such as lubricators. Not all states have regulations and policies specific to wireline operations pressure testing.

State jurisdictions include all onshore oil and gas activities within the state's boundaries, as well as offshore oil and gas activities within state waters. Most state waters extend three nautical miles from the coastline, including Alaska, California, Louisiana, and Mississippi; the state waters of Texas and Florida extend nine miles from the coastline. (NOAA, 2012)

3.2.1.1 ALABAMA

The regulatory agency for oil and gas activities in Alabama is the State of Alabama Oil and Gas Board. Alabama has prescriptive requirements for wireline pressure testing in Alabama Administrative Code 400-1-4-.09(4)(c)4, which states:

> *…Ram type and annular type blowout preventers and related control equipment shall be tested when installed; before drilling out after each casing string has been set; except for blind and blind shear rams, at least once each week, but not exceeding seven (7) days between tests; and following repairs that required disconnecting a pressure seal in the assembly. A period of more than seven (7) days between blowout preventer tests may be allowed, with the Supervisor's approval when good operations prevent testing, provided the tests will be conducted as soon as possible before normal operations resume and the reason for postponing testing is entered in the driller's log, or when written justification has been submitted to and approved by the Supervisor justifying an extension between blowout preventer pressure tests.* (Alabama, 2017)

Section 5 states:

> *…Ram-type and related control equipment shall be tested at the anticipated surface pressure or at seventy percent (70%) of the minimum internal yield pressure of the casing, whichever is lesser*. (Alabama, 2017)

Summary: Alabama wireline operation regulations are prescriptive regulations. Wireline pressure control equipment must be tested when installed in the field, at least once each week during operation, and whenever the pressure seal in the system has been broken. Pressure control equipment must be tested at anticipated surface pressure or 70% of the minimum internal yield pressure of the casing, whichever pressure is less.

3.2.1.2 ALASKA

The regulatory agency for oil and gas activities in Alaska is the Alaska Oil and Gas Conservation Commission, and the relevant regulations are found under Title 20 of the Alaska Administrative Code (AAC), Chapter 25, Section 287, which states the following:

> *…Well control equipment must include: (1) a set of wireline rams suitable or sized for each diameter of wire passing through the wireline valve; (2) a lubricator or pressure deployment system; and (3) a high-pressure pack-off, stripper, or grease head with line wiper, stripper, or pack-off. (c) The rated working pressure of the well control equipment must exceed the maximum potential surface pressure to which it may be subjected. If an approved Application for Sundry Approvals (Form 10-403) is required under 20 AAC 25.280, the commission will specify in that approved application the working pressure that the equipment must be rated to meet or exceed. However, the rated working pressure of an annular type preventer need not exceed 5,000 psi. (d) The operator shall test the well control equipment as follows: (1) at least once a month, wireline valves must be dismantled and rebuilt to ensure the integrity of the inner seals, following rebuild, the wireline rams must be closed and function pressure-tested before well bore entry, using a non-compressible fluid, to the required working pressure specified in an approved Application for Sundry Approvals under 20 AAC 25.280 or, if that application is not required, to the maximum potential surface pressure to which that equipment may be subjected; (Eff. 11/7/99, Register 152; Eff. 11/03/2013, Register 208) (2) after each installation of the well control*

equipment, that equipment must be pressure tested, before well bore entry, to the maximum potential wellhead pressure to which that equipment may be subjected; (3) if the wireline valve rams have been used, repaired or changed, the wireline rams must be closed and function pressure-tested before well bore entry, using a non-compressible fluid, to the required working pressure specified in an approved Application for Sundry Approvals under 20 AAC 25.280 or, if that application is not required, to the maximum potential surface pressure to which they may be subjected. (Alaska, 2017)

Summary: Alaska's wireline operation regulations are prescriptive. The rated working pressure of the lubricator and wireline rams must exceed the potential surface pressure encountered during well operations. Each month, the wireline rams must be dismantled and inspected and pressure tested to its permitted working pressure. After each installation of the pressure control equipment to the wellhead, the equipment must be tested to the maximum potential wellhead pressure that may be encountered. If the wireline rams have been used, repaired, or changed during operations, the rams must be closed and function pressure tested to working pressure using a non-compressible fluid, such as water.

3.2.1.3 CALIFORNIA

The regulatory agency in California is the California State Lands Commission, and the relevant regulations are under Title 2, Division 3, Chapter 1, Article 3.3 Oil and Gas Production Regulations, which states:

…All perforation and wireline operations conducted under pressure shall be performed through a lubricator installed on appropriate wireline blowout-prevention equipment. The pressure rating of the lubricator shall be equal to or greater than the maximum possible surface shut-in pressure of the well. (California, 2017)

Summary: California wireline operation regulation is prescriptive. The regulation does not require specific pressure testing, but does require that a lubricator be used during wireline operations and that the rated working pressure of the lubricator be greater than the surface shut-in pressure of the well.

3.2.1.4 COLORADO

The regulatory agency in Colorado is the Oil and Gas Conservation Commission, and the relevant regulations are in Series 300, Drilling, Development, Production, and Abandonment. Section 317 states:

…The operator shall take all necessary precautions for keeping a well under control while being drilled or deepened. (Colorado, 2017)

Section 327 states:

…The operator shall take all reasonable precautions, in addition to fully complying with Rule 317 to prevent any oil, gas or water well from flowing uncontrolled and shall take immediate steps and exercise due diligence to bring under control any such well. (Colorado, 2017)

Summary: Colorado's wireline operation regulations are performance-based, allowing operators to demonstrate compliance by any means to meet the stated objective, which is to prevent blowouts.

3.2.1.5 LOUISIANA

The regulatory agency in Louisiana is the Department of Natural Resources. While there are currently no Louisiana rules related to pressure testing of wireline operations, the Department published an advanced notice of proposed rulemaking in 2012 that stated:

… All wireline perforating operations and all other wireline operations where communication exists between the completed hydrocarbon-bearing zone(s) and the well bore shall use a lubricator assembly containing at least one wireline valve. When the lubricator is initially

> *installed on the well, it shall be successfully pressure tested to the expected shut-in surface pressure*. (Louisiana DNR, 2012)

Summary: Louisiana's proposed wireline operation regulation is prescriptive, with a requirement to have both a lubricator and wireline rams installed during wireline operations, and the lubricator must be tested to the expected surface shut-in pressure, similar to the BSEE requirement in 30 CFR §250.620.

3.2.1.6 MISSISSIPPI

The regulatory agency for the state of Mississippi is the State Oil and Gas Board, and the relevant regulations are found under Title 53, Chapter 2. Under Rule 13 Blowout Preventers and Well Control, the regulations state:

> *…On completion operations, BOPs must be installed before entering the wellbore with any tubing. For wireline work prior to running tubing, a manual valve may be used in lieu of the BOP stack.* (Mississippi State Oil and Gas Board, 2014)

Summary: Mississippi's wireline operation regulation is prescriptive. The regulatory language is specific to completion operations and allows for the use of wireline rams, without a BOP, for wireline operations.

3.2.1.7 NEW YORK

The regulatory agency in the state of New York is the Department of Environmental Conservation. The relevant rules are in Title 6, Chapter V, Subchapter B, Part 554, Cable Tool Drilling Practices. The regulations state:

> *…On all wells where cable tools are employed, the surface casing shall be tested by bailing to insure a shutoff before drilling below the casing point proceeds. Wellhead connections adequate to control blowouts will be employed*. (New York, 2017)

Summary: New York's wireline operation regulation is performance-based, allowing operators to demonstrate compliance by any means to meet the stated objective, which is to prevent blowouts.

3.2.1.8 OKLAHOMA

The regulatory agency for Oklahoma is the Corporation Commission, Oil and Gas Division. The relevant rules are found in the Oklahoma Administrative Code, Title 165, Chapter 10, Subchapter 3, Section 4. The regulations state:

> *…All reasonable and prudent precautions shall be taken for keeping the well under control during drilling operations, including but not limited to the use of blowout preventers or other similar equipment with appropriate pressure fittings attached to properly cemented casing strings and the maintenance of mud-laden fluid of sufficient weight to provide proper well control. A blowout preventer or other equipment necessary to maintain control of the well shall be installed prior to drilling out of the surface casing. Blowout preventers and associated equipment shall be maintained in good working order.* (Oklahoma, 2017)

Under Subchapter 3, Section 10, the regulations state:

> *…All wellhead connections, surface equipment, and tank batteries shall be maintained at all times so as to prevent leakage of oil, gas, saltwater, or other deleterious substances*. (Oklahoma, 2017)

Summary: Oklahoma's wireline operation regulations are performance-based, allowing operators to demonstrate compliance by any means to meet the stated objective, which is to prevent blowouts and loss of well fluids from surface equipment, including lubricators and wireline rams.

3.2.1.9 FLORIDA, NORTH DAKOTA, PENNSYLVANIA, TEXAS, AND WEST VIRGINIA

Five states (Florida, North Dakota, Pennsylvania, Texas, and West Virginia) were found to have no specific regulations related to wireline operations pressure testing. While wireline operators in these states may conduct pressure tests on wireline pressure control equipment (i.e., lubricators and wireline rams) based on voluntary consensus standards or company policies, this testing is not required under current state law.

3.2.1.10 SUMMARY TABLE OF U.S. STATE REGULATIONS

Table 7 shows a summary of U.S. state regulations that were researched.

Table 7. Summary of U.S. State Regulations

State	Regulator	Jurisdiction	Summary of Regulations
Alabama	State Oil and Gas Board	Onshore, inland waters, and coastal state waters (3 nautical miles [nm] from national baseline)	Prescriptive: notification of wireline operations
Alaska	Oil and Gas Conservation Commission	Onshore, inland waters, and coastal state waters (3 nm from national baseline)	Prescriptive: test to surface shut-in pressure
California	State Lands Commission	Onshore, inland waters, and coastal state waters (3 nm from national baseline)	Prescriptive: rated working pressure of lubricator must be above surface shut-in pressure
Colorado	Oil and Gas Conservation Commission	Onshore	Performance-based: prevent well bore fluids from flowing uncontrolled
Florida	Department of Environmental Protection	Onshore, inland waters, and coastal state waters (9 nm from national baseline)	No wireline pressure testing requirements
New York	Department of Environmental Conservation	Onshore, inland waters, and coastal state waters (3 nm from national baseline)	Performance-based: equipment must control blowouts
Louisiana	Department of Natural Resources	Onshore, inland waters, and coastal state waters (3 nm from national baseline)	Prescriptive: test to surface shut-in pressure
Mississippi	State Oil and Gas Board	Onshore	May use wireline rams in lieu of a BOP
North Dakota	Department of Mineral Resources	Onshore	No wireline pressure testing requirements
Oklahoma	Oil and Gas Division	Onshore	Performance-based: maintain well control
Pennsylvania	Department of Environmental Protection	Onshore	No wireline pressure testing requirements
Texas	Railroad Commission	Onshore, inland waters, and coastal state waters (9 nm from national baseline)	No wireline pressure testing requirements

State	Regulator	Jurisdiction	Summary of Regulations
West Virginia	Department of Environmental Protection	Onshore	No wireline pressure testing requirements

3.2.2 INTERNATIONAL REGULATORS' FORUM COUNTRIES

Nine countries of the IRF were researched for regulations related to testing of wireline operations pressure control equipment, such as lubricators. Research was limited to regulations and regulatory entities with offshore jurisdictions.

3.2.2.1 AUSTRALIA

The regulatory agency in Australia is the National Offshore Petroleum Safety and Emergency Management Authority (NOPSEMA), and the applicable regulations are the Offshore Petroleum and Greenhouse Gas Storage Regulations of 2011. Under these rules, operators must submit a Well Operations Management Plan (WOMP) to NOPSEMA for approval before operations can begin. The WOMP requires a description of the well activities to be performed and how risks are to be reduced to a level "As Low As Reasonably Practicable" (ALARP). According the regulations, a WOMP must contain:

> *…a description of the well, and the well activities relating to the well, to which the plan applies; (b) a description of the risk management process used to identify and assess risks to the integrity of the well; (c) a description and explanation of the design, construction, operation and management of the well, and conduct of well activities, showing how risks to the integrity of the well will be reduced to as low as reasonably practicable; (d) a description of the performance outcomes against which the performance of the titleholder in maintaining the integrity of the well is to be measured*. (Australia, 2011)

NOPSEMA provides additional detail on how ALARP is defined in the context of well integrity in Guidance Note N-04600-GN1616. The guidance note suggests that industry standards, such as those established by Norsk Sokkels Konkuranseposisjon (NORSOK) can be used by operators to achieve risks that are ALARP. The note states:

> *…In most situations, deciding whether the risks are ALARP involves a comparison between the control measures a titleholder has in place, or is proposing, and the measures NOPSEMA would normally expect to see in such circumstances e.g., relevant good practice. Good practice is defined as commonly accepted in the industry and supported by sound engineering principles and relevant internationally accepted standards and guidance e.g., Oil & Gas UK Well Life Cycle Integrity Guidelines, NORSOK Standard D-010, International Standards Organization Draft International Standard 16530 (ISO/DIS 16530) Well Integrity*. (NOPSEMA, 2017)

The current version of NORSOK Standard D-010 is Revision 4, 2013. D-010 defines well barrier elements (WBE) as "a physical element which in itself does not prevent flow but in combination with other WBE's forms a well barrier." Wireline lubricators and wireline rams are WBE. The standard sets forth conditions under which WBE must be pressure tested under Section 4.2.3.6.1:

> *…Pressure testing of well barriers or WBEs shall be performed: a) before it can become exposed to a pressure differential in its operating phase; b) after replacement of pressure confining components of a WBE; c) when there is a suspicion of a leak; d) when an element will be exposed to different pressure/load than it was originally tested to; e) if the barrier element has been accidently exposed to differential pressure/load higher than original well design values.* (NORSOK, 2013)

To summarize, according to the standard, wireline lubricators and valves must be pressure tested before beginning each well operation. Specific procedures for the pressure tests are set forth in Section 4.2.3.6.4:

> *…A low-pressure test to 15–20 bar [218 to 290 psi] for minimum 5 minutes stable reading should be performed prior to high pressure testing in the drilling, completion and intervention activities. For periodic testing of wells in production/injection phase, a low-pressure test is not required. The high-pressure test value shall be equal to, or exceed the maximum differential pressure that the WBE may become exposed to. Static test pressure shall be observed and recorded for minimum 10 minutes with stable reading. In the production/injection phase, a 70 bar [1,015 psi] pressure differential should be applied for all WBEs with an allowable leak rate. Less differential pressure (i.e., if the well pressure is less) may be used provided that the allowable leak rate is changed proportionally. Inflow tests should last for a minimum of 30 minutes with stable reading (or longer due to large volumes, high compressibility fluids, or temperature effects). The test pressure values shall not exceed the well design pressure or rated working pressure of exposed WBEs. The following should apply to qualify a pressure test: a) consider the monitored volume when setting the test acceptance criteria; b) establish maximum acceptable deviation from test pressure (x bar deviation from test pressure, e.g., 5 bar [73 psi] for a 345 bar [5,004 psi] test); c) establish maximum allowable pressure variation over the defined time interval (e.g., 1% or 3.45 bar for a 345 bar test over 10 minutes); d) A condition for the criteria in b) and c) is that the pressure change over time ($\Delta p/\Delta t$) is declining*. (NORSOK, 2013)

Summary: Australia's NOPSEMA has a performance-based requirement for operators to submit a WOMP that describes how risks of the loss of well control will be reduced to As Low As Reasonably Practicable, or ALARP. NOPSEMA guidance states that industry standards, such as NORSOK D-010 can be followed by operators to achieve ALARP. NORSOK D-010 states that WBE such as wireline lubricators and wireline rams should be pressure tested when installed on the well, before operations commence. A low-pressure test of about 220 psi to 290 psi should be conducted and pressure should be held for a minimum of 5 minutes. A high-pressure test should be conducted to the MASP or greater and should be held for 10 minutes without a pressure drop.

3.2.2.2 CANADA

Offshore wireline operations in Canada are regulated by three boards with distinct geographic jurisdictions. The Newfoundland-Labrador Offshore Petroleum Board (C-NLOPB) and Nova Scotia Offshore Petroleum Board (C-NSOPB) regulate offshore activities on the eastern, Atlantic coast of Canada, and the National Energy Board (NEB) regulates offshore activities in the Canadian Arctic. There is no offshore oil and gas activity on Canada's Pacific Coast (see Figure 5). (National Energy Board, 2016)

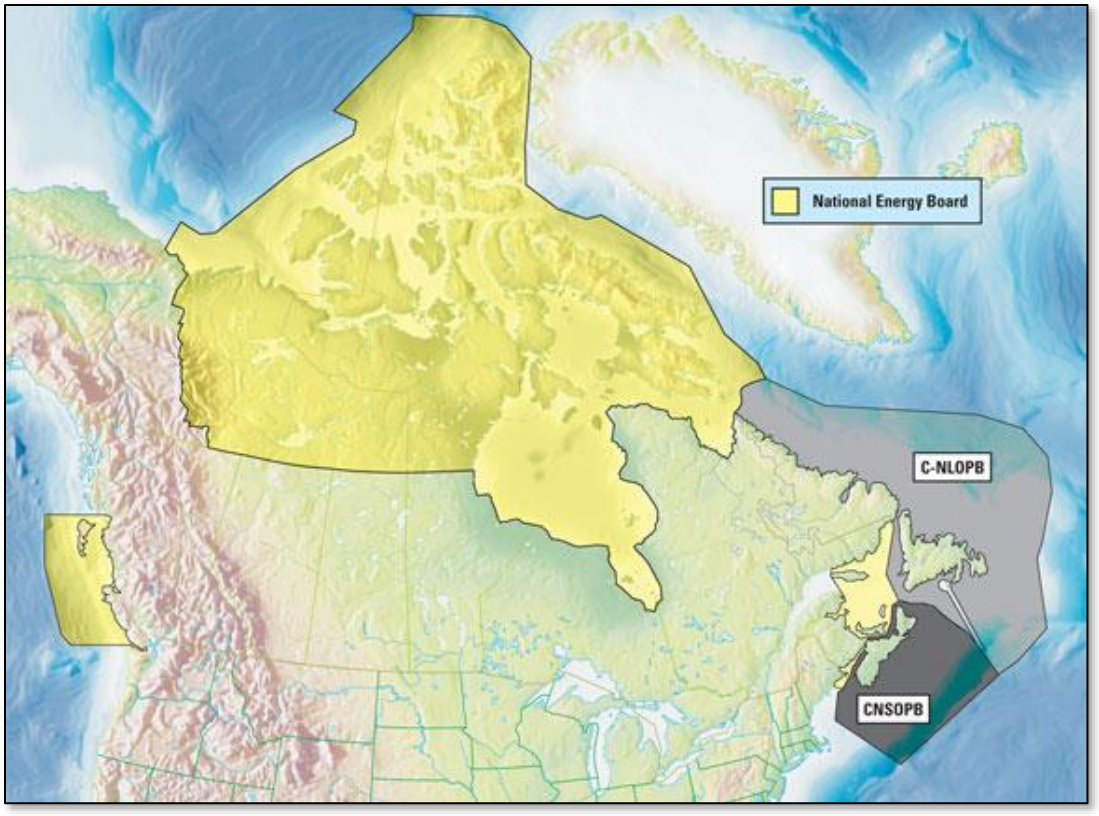

Figure 5. Jurisdictions of Canadian Regulatory Agencies. Source: National Energy Board, accessed at https://www.neb-one.gc.ca/nrth/rctcffshrdrllngrvw/rctcffshrdrllngrvwq1-eng.html

The regulations for the NEB are the Canada Oil and Gas Drilling and Production Regulations, and they do not contain provisions related to wireline pressure testing. Offshore oil and gas activities, including wireline operations, are regulated under the Newfoundland Offshore Drilling and Production Regulations and the Nova Scotia Offshore Drilling and Production Regulations (most provisions of these regulations are identical, including the following). The regulations state, under Section 37:

> *…The operator shall ensure that pressure control equipment associated with drilling, coil tubing, slickline and wire line operations is pressure-tested on installation and as often as necessary to ensure its continued safe operation*. (Canada, 2009a) (Canada, 2009b)

This performance-based requirement in the regulations is described in greater detail in C-NLOPB/C-NSOPB Drilling and Production Guidelines, under Sections 37.1 through 37.3 (note that "related pressure control equipment" includes wireline lubricators and wireline rams):

> *General*
>
> *The operator is expected to ensure that BOPs and related pressure control equipment, as well as pressure control equipment utilized for slickline, wireline or coiled tubing operations have a rated working pressure greater than the well design maximum calculated surface pressure*
>
> *Guidelines for Pressure Testing*
>
> *The operator is expected to ensure that BOPs, and other pressure control equipment (choke manifold, the choke and kill lines, high pressure riser if applicable, safety valves, stabbing valves, inside BOPs and any other well control equipment) are pressure tested as follows: after*

installation (If the offshore BOP stack has been fully stump tested, a body test should be conducted to ensure that the wellhead connector is sealed); before drilling out any string of casing; before commencing a formation flow test; following repairs or any event that requires disconnecting a pressure seal; and once every 14 operational days. Where well conditions or other hazards preclude pressure testing within the 14-day timeframe, the test may be delayed by no more than 7 days.

Pressure Testing BOPs and Associated Equipment

The swabbing valve, inside BOP, and lower kelly cock should be pressure tested from the bottom. An inside BOP consisting of a pump down check valve and a landing sub that is an integral part of the string should also be in-flow pressure tested.

A low-pressure test in the range of 1,400-2,000 kilopascals (kPa) [203 to 290 psi]] should be conducted prior to the high-pressure test. The BOPs and other pressure control equipment should be tested to a pressure greater than the maximum anticipated surface pressure. The annular(s) should be tested to at least 50 per cent of the working pressure. For a satisfactory test, all components should maintain a stabilized pressure of at least 90 per cent of the required test pressure over a 5-minute (low test) and 10-minute (high test) interval.

Guidelines for Function Tests

The BOPs and other well pressure control equipment should be function tested daily and in such a manner as to ensure all components (including failsafe valves if appropriate) have been tested at least once per week (i.e., a minimum of one component function test per day or preferably per shift to ensure control system operating). A case may be made to do all function tests weekly provided there is a daily check of the control closing system and the accumulators, but the former is preferred. In the case of subsea wells, function tests are to alternate between control pods and between control stations. (C-NLOPB and C-NSOPB, 2011)

Summary: Under Canadian regulations, operators are required to pressure test wireline lubricators and wireline rams between installation on the wellhead and operation, after any disconnection of the pressure seal, and once every 14 operational days. A low-pressure test must be performed at about 200 psi to 300 psi and should hold at least 90% of the test pressure for 5 minutes. A high-pressure test should be performed at a pressure greater than MASP and should hold at least 90% of the test pressure for 10 minutes. Function tests of the wireline rams should be conducted daily while in the field.

3.2.2.3 MEXICO

The regulatory agency in Mexico is the National Hydrocarbons Commission (CNH), and the relevant regulations are the Well Drilling Guidelines. Article 9 of the Well Drilling Guidelines states:

[translated from Spanish] *"Oil Operators should observe the Best Practices of the industry for Well Drilling."*

...For this purpose, it will be mandatory for Petroleum Operators to observe at least the Best Practices indicated in Annex II of these Guidelines and the operational practices indicated in Annexes IV and V of these Guidelines. The Commission will monitor compliance with the Best Practices and based on these, it makes its technical assessment.

Without prejudice to the foregoing, Petroleum Operators may propose to the Commission, at the time of submitting their Authorization requests, the adoption of equivalent operating practices or standards, different or superior to those indicated in Annexes II, IV and V of the Guidelines, or that would be better adapted to be more efficient or effective for the geological characteristics or geophysical conditions and other requirements inherent to Well Drilling. (Mexico, 2016)

Annex II of the Well Drilling Guidelines refers to API RP 54, which states under Section 13.6.3 through 13.6.5:

> *…A periodic drift, visual, and pressure test check of all sections of the lubricator shall be made at intervals not to exceed twelve (12) months. The equipment pressure test shall be effected using ambient temperature water or other suitable fluid to a minimum of the lubricator rated working pressure. The wireline blowout preventer shall be tested in the open and closed positions.*
>
> *All pressure tests should consist of three parts: (a) a primary pressure holding period; (b) reduction of pressure to zero; and (c) a second pressure holding period. Both pressure holding periods should be a minimum of three (3) minutes, with the time starting when the test pressure has been reached stabilized and the external surfaces have been thoroughly dried. Each periodic test shall be documented.*
>
> *The rated working pressure of all sections of the lubricator, including stuffing box, wireline valve connections, and adapters should not be exceeded.*
>
> *Each high pressure [over 5,000 psi (34.5 megapascals [MPa]) rated working pressure] lubricator, wireline valve, oil saver, and stuffing box should conform to the following: a. Lubricators should have a minimum of two (2) bleed valves located on the main body on the lower end of the bottom section. Two (2) bleed valves should be opened when bleeding pressure from the lubricator. b. Nondestructive testing, such as surface nondestructive examination and visual inspection, shall be effected on lubricators, stuffing boxes, valves, connections, and adapters at intervals not to exceed every twelve (12) months. A copy of the inspection certificate(s) shall be kept on file for future reference*. (API, 1999)

Summary: Mexico's Well Drilling Guidelines incorporate by reference API RP 54, which states that the wireline lubricator and wireline rams should be pressure tested every 12 months at a minimum to the equipment's rated working pressure. Wireline rams should be tested in the open and closed position. Pressure tests should hold the test pressure for 3 minutes, lower pressure to 0, then increase to test pressure once again and hold for 3 minutes.

3.2.2.4 NEW ZEALAND

The New Zealand regulatory agency is New Zealand Petroleum and Minerals (NZPM), and the relevant regulation is the Health and Safety at Work (Petroleum Exploration and Extraction) Rule of 2016. The regulations do not contain specific requirements for pressure testing for wireline lubricators or wireline rams, but do feature a requirement to notify NZPM before commencing well intervention operations such as wireline operations. During a phone interview with a representative from NZPM, it was stated that NZPM inspectors apply the standards set forth in API RP 54 when conducting inspections of wireline operations. See Section 3.2.2.3 above for the relevant sections of API RP 54. (New Zealand, 2016)

Summary: While New Zealand regulations do not have specific pressure testing requirements for wireline pressure control equipment, a NZPM representative stated that API RP 54 is the standard used by NZPM inspectors. API RP 54 states that the wireline lubricator and wireline should be pressure tested every 12 months at a minimum to the equipment's rated working pressure. Wireline rams should be tested in the open and closed position. Pressure tests should hold the test pressure for 3 minutes, lower pressure to 0, then increase to test pressure once again and hold for 3 minutes.

3.2.2.5 NORWAY

The regulatory agency in Norway is the Norwegian Petroleum Safety Authority (PSA), and the relevant regulations are the Activities Regulations under Section 51, Specific Requirements for Testing of Blowout Preventer and Other Pressure Control Equipment, which state:

> *…Blowout preventers with control functions and other pressure control equipment shall be pressure and function tested. Blowout preventers with control functions and other pressure control equipment shall undergo a complete overhaul and recertification every five years.* (Norway, 2017a)

PSA has additional guidelines for Section 51, which state:

> *…To fulfil the requirement relating to testing, complete overhaul and recertification so that the equipment can fulfil its required functions, the NORSOK D-001 standard, Chapter 6.35.3, and the NORSOK D-010 standard, Chapters 4.2.3.5 and 4.2.3.6 as well as tables 15.4, 15.14, 15.19, 15.21, 15.32, 15.37, 15.38, 15.47, 15.53, 15.57, 15.58 and 15.59 and Appendix A, Table 39, Det Norske Veritas Germanischer Lloyd Offshore Standard E101 (DNVGL-OS-E101) as well as Det Norske Veritas Recommended Practice E101 (DNV-RP-E101) should be used. See Section 47 as regards this type of equipment in well interventions and overhaul of subsea wells.*
>
> *Complete overhaul and recertification as mentioned in the second subsection, may be carried out continuously and in a manner which ensures that single components and the whole unit will be overhauled in a rolling five-year period. The complete overhaul does not necessarily imply a full dismantling of all the parts, cf. design, operation and maintenance history, lifetime and associated risk assessments (classification) etc., but must be carried out in a way that will be eligible for recertification*. (Norway, 2017b)

NORSOK D-001 Chapter 6.35.3 is applicable to drilling BOPs and not wireline pressure control equipment. NORSOK D-010 is directly applicable to wireline pressure control equipment, and the relevant sections are described in Section 3.2.2.1, Australia, of this report.

DNVGL-OS-E101 has general requirements for pressure testing of pressure holding equipment, which includes wireline pressure control equipment, in Section 4.2, which states:

> *…Pressure containing piping and components shall be subject to a hydrostatic pressure test in accordance with applied codes and standards.*
>
> *The test pressure shall be determined by the working pressure. This shall be minimum 1.5 × maximum working pressure if not otherwise specified in applied codes and standards.*
>
> *The holding time shall be minimum 15 minutes, and shall at least be sufficiently long to allow for thorough visual examination after the pressure has stabilized. A shorter holding time can be considered for very small components in accordance with recognized standards.*
>
> *The pressure and holding time results shall be systematically recorded and documented so as to be fully traceable.*
>
> *Where hydrostatic pressure testing of piping represents particular problems, alternative suitable test methods may be applied where justified as suitable*. (DNVGL, 2015)

DNV-RP-E101 describes a recertification process for pressure control equipment and is applicable to wireline lubricators and wireline rams. The certification process, done once every five years, involves a review of the history of the use of the equipment, dismantling and reassembly, and a pressure test. Under Section 7.11, the standard states:

> *…Unless the equipment has been subjected to repair e.g., welding and/or machining of pressure exposed components, the pressure/load test shall be limited to maximum working pressure (MWP)/load, including low pressure seal test.*
>
> *The equipment shall be function tested in accordance with an approved procedure and to the specified recognized standards or codes.*

> *Welding with or without heat treatment, or machining, of pressure/load exposed components will require a body pressure test according to the design. The test pressure should normally be 1.5 times the MWP.*
>
> *Pressure recording instruments shall be used during testing. Recording instruments shall be calibrated at least once every year.* (DNV, 2012)

Summary: Norway's regulations require wireline pressure control equipment to be function tested and pressure tested, as well as an overhaul and recertification every 5 years. PSA Guidance specifies that performance-based requirements can be met by applying voluntary consensus standards such as NORSOK D-001, DNVGL-OS-E101, and DNV-RP-E101. NORSOK D-010 states that WBE such as wireline lubricators and wireline rams should be pressure tested when installed on the well before operations commence. A pressure test of about 220 psi to 290 psi should be conducted and pressure held for a minimum of 5 minutes. A high-pressure test should be conducted to the MASP or greater, and held for 10 minutes without a pressure drop. DNVGL-OS-E101 states that wireline pressure control equipment should be tested to 1.5 times MWP of the equipment, the test pressure should be held for 15 minutes, and the test should be documented and recorded. DNV-RP-E101 states that wireline pressure control equipment must be disassembled, overhauled, pressure tested, and recertified every 5 years. The test pressure should be 1.5 times the MWP of the equipment.

3.2.2.6 UNITED KINGDOM

The regulatory agency in the United Kingdom is the Health and Safety Executive (HSE), and the relevant regulations are the Offshore Installations Regulations. These regulations contain a requirement to provide a well notification to HSE before well operations begin, including information on well control and well barriers in Section 2.1:

> *…The well operator must include with the notification sent to the competent authority a statement, made after considering reports by the well examiner under regulation 11(2) (b), that the risk management relating to well design and its barriers to loss of control are suitable for all anticipated conditions and circumstances.* (United Kingdom, 2015)

HSE provides additional details in the Offshore Installations Regulations Guidance in Guidance Schedule 9, Section 518,

> *…The description should include the sequence of operations which can be reasonably foreseen, emphasizing details of the safety-related steps, such as: casing/tubing pressure tests; formation integrity tests; details of cementing/cement tops; blowout preventer function and pressure tests; and barrier inflow and pressure tests*.

These performance-based regulations do not feature specific pressure testing requirements for wireline pressure control equipment; however, an HSE representative stated that HSE inspectors look for the use of voluntary consensus standards by operators to ensure that their safety case is valid. The HSE representative also cited the Oil and Gas UK standard entitled Well Life Cycle Integrity Guidelines.[5]

Summary: The United Kingdom does not have specific pressure testing requirements for wireline pressure control equipment; however, an HSE representative reported that voluntary consensus standards, such as those written by Oil and Gas UK, can be used by operators to support their safety case.

3.2.2.7 BRAZIL, DENMARK, AND NETHERLANDS

Three countries (Brazil, Denmark, and the Netherlands) were found to have no specific regulations related to wireline operations pressure testing. A representative from Denmark's Working Environment

[5] The research team was unable to access a copy of the Oil and Gas UK Well Lifecycle Integrity Guidelines

Authority (WEA) confirmed via email that Denmark does not have such requirements. While operators in this country may perform pressure testing of lubricators during wireline operations, there is no specific regulatory requirement for them to do so.

3.2.2.8 SUMMARY TABLE OF IRF COUNTRY REGULATIONS

Table 8 shows a summary of the wireline operations regulations for the IRF countries that were researched.

Table 8. Summary of IRF Country Regulations

Country	Regulator	Summary of Regulations
Australia	National Offshore Petroleum Safety and Emergency Management Authority (NOPSEMA)	Performance-based wireline pressure testing; may use standards
Brazil	National Agency of Petroleum (ANP)	No wireline pressure testing requirements
Canada	Nova Scotia Offshore Petroleum Board (C-NSOPB), Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), National Energy Board (NEB)	Prescriptive pressure testing requirements
Denmark	Working Environment Authority (WEA)	No wireline pressure testing requirements
Mexico	National Hydrocarbons Commission (CNH)	Prescriptive pressure testing requirements
Netherlands	State Supervisor of Mines	No wireline pressure testing requirements
New Zealand	WorkSafe	Performance-based wireline pressure testing; may use standards
Norway	Petroleum Safety Authority (PSA)	No wireline pressure testing requirements
United Kingdom	Health and Safety Executive (HSE)	Performance-based wireline pressure testing; may use standards

4.0 DISCUSSION

4.1 INDUSTRY SURVEY DISCUSSION

This discussion section is structured around the five questions posed by BSEE in Task 1 of the Statement of Work (SOW) for this contract.

4.1.1 QUESTION 1: WIRELINE PRESSURE TESTING

What pressures are used for both routine and non-routine operations to test the wireline lubricator and wireline rams? Are these well bore pressures or pump pressures? Is it acceptable to test with well bore pressure? If well bore pressure is allowed for testing, when will it be allowed and what safety precautions and barriers need to be in place?

All companies surveyed reported that there are two broad categories of pressure tests conducted on wireline pressure control equipment – field tests and shop tests. Field tests are performed at the well site once pressure control equipment has been attached to the wellhead. They are typically performed each time a wireline operation commences in the field and may occur more frequently (e.g., every time a new connection is made). Shop tests are performed at less frequent regular intervals (e.g., annually or every five years) and are conducted in a controlled pressure testing facility, often by the equipment owner or manufacturer. Shop pressure tests are designed to certify safe and proper functioning of pressure control equipment for long periods of time and, therefore, test at higher pressures.

For field pressure tests, Companies A, B, and D reported conducting a low-pressure test from 250 psi to 350 psi. Companies C and E do not conduct low-pressure field tests. Companies A and B use a high-pressure field test of 500 psi above MASP, Companies D and E use high-pressure field tests of 20% above MASP, and Company C uses a test of 500 psi to 1,000 psi above surface shut-in pressure.

For shop pressure tests, Companies C, D, and E perform low-pressure tests within a range of 200 psi to 350 psi. Companies A and B are operators who have equipment suppliers perform the shop test on their behalf and, therefore, were not aware of the test pressures used by the equipment suppliers. Companies C and E perform high-pressure tests at some proportional margin above RWP (1.5 × RWP or 2 × RWP), while Company D tests at RWP.

Companies A, B, and D do not perform any pressure tests using well bore pressure. Company C performs the initial field pressure test using surface pump pressure, then performs subsequent tests during the same well operation using well bore pressure. Company E tests using well bore pressure only when surface pressure is less than 5,000 psi.

To summarize, the companies surveyed generally perform field low-pressure tests around 250 to 350 psi and high-pressure field tests at some margin above MASP. Low-pressure shop tests are performed at similar pressures to low-pressure field tests (200 psi to 350 psi), while high-pressure shop tests are performed at significantly higher pressures than high-pressure field tests, at some margin above RWP. Table 9 shows a summary of these survey results. Well bore pressure is rarely used for field pressure tests, except when well bore pressures are low or when a surface pump pressure has already been conducted. This approach to using well bore pressure appears to be straightforward and logical, since surface pump pressure is required to increase test pressures to pressures above what is expected in the well, creating a safety margin. Well bore pressure cannot be used to raise test pressures above MASP; therefore, there is no assurance that the equipment will withstand increased well bore pressures above MASP.

Table 9. Summary of Survey Results for Lubricator and Wireline Test Pressures

Question	Company				
	A	B	C	D	E
Low-Pressure Field Test (psi)	250 – 350 (wireline BOP and lubricator)	250 – 350	None	250 – 350	None
High-Pressure Field Test (psi)	MASP + 500 (wireline BOP and lubricator)	MASP + 500	Surface shut-in pressure + 500 – 1,000	20% above MASP	20% above MASP
Low-Pressure Shop Test (psi)	Equipment supplier	Equipment supplier	200	250 – 350	300

Question	Company				
	A	B	C	D	E
High-Pressure Shop Test (psi)	performs shop tests, survey respondent did not know the shop test procedures	performs shop tests, survey respondent did not know the shop test procedures	1.5 × RWP	RWP	RWP ≥5,000: 1.5 × RWP RWP <5,000: 2 × RWP
Well Bore Pressure Test?	No	No	Initial test with pump, other tests with well bore pressure	No	Only when surface pressure <5,000

4.1.2 Question 2: Charting

Are the lubricator tests being charted? The current regulations do not state that lubricator tests need to be charted. How are operators verifying that the test is successful if the test is not being charted?

Charting is a method of measuring and recording the results of pressure tests. While charting tests of wireline pressure control equipment is not currently required by BSEE regulations, it could be a potential way to check compliance with pressure testing policies since it generates a verifiable record. Based on survey responses, it is clear that nearly all shop lubricator tests use charts; therefore, our discussion here is focused on whether charts are used for field tests. A variety of charts are used by industry, including digital charts that create electronic records, as well as circular, analog charts that can be stored as hard copies on paper or scanned and stored digitally. Companies A, B, and D reported that they always chart lubricator pressure tests. Company C does not chart lubricator tests, while Company E, a wireline service company, relies on customer companies to determine whether to chart tests. Only Company A uses circular, analog charts exclusively, while Companies B, D, and E use a mixture of digital and circular, analog charts. Companies typically chart field pressure tests and use a mixture of digital and analog devices. Table 10 shows a summary of these results.

Table 10. Summary of Survey Results for Charting of Field Lubricator Tests

Question	Company				
	A	B	C	D	E
Are Field Lubricator Tests Charted?	Yes	Yes	No	Yes	Yes, if required by customer
Type of Chart Used	Analog	Digital and analog	N/A	Digital and analog	Digital and analog

4.1.3 Question 3: Wireline Rams

When are wireline rams used? If wireline rams are used, are the pressure tests being charted?

Wireline rams are used in all wireline operations by Companies A, B, and C. Companies D and E use wireline rams for any operations under pressure. The companies surveyed apply the same criteria to charting of wireline rams as they did to charting for lubricators. Companies A, B, and D chart wireline

ram pressure tests. Company C does not chart these tests, and Company E charts these tests based on customer request. As with lubricator pressure tests, a variety of digital and analog charts are used. Table 11 shows a summary of these survey results.

Table 11. Summary of Survey Results for Charting of Field Wireline Ram Tests

Question	Company				
	A	B	C	D	E
Are Wireline Rams Used?	Yes, for all operations	Yes, for all operations	Yes, for all operations	Any operation under pressure	Any operation under pressure
Are the Pressure Tests Charted?	Yes	Yes	No	Yes	Yes, if required by customer
Type of Chart Used	Circular, analog	Digital and circular, analog	N/A	Digital and circular, analog	Dependent on customer

4.1.4 Question 4: Criteria for Successful Pressure Tests

What criteria do operators currently use as a successful pressure test of the wireline rams and lubricator?

Companies apply different criteria for determining a successful pressure test for wireline rams and lubricators. Generally, these criteria involve an amount of time that the test pressure is held, and a maximum allowance for a pressure drop encountered during this holding period.

- Company A reported that all pressure tests must be conducted for a duration of 5 minutes with no allowable pressure drop.
- Company B requires holding of test pressures for 5 minutes and did not specify acceptable pressure drops.
- Company C reported that they comply with API RP 54, which calls for 2 pressure holding periods, every 3 minutes duration.
- Company D requires a pressure holding period of 15 minutes and the test pressure cannot decrease by more than 1% during this holding time.
- Company E did not specify test pressure holding durations, but reported that test pressure must not drop more than 5% of test pressure, or 500 psi, whichever value is lower.

These results may be evidence of some inconsistency among use of successful pressure test criteria. Establishment of clear requirements in the BSEE regulations or incorporation by reference of API standards such as API RP 53 or API RP 54 could ensure more consistent practices among industry operators. A summary of these survey results is shown in Table 12.

Table 12. Summary of Survey Results for Pressure Test Criteria

Question	Company				
	A	B	C	D	E
Criteria for Successful Pressure Test	Pressure is held for 5 minutes with no allowable pressure drop	Low and high test; hold pressure for 5 minutes	API RP 54, para. 13.6.3: 2 pressure holding periods 3 minutes in length	Hold pressure for 15 minutes, pressure cannot decrease more than 1%	Pressure must not drop more than 5% of the test pressure or 500 psi, whichever is lower

4.1.5 QUESTION 5: PRESSURE TESTING STACKED ON A DRILLING BOP

Most operators are requesting to lower their test pressure to 1,000 psi when stacked up on top of a BOP stack. This is a departure from 30 CFR §250.620(c) to not test to expected shut-in surface pressure when the lubricator is initially installed. The reason operators are requesting this departure is because they say testing to a high pressure will damage their blind shear rams. Is this reason accurate? Is granting this departure a safe practice? Will the blind shear ram of the rig BOP shear and seal on the wireline cable? Compare available OEM make, model, and size of blind shear rams for shear and seal. Are the OEM's claims based on physical testing or modelling? Is this information available? What type of damage do operators expect of the blind shear rams due to high-pressure testing?

During wireline operations in the drilling phase, there is often a rig BOP installed on the wellhead, making it necessary to right the wireline lubricator and wireline rams above the BOP, with the wireline cable extending through the BOP and opened BOP rams. This creates a number of potential safety concerns with regards to well control. The presence of the cable through the BOP could present a potential obstruction to the closing of the BOP blind shear rams in a well control event.[6] The presence of a BOP (rather than a Christmas tree as in the production phase), means that the BOP blind shear rams must be used to create a pressure seal below the wireline pressure control equipment for the purpose of pressure tests.

BSEE has reported that operators are asking for a departure from the regulatory requirement to test to surface shut-in pressure for wireline equipment when stacked above a BOP because operators believe the blind shear rams cannot withstand pressures greater than 1,000 psi from above. Industry responses on these issues were mixed, with significant variance in procedures, opinions, and recommended solutions. Companies A and C reported that when rigged on top of a BOP, they close the BOP blind shear rams to form a pressure seal below the wireline equipment and limit their test pressure to 1,000 psi (which is lower than the required surface shut-in pressure) to avoid damaging the blind shear rams. They were not aware of the source of the purported 1,000-psi limit on pressure from above the blind shear rams.

Companies B and E explained that pressure above the blind shear rams may not cause permanent damage but the rams may leak when subjected to pressure from above. BOP rams are designed to hold pressure from below and are, therefore, designed so that pressure from below tends to force the rams shut. For this reason, pressure from above tends to pry the rams open, causing leaks. Company E reported that pressure from above could also damage the sealing surface of the rams.

[6] Per the BSEE Well Control Rule (81 FR 25888; April 29, 2016) and the regulations in 30 CFR §250.732(b)(1)(i), operators must demonstrate "*that the BOP will shear the drill pipe and any electric-, wire-, and slick-line to be used in the well, no later than April 30, 2018*."

Companies B and E reported that BOP blind shear rams are generally able to shear wireline cables. Company E, a BOP manufacturer, provided extensive details on these cable shearing capabilities, including a company publication documenting these capabilities.

Companies A, C, and E also proposed solutions for addressing this issue. Companies A and E described a test plug that could be placed in the well to serve as a pressure seal below the wireline equipment for the purposes of pressure testing. This would obviate the need for closing the blind shear rams and subjecting them to pressure from above. Company C uses kill-weight fluid in the well bore when rigged on top of a BOP to create an additional safety margin given that they do not test to surface shut-in pressure. Company E also suggested that an inverted blind shear ram could be installed strictly for the purposes of pressure testing wireline equipment. An additional set of BOP rams could be costly and difficult to justify for such a narrow application. A summary of these survey results is shown in Table 13.

Table 13. Summary of Survey Results for Rigging Above a BOP

Question	Company				
	A	B	C	D	E
How to Test Above a Rig BOP	Close blind shear rams and test to 1,000 psi	-	Close blind shear rams and test to 1,000 psi	-	-
Potential Damage to BOP Shear Rams from Pressure Above	-	Pressure from above will cause rams to leak	-	-	Damage to sealing surfaces of rams, leaks
Can Shear Rams Sever Wireline Cable?	-	Yes	-	-	Yes
Potential Solution	Test plug	-	Kill-weight fluid in well bore	-	Inverted blind rams, test plug

4.2 GAP ANALYSIS OF U.S. AND IRF COUNTRY REGULATIONS DISCUSSION

This section features a discussion of the results of the research of wireline operations pressure testing regulations from states and foreign countries.

4.2.1 PRESCRIPTIVE AND PERFORMANCE-BASED REGULATIONS

The regulations researched under Task 3 of this study were assessed based on their relative composition of either prescriptive or performance-based regulations and policies. Prescriptive regulations are those that prescribe a specific action that the regulated community must take based on specific numeric or quantitative targets. For example, BSEE's regulations in 30 CFR §250.620 are prescriptive because they require operators to test wireline lubricators to the surface shut-in pressure. Performance-based regulations direct the regulated community to conduct any action sufficient to achieve a given outcome without prescribing exactly *how* that outcome will be achieved. For example, Australia's regulations for wireline operations pressure tests are performance-based because they require operators to eliminate risks to ALARP, without specifying how that must be done. Most regulatory regimes use a mixture of both

types of policies and can, therefore, be assessed based on a sliding scale from entirely prescriptive regulations to entirely performance-based regulations.

4.2.2 Discussion of State Regulations

State regulations were found to be relatively brief and generally lacked the detail found in the regulations of the IRF countries. Of the 13 states researched, 5 were found to have no requirements for wireline pressure testing, 3 had performance-based requirements, and 3 had specific requirements to test at surface shut-in pressure (see Figure 6). Two states' regulations were categorized as neither performance-based or prescriptive but rather were considered "Other" and are discussed below.

Performance-based regulations are used by New York, Oklahoma, and Colorado. The three states frame the goals of the performance-based regulations differently. Colorado requires operators to "take all necessary precautions" to keep the well under control, and to "take all reasonable precautions" to prevent any oil well from flowing uncontrolled. Oklahoma requires that "all reasonable and prudent precautions shall be taken" to maintain well control, and also requires that all surface equipment "shall be maintained at all times so as to prevent leakage of oil, gas, saltwater or other deleterious substances." New York requires that operators establish "wellhead connections adequate to control blowouts," which is applicable to wireline lubricators.

Louisiana, Alaska, and Alabama have prescriptive requirements for operators to test wireline lubricators to the surface shut-in pressure before wireline operations commence, similar to BSEE's lubricator pressure test requirements in 30 CFR §250.620. Louisiana requires the lubricator to be tested to the "expected shut-in surface pressure." This language is nearly identical to BSEE's requirements. Alaska requires lubricators and wireline rams to be tested to the "maximum potential wellhead pressure" to be encountered. Alabama requires wireline pressure control equipment to be tested to the "anticipated surface pressure." While "expected shut-in surface pressure," "anticipated surface pressure," and "maximum potential wellhead pressure" are slightly different terminology, we assess that these three standards have identical meaning. They are the highest pressure that is anticipated to be encountered at the wellhead. The Schlumberger Oilfield Glossary defines shut-in pressure as:

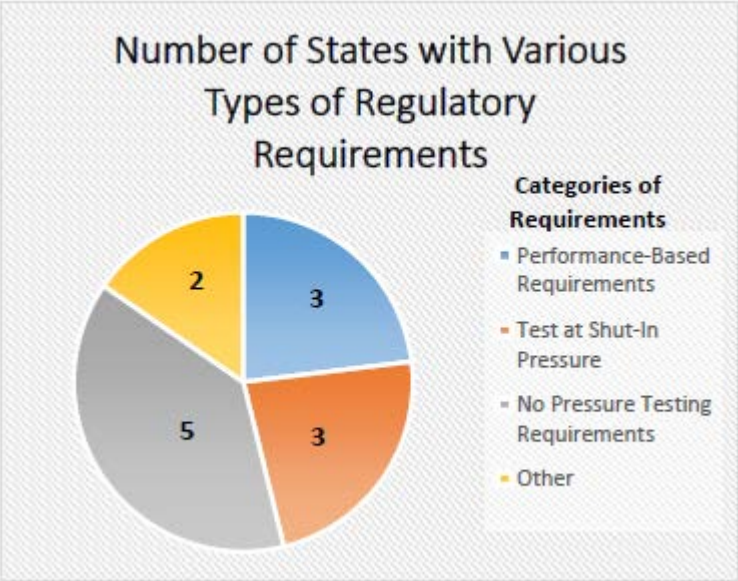

Figure 6. Numbers of the 13 states researched with various types of requirements

> *…The surface force per unit area exerted at the top of a well bore when it is closed at either the Christmas tree or the BOP stack. The pressure may be from the formation or an external and intentional source.* (Schlumberger, 2017)

California and Mississippi are categorized as "Other" in Figure 6 above. California requires all wireline operations to use a lubricator and other "wireline blowout prevention equipment," which includes wireline rams. The "pressure rating" of the lubricator must be greater than the surface shut-in pressure of the well. Here "pressure rating" has the same meaning as "rated working pressure," which is defined by the IADC Oil and Gas Drilling Glossary as:

> *...The maximum internal pressure that equipment is designed to contain and/or control. Working pressure is not to be confused with test pressure.* (IADC, 2017)

Mississippi's relevant regulation is not a requirement. It simply allows operators to use wireline rams, rather than a BOP, during certain completion activities. Discussion of IRF Country Regulations

Regulations of the 9 IRF countries researched were more detailed and specific than the state regulations researched and generally reflected the level of detail in the BSEE regulations in 30 CFR §250.620. Two countries were found to have prescriptive requirements for pressure testing of wireline pressure control equipment, 3 countries were found to have performance-based requirements, and 4 countries had no specific requirements for wireline operations pressure testing (see Figure 7).

Canada and Mexico are the 2 countries with prescriptive pressure testing requirements. While Canada has testing procedures and target test pressure written directly into its guidance documents, Mexico requires operators to follow API RP 54. Canada requires operators to pressure test wireline lubricators and wireline rams once they are installed on the wellhead and before operations commence, after any disconnection of the pressure seal, and once every 14 operational days. A low-pressure test should be performed at about 200 to 300 psi and should hold at least 90% of the test pressure for 5 minutes. A high-pressure test should be performed at a pressure greater than the MASP and should hold at least 90% of the test pressure for 10 minutes. The IADC defines MASP as:

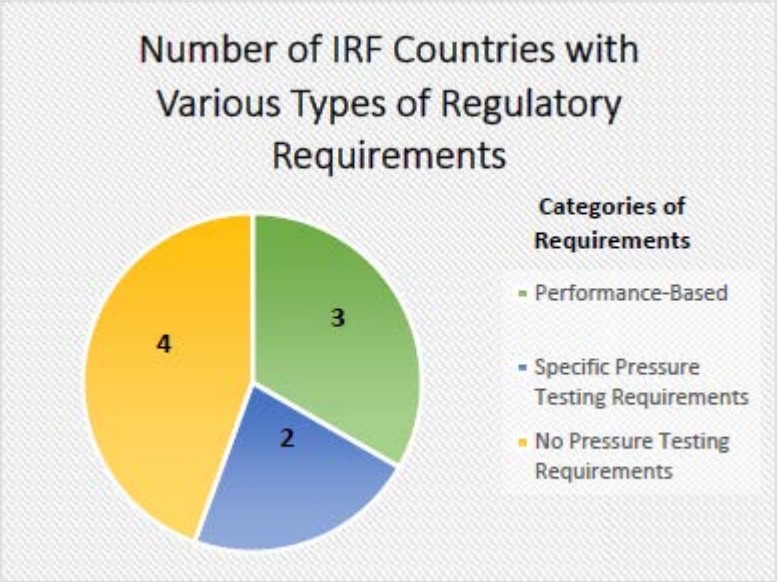

Figure 7. Numbers of the IRF Countries with various types of requirements

> *...A design load that represents the maximum pressure that may occur in the well during the construction of the well. NOTE: As with land and shelf wells, the MASP is a surface pressure.* (IADC, 2017)

Canada's requirements differ from Mexico's in that they apply to different phases of the life cycle of the pressure control equipment. Canada's pressure tests are to be applied in the field, when the equipment is installed on the wellhead. Mexico's requirements (API RP 54) apply to an annual certification test of the pressure control equipment that will be conducted at a test facility, rather than in the field. These non-field test are often referred to as "shop" tests. API RP 54 states that the wireline lubricator and wireline rams should be pressure tested every 12 months at a minimum to the equipment's rated working pressure. Wireline rams should be tested in the open and closed position. Pressure tests should hold the test pressure for 3 minutes, lower pressure to 0, then increase to test pressure once again and hold for 3 minutes.

Norway, the United Kingdom, and Australia all have performance-based requirements that allow operators to follow voluntary consensus standards to meet their regulatory requirements. Australia's guidance states that a variety of standards can be used by operators in order to lower risk to ALARP, but specifically cites NORSOK D-010 as an example. NORSOK D-010 requires a field pressure test of about

220 psi to 290 psi to be conducted and pressure to be held for a minimum of 5 minutes. A high-pressure test should be conducted to MASP or greater and should be held for 10 minutes without a pressure drop.

Norwegian regulations require pressure control equipment to be "pressure tested and function tested." Guidance for the regulations states that NORSOK D-010, DNVGL-OS-E101, and DNV-RP-E101 can be used by operators to satisfy the performance-based requirements. As discussed above, NORSOK D-010 describes requirements for field pressure test for wireline pressure control equipment. DNVGL-OS-E101 is a field test, similar to NORSOK D-010, while DNV-RP-E101 is a shop recertification test, similar to API RP 54. DNVGL-OS-E101 states that wireline pressure control equipment should be tested to 1.5 times the MWP of the equipment, the test pressure should be held for 15 minutes, and the test should be documented and recorded. DNV-RP-E101 states that wireline pressure control equipment must be disassembled, overhauled, pressure tested, and recertified every 5 years. The test pressure should be 1.5 times the MWP of the equipment.

The remaining countries researched — Brazil, Denmark, the Netherlands, and New Zealand — do not have specific requirements for wireline operations pressure testing included in their regulations or guidance policies. During a phone interview, a representative from WorkSafe New Zealand stated that, while the regulations contain no specific requirements for wireline pressure testing, government inspectors use API RP 54 when conducting inspections on oil and gas operations. The research team attempted to contact representatives from Brazil, Denmark, and the Netherlands, but phone interviews were not able to be conducted. A representative from Denmark confirmed, via email, that the Danish regulations do not have prescriptive requirements for pressure testing but do have a performance-based requirement to pressure test to ensure safe operations.

4.2.3 Discussion of Relevant Voluntary Consensus Standards

A number of countries cite specific voluntary consensus standards either for incorporation by reference into their regulations (as in the case of Mexico) or as a suggested method of complying with performance-based requirements (as in Norway and Australia). Voluntary consensus standards are technical standards developed by industry experts through voluntary participation and are not mandatory unless adopted or incorporated by reference by a government regulator. The standards discussed in this report are API RP 54, NORSOK D-010, DNVGL-OS-E101, and DNV-RP-E101. API RP 54 and DNV-RP-E101 are both methods for shop recertification tests, while NORSOK D-010 and DNVGL-OS-E101 are both methods for field tests of wireline pressure control devices. Table 14 shows a comparison of the various features and requirements of these four standards.

Table 14. Voluntary consensus standards for wireline operations pressure testing

Standard	Type of Pressure Test	Frequency	Low-Pressure Test		High-Pressure Test	
			Pressure	Hold time	Pressure	Hold time
API RP 54	Shop	Every 12 months	-	3 min minimum	Lubricator RWP	3 min minimum
DNV-RP-E101	Shop	Every 5 years	Conduct test, pressure not specified	Not specified	RWP	Not specified
NORSOK D-010	Field	Each rig up	220 to 290 psi	5 min minimum	MASP minimum	10 min minimum
DNVGL-OS-E101	Field	Each rig up	-	-	1.5 × RWP/MWP	15 min

The researched regulations, guidance, and standards used for wireline operations pressure testing in the U.S. states and IRF countries can provide a menu of policy options that BSEE can consider for adoption and potential updates to BSEE regulations. Generally, the policies include low-pressure tests, high-pressure tests, at or above the rated working pressure of the equipment, or expected surface shut-in pressure of the well. Another policy option is the use of regularly scheduled shop recertification tests, during which more rigorous overhaul and pressure testing can be conducted. BSEE could also choose to incorporate voluntary consensus standards by reference or use performance-based requirements that operators may fulfill by adhering to these standards.

5.0 RECOMMENDATIONS

This section provides recommendations for expanding BSEE's wireline pressure testing regulations in 30 CFR §250.620. Our recommendations are based on the three questions posed in the BSEE SOW under Task 2.

5.1 SPECIFY CONSISTENT TESTING AND PERFORMANCE CRITERIA FOR A SUCCESSFUL PRESSURE TEST

5.1.1 REVIEW OF RESULTS

Our results from the Task 1 Industry Survey and Task 3 Gap Analysis indicate that pressure tests for wireline pressure control devices should be divided into two general categories: field tests, which are performed in the field when the wireline pressure control devices are installed on the wellhead, and shop tests, which occur in a testing facility and are performed at a regular time interval (e.g., annually). Table 15 shows a summary of this study's findings related to field pressure testing including results from U.S. states, foreign countries, industry survey participants, and voluntary standards. Table 16 shows the same results for shop pressure testing. Table 15 and Table 16 do not distinguish between pressure tests for lubricators and wireline rams because they are typically tested simultaneously and, therefore, are subject to identical pressure test procedures. Table 17 presents the industry survey results for the issue of pressure testing when wireline equipment is rigged above a drilling BOP stack.

Table 15. Summary of Results for Field Pressure Tests for U.S. States, Foreign Countries, Industry Survey Participants, and Voluntary Standards

Entity (State, Country, Company, or Standard)	Field Low-Pressure Test	Field High-Pressure Test	Frequency
Alabama	None specified	Anticipated surface pressure or 70% of the minimum internal yield pressure casing, whichever is less	When installed, after the connection is broken, and at least once a week during operations
Alaska	None specified	Maximum potential wellhead pressure	Upon initial installation
Colorado	Performance-based, no pressure specified		Not specified
New York	Performance-based, no pressure specified		Not specified

Entity (State, Country, Company, or Standard)	Field Low-Pressure Test	Field High-Pressure Test	Frequency
Louisiana	None specified	Lubricator tested to expected surface shut-in pressure	Upon initial installation
Oklahoma	Performance-based, no pressure specified		Not specified
Australia	Performance-based, no pressure specified		Not specified
Canada	200 psi to 300 psi	> MASP	Upon initial installation, after the connection is broken, and at least once every 14 operational days
Norway	Performance-based, no pressure specified		Not specified
United Kingdom	Performance-based, no pressure specified		Not specified
Company A	250 psi to 350 psi	MASP + 500 psi	Upon initial installation, after the connection is broken
Company B	250 psi to 350 psi	MASP + 500 psi	Upon initial installation, after the connection is broken
Company C	None specified	Surface shut-in pressure + 500 psi to 1,000 psi	Upon initial installation, after the connection is broken
Company D	250 psi to 350 psi	20% above MASP	Upon initial installation, after the connection is broken
Company E	None	20% above MASP	Upon initial installation
NORSOK D-010	220 psi to 290 psi	≥ MASP	Upon initial installation
DNVGL-OS-E101	None specified	1.5 × RWP	Not specified
Note: Results for California, Florida, Mississippi, North Dakota, Pennsylvania, Texas, West Virginia, Brazil, Canada, Denmark, Mexico, Netherlands, New Zealand, Norway, API RP 54, and DNV-RP-E101 are not included in this table because their regulations do not specify any performance-based or prescriptive field pressure tests.			

Table 15 shows that, for those entities that specified a low-pressure field test, it was typically specified in the range of 200 psi to 350 psi. For entities that specified a high-pressure field test, it is typically performed at some safety margin above the MASP, or surface shut-in pressure. In some cases, the margin is a fixed value such as 500 psi, and in other cases, a proportional margin above MASP is used (e.g., 20% above MASP). Most entities require or cite field pressure testing when the pressure control equipment is initially installed and after any connection is broken. Table 16 shows a summary of results for shop pressure tests.

Table 16. Summary of Study Results for Shop Pressure Tests for U.S. States, Foreign Countries, Industry Survey Participants, and Voluntary Standards

Entity (State, Country, Company, or Standard)	Shop Low-Pressure Test	Shop High-Pressure Test	Frequency
Alaska	None specified	Wireline rams tested to permitted working pressure	Monthly
Australia	Performance-based, no pressure specified		None specified
Mexico	None specified	Lubricator tested to RWP	Annual
New Zealand	Performance-based, no pressure specified		None specified
Norway	Performance-based, no pressure specified		Recertification every 5 years
United Kingdom	Performance-based, no pressure specified		None specified
Company A	Equipment supplier performs shop tests, survey respondent did not know shop test procedures		Annual
Company B	Equipment supplier performs shop tests, survey respondent did not know shop test procedures		Annual
Company C	200 psi	1.5 x RWP	Annual
Company D	250 psi to 350 psi	RWP	Every 6 months
Company E	300 psi	RWP ≥ 5,000: 1.5 × RWP RWP < 5,000: 2 × RWP	Annual and every 5 years
API RP 54	None specified	Lubricator and wireline rams tested to lubricator RWP, wireline rams tested in open and closed position	Annual
DNV-RP-E101	Conduct test, pressure not specified	RWP	Every 5 years

Note: Results for Alabama, California, Colorado, Florida, Louisiana, Mississippi, North Dakota, New York, Oklahoma, Pennsylvania, Texas, West Virginia, Brazil, Canada, Denmark, Netherlands, NORSOK D-010, and DNVGL-OS-E101 are not included in this table because their regulations do not specify any performance-based or prescriptive shop pressure tests.

The results in Table 16 show that entities that perform or require low-pressure shop tests cite pressures of about 200 psi to 350 psi, a similar range as the field low-pressure tests. High-pressure shop tests are typically performed at RWP or some proportional margin above RWP, including 50% above RWP and two times RWP. Company E's approach to shop high-pressure testing is to use different proportional margins above RWP depending upon equipment RWP. For equipment with RWP of 5,000 psi or above, tests are performed at 50% over MASP. For equipment with RWP below 5,000 psi, the margin is twice the RWP. Shop test frequencies include every 6 months, annually, and once every 5 years. Of the entities that specified testing periods, most cited an annual testing requirement.

Table 17 shows the results for pressure testing when rigged above a drilling BOP. The table only shows results from the industry survey because none of the other data sources (i.e., state and country regulations, and voluntary standards) specifically addressed the issue of how to conduct field pressure tests with surface pump when rigged above a BOP.

Table 17. Summary of Survey Results for Rigging Above a BOP

Question	Company				
	A	B	C	D	E
How to Test Above a Rig BOP	Close blind shear rams and test to 1,000 psi	-	Close blind shear rams and test to 1,000 psi	-	-
Potential Damage to BOP Shear Rams from Pressure Above	-	Pressure from above will cause rams to leak	-	-	Damage to sealing surfaces of rams, leaks
Can Shear Rams Sever Wireline Cable?	-	Yes	-	-	Yes
Potential Solution	Test plug	-	Kill-weight fluid in well bore	-	Inverted blind rams, test plug

Some industry survey respondents were unable to provide information for all survey questions related to this issue, and this is reflected in the blank cells in Table 13 above. With the limited information available on this issue, it is clear that some companies are only testing their wireline pressure control equipment to 1,000 psi in the field. In most cases, a test pressure of 1,000 psi is not adequate to ensure safe wireline operations offshore. Field test pressure for wireline pressure control equipment should be determined by the pressures expected in the well bore, *not* the limitations of the BOP blind shear rams. Further, it is clear from industry participants that closing the drilling BOP blind shear rams and subjecting them to greater than 1,000 psi from above is a potentially unsafe practice, as reported by Company E, which is a BOP manufacturer. The blind shear rams are designed to withstand pressure from below and are designed such that pressure from below forces the rams together, resulting in a tighter seal. Company E reported that pressure from above will tend to pry the blind shear rams apart, potentially leading to leaks and damaging the sealing surface of the rams. Industry participants offered two potential solutions for testing to appropriate pressures when rigged above a BOP. Company A reported that they have tested the use of a special test plug that can be placed in the well bore below the BOP to create a seal, and Company E suggested that a set of inverted blind shear rams can be installed on the rig BOP and closed so that they are subject to pressure from the proper direction during pressure tests.

5.1.2 RECOMMENDATIONS

Based on the findings of this study, we recommend that BSEE update their regulations in 30 CFR §250.620 with the following requirements:

Field pressure tests for wireline rams and lubricators
Conduct field low- and high-pressure tests of the wireline rams and lubricator when installed and after each time a connection is broken.

- Low-pressure test from 250 psi to 350 psi
- High-pressure test 20% above MASP
    - Departures from this requirement should not be granted to allow for testing to only 1,000 psi when rigged above a drilling BOP. When lubricators are rigged above drilling

BOPs, operators should either use a test plug or install inverted blind rams in the BOP stack designed to hold pressure from above to allow pressure testing to 20% above MASP.

Maintenance shop pressure test for wireline rams and lubricators

Conduct low- and high-pressure tests periodically at a pressure test facility.

- Low-pressure test at any pressure from 250 psi to 350 psi
- High-pressure test at RWP

Recertification shop pressure test for wireline rams and lubricators

Conduct low- and high-pressure tests annually at a pressure test facility.

- Low-pressure test at 250 psi to 350 psi
- High-pressure test at 50% above RWP

5.2 DETERMINE WHAT SHOULD BE CHARTED AND HOW LONG THE PRESSURE TEST MUST BE HELD

5.2.1 REVIEW OF RESULTS

Our results from Task 1 and Task 3 of this study indicate that charting is nearly always performed during shop tests because the equipment is readily available at testing facilities. Therefore, our discussion of charting focuses on whether charting is used during field pressure tests. Table 18 shows our results for charting and for acceptance criteria for pressure tests, including test pressure hold time and allowable pressure drop during the test.

Table 18. Summary of Study Results for Charting and Test Pressure Hold Time

Entity (State, Country, Company, or Standard)	What is Charted?	Type of Chart	Test Pressure Hold Time
Canada	Charting not addressed		Low-Pressure Field Test: hold 90% of test pressure for 5 minutes High-Pressure Field Test: hold 90% of test pressure for 10 minutes
Mexico	Charting not addressed		Shop High-Pressure Test: hold test pressure for 3 minutes, lower pressure to 0, then increase to test pressure and hold for 3 minutes
Company A	Lubricator and wireline rams	Circular, analog	Pressure is held for 5 minutes with no allowable pressure drop
Company B	Lubricator and wireline rams	Digital and circular, analog	Low and high test; hold pressure for 5 minutes
Company C	Lubricator and wireline rams NOT charted	N/A	Shop High-Pressure Test: hold test pressure for 3 minutes, lower pressure to 0, then increase to test pressure and hold for 3 minutes
Company D	Lubricator and wireline rams	Digital and circular, analog	Hold pressure for 15 minutes, maximum pressure drop of 1%
Company E	Lubricator and wireline rams if required by customer	Digital and circular, analog	No visible leakage. Maximum pressure drop of 5% or 500 psi, whichever is lower

Entity (State, Country, Company, or Standard)	What is Charted?	Type of Chart	Test Pressure Hold Time
API RP 54	Charting not addressed		Shop High-Pressure Test: hold test pressure for 3 minutes, lower pressure to 0, then increase to test pressure and hold for 3 minutes
DNV-RP-E101	Lubricator and wireline rams	Not specified	Not specified
NORSOK D-010	Lubricator and wireline rams	Not specified	Minimum 10-minute hold time for field low- and high-pressure tests
DNVGL-OS-E101	Lubricator and wireline rams	Not specified	15-minute hold time for field high-pressure test
Note: Results for Alabama, Alaska, California, Colorado, Florida, Louisiana, Mississippi, North Dakota, New York, Oklahoma, Pennsylvania, Texas, West Virginia, Australia, Brazil, Canada, Denmark, Mexico, Netherlands, New Zealand, Norway, United Kingdom, API RP 54, DNV-RP-E101, NORSOK D-010, and DNVGL-OS-E101 are not included in this table because their regulations do not specify any performance-based or prescriptive requirements for charting and pressure hold time.			

As Table 18 shows, most information on charting collected in this study was provided by the industry survey. State and country regulations generally did not address charting; however, some voluntary standards do address charting. Industry survey participants reported using a mixture of digital charts and analog charts, which are typically circular paper charts. The study results show a wide variety of acceptance criteria for successful test pressure holding times and pressure drops. Holding times include 3, 5, 10, and 15-minute periods. Allowable pressure drops also varied and ranged from 0 psi, to a 1% drop, 5% drop, and a 10% drop. This range in practices and requirements suggests that updated BSEE regulations that specify testing procedures and acceptance criteria would be beneficial by creating more uniform practices among industry wireline operators.

5.2.2 RECOMMENDATIONS

Based on the findings of this study, we recommend that BSEE update their regulations in 30 CFR §250.620 with the following requirements:

Pressure-test charting

All wireline ram and lubricator field pressure tests must be charted, and records of the test results maintained for the life of the well, with the following exception:

- For wells with pressure below 1,000 psi, charting is not required; however, operators must document their observation of the pressure tests in a formal record such as a well log
- Both analog and digital charts are acceptable records

Acceptance criteria for pressure tests

All field pressure tests must be held for a minimum of 5 minutes.

- Maximum allowable pressure drop: 5%

5.3 DETERMINE WHEN IT IS APPROPRIATE TO TEST WITH WELL BORE PRESSURE AND WHAT BARRIERS NEEDS TO BE IN PLACE WHEN TESTING

5.3.1 REVIEW OF RESULTS

Table 19 shows our study results for pressure testing with well bore pressure and what well control barriers are required for wireline operations. To conduct a pressure test in the field, pressure must be introduced to the bodies of the wireline pressure control equipment. This can be done by either using a surface pump or introducing the equipment to the pressure present in the well bore. While testing with well bore pressure may be technically less complex and less costly, it does not allow for testing above the pressure present in the well bore. Testing above well bore pressure can only be achieved by using a surface pump.

Table 19. Summary of Study Results for Testing with Well Bore Pressure and Well Barriers

Entity (State, Country, Company, or Standard)	Field Test with Well Bore Pressure?	Barriers required or Used
Alaska	Not addressed	• Wireline rams • Lubricators
California	Not addressed	• Wireline rams • Lubricator
Louisiana	Not addressed	• Wireline rams • Lubricator
Canada	No, must test above MASP	Not addressed
Company A	No	• For slickline operations, bottom shear seal ram with two wireline rams above • For wireline operations, bottom blind shear ram, then inverted blind shear ram, with two wireline rams above • Lubricator
Company B	No	• Bottom blind shear ram, then an inverted wireline ram, then two upright wireline rams • Lubricator
Company C	Initial test with pump, other tests with well bore pressure	• For pressures < 10,000 psi, two sets of wireline rams • For pressures ≥ 10,000 psi, three sets of wireline rams • Lubricator
Company D	No	• Wireline rams for any operations under pressure • Lubricator
Company E	Only when surface pressure < 5,000 psi	• Wireline rams for any operations under pressure • Lubricator

Entity (State, Country, Company, or Standard)	Field Test with Well Bore Pressure?	Barriers required or Used
DNVGL-OS-E101	No, field test is to 1.5 × RWP	No specific barriers addressed
Note: Results for Alabama, Colorado, Florida, Mississippi, North Dakota, New York, Oklahoma, Pennsylvania, Texas, West Virginia, Australia, Brazil, Denmark, Mexico, Netherlands, New Zealand, Norway, United Kingdom, API RP 54, DNV-RP-E101, and NORSOK D-010 are not included in this table because their regulations do not specify any performance-based or prescriptive requirements for testing with well bore pressure or required well barriers.		

As Table 19 shows, most information gathered on testing with well bore pressure was collected from industry surveys. States and countries generally did not address the issue of testing with well bore pressure with the exception of Canada, which requires pressure tests above MASP, thus requiring the use of a surface pump. Company C and Company E had unique approaches to testing with well bore pressure. Company C performs the initial field pressure test using surface pump, then uses well bore pressure for subsequent tests. Company E only uses well bore pressure when surface shut-in pressure is less than 5,000 psi. Nearly all entities that described well barriers used during wireline operations cited the use of wireline rams and lubricators for all wireline operations under pressure.

5.3.2 RECOMMENDATIONS

Based on the findings of this study, we recommend that BSEE update their regulations in 30 CFR §250.620 with the following requirements:

Testing with well bore pressure
Lubricators and wireline rams must be tested with a surface pump to a safety margin above surface shut-in pressure for wells with more than 1,000 psi pressure.
Well bore pressure testing is allowable only for wells with surface shut-in pressure of 1,000 psi or less. For these low-pressure wells, the lubricator and wireline rams may be tested to surface shut-in pressure.

Barriers required for wireline operations
When pressure is present in the well bore, all wireline operations must feature at least one set of wireline rams and one device capable of cutting the wireline cable (e.g., a wireline cutter or a blind shear ram).

5.4 FINAL SUMMARY TABLE OF RECOMMENDATIONS

Table 20 presents a summary of all our recommendations for expanding BSEE's wireline pressure testing regulations in 30 CFR §250.620.

Table 20. Recommendations for Updated BSEE Wireline Pressure Testing Regulations

Category	No.	Recommendation
Pressure Testing	1	**Field pressure tests for wireline rams and lubricators** Conduct field low- and high-pressure tests of the wireline rams and lubricator when installed and after each time a connection is broken. ▪ Low-pressure test at any pressure from 250 psi to 350 psi ▪ High-pressure test 20% above MASP Departures from this requirement should not be granted to allow for testing to only 1,000 psi when rigged above a drilling BOP. When lubricators are rigged above drilling BOPs, operators should either use a test plug or install inverted blind rams in the BOP stack designed to hold pressure from above to allow pressure testing to 20% above MASP.
	2	**Maintenance shop pressure test for wireline rams and lubricators** Conduct low- and high-pressure tests periodically at a pressure test facility. ▪ Low-pressure test at any pressure from 250 psi to 350 psi ▪ High-pressure test at RWP
	3	**Recertification shop pressure test for wireline rams and lubricators** Conduct low- and high-pressure tests annually at a pressure test facility. ▪ Low-pressure test at 250 psi to 350 psi ▪ High-pressure test at 50% above RWP
Charting	4	**Pressure-test charting** All wireline ram and lubricator field pressure tests must be charted, and records of the test results maintained for the life of the well, with the following exception: ▪ For wells with pressure below 1,000 psi, charting is not required; however, operators must document their observation of the pressure tests in a formal record such as a well log ▪ Both analog and digital charts are acceptable records
	5	**Acceptance criteria for pressure tests.** All field pressure tests must be held for a minimum of 5 minutes. ▪ Maximum allowable pressure drop: 5%
Testing with Well Bore Pressure and Required Barriers	6	**Testing with well bore pressure** Lubricators and wireline rams must be tested with a surface pump to a safety margin above surface shut-in pressure for wells with more than 1,000 psi pressure. ▪ Well bore pressure testing is allowable only for wells with surface shut-in pressure of 1,000 psi or less. For these low-pressure wells, the lubricator and wireline rams may be tested to surface shut-in pressure.
	7	**Barriers required for wireline operations** When pressure is present in the well bore, all wireline operations must feature at least one set of wireline rams and one device capable of cutting the wireline cable (e.g., a wireline cutter or a blind shear ram).

6.0 GLOSSARY

Blind Shear Ram – a BOP closing element with a hardened steel blade designed to cut through drill pipe or wireline cable and close off the well bore to prevent a blowout (Schlumberger, 2017).

Blowout Preventer (BOP) – a large valve or series of valves on top of a well designed to close and prevent the loss of well bore fluids to the environment and maintain well control. Multiple BOPs are typically deployed stacked on top of each other and are referred to collectively as a BOP stack. (Schlumberger, 2017)

Blowout – the uncontrolled flow of hydrocarbons out of the well (Schlumberger, 2017).

Casing – a large diameter pipe typically cemented in place and designed to maintain the integrity of the well bore. (Schlumberger, 2017)

Charting – making a record of pressure over time, usually during a pressure test. Charting can be done with circular, analog charts that make a paper record, or with digital devices whose results can be saved and viewed on a personal computer (Recorders Charts & Pens, Inc, 2017).

Completion – a general term used to describe the processes and equipment used to bring a well from the drilling phase into the production phase. Completion operations can include perforations, installation of packers, and installation of production tubing (Schlumberger, 2017).

Drilling Phase – the phase of oil and gas activities in which a drill bit is used to drill a hole in the ground or the seabed. The drilling phase includes drilling of the well, installation of the casing, and cementing of the casing, and occurs before the production phase (Schlumberger, 2017).

Fishing Operations – the use of tools and techniques to remove debris or lost tools from the well bore (Schlumberger, 2017).

Function Test – a test of the moving parts of a device. In the case of a BOP or wireline rams, this involves opening and closing the rams (IADC, 2017).

Gas Buster – a device used to separate gas from liquids circulating within the well bore, which could include drilling fluids. (Schlumberger, 2017)

Incorporation by Reference – the process of incorporating text from one document into another document. Legal documents, such as government regulations, can incorporate other documents by reference, avoiding the need to copy the entire document. For example, regulations can make voluntary consensus standards legal requirements within their jurisdictions by incorporating them by reference.

International Regulators Forum (IRF) – a group of 10 countries' regulators of offshore oil and gas that collaborate to improve health, safety, and environmental protection (International Regulators' Forum, 2017).

Kill-Weight Fluid – an amount or density of drilling fluid that provides hydrostatic pressure to prevent the influx of formation fluids into the well bore (Schlumberger, 2017).

Lubricator – a length of tubular pipe fitted to the top of an under-pressure well designed to provide access for wireline and slickline tools (Schlumberger, 2017).

Maximum Anticipated Surface Pressure (MASP) – the maximum pressure that may occur at the surface of the well. This is equivalent to surface shut-in pressure (IADC, 2017).

Maximum Working Pressure (MWP) – the maximum pressure at which a valve can be operated. This is equivalent to rated working pressure (Schlumberger, 2017).

Pack-Off – a device used to create a seal in the annulus of the well, which consists of an elastomer element. Pack-offs form a seal in the annulus when pressure is applied from below (IADC, 2017).

Perforation – the creation of holes in the casing to allow communication between the reservoir fluids and the well bore so production can occur (Schlumberger, 2017).

Pressure Control Equipment – devices such as BOPs, wireline rams, lubricators, and quick test subs designed to seal off the well bore and maintain well control.

Production Phase – the phase of oil and gas operations in which hydrocarbons flow freely through the well bore in a controlled manner and typically through a Christmas tree before being brought to market (Schlumberger, 2017).

Pump-In Sub – a device that allows pumping of fluids into pressure-control equipment for the purpose of conducting hydrostatic pressure tests (Hunting, 2017).

Quick Test Sub – a device connected to the wireline pressure control assembly above the wireline rams at the position of the joint used to insert and retrieve tools from the lubricator. After the initial pressure test, subsequent pressure tests can be performed using the quick test sub (NOV, 2017b).

Rated Working Pressure (RWP) – the maximum pressure a piece of equipment is designed to hold. This is equivalent to maximum working pressure (IADC, 2017).

Shut-In Surface Pressure – the pressure at the top of the well bore when the well is sealed. This is equivalent to maximum anticipated surface pressure (Schlumberger, 2017).

Slickline – a single stand of cable used to lower and retrieve tools during well intervention operations (Schlumberger, 2017).

Stuffing Box – the annular space around a valve stem in a pressure sealing system into which a deformable packing, such as grease, is inserted (Schlumberger, 2017).

Swab Valve – the top valve on a Christmas tree that gives vertical access to the well bore (Schlumberger, 2017).

Voluntary Consensus Standards – technical standards developed by voluntary, non-governmental, domestic, or international organizations through agreed-upon processes. Voluntary consensus standards are made available for use free of charge or through non-discriminatory, reasonable fees (IEEE, 2017).

Well Intervention – the insertion of a tool into a well bore for maintenance or remedial activities. Well intervention is typically used interchangeably with well workover (Schlumberger, 2017).

Wireline – a braided cable used to lower and retrieve tools in a well bore (Schlumberger, 2017).

Wireline Cutter – a tool that is used to cut a wireline or slickline when a wireline tool becomes stuck in the well bore. The wireline cutter is attached to the wireline at the surface and dropped into the well bore. When the cutter contacts the stuck tool string, it severs and frees the cable (Schlumberger, 2017).

Wireline Ram (also referred to as a wireline valve or wireline BOP) – a manual valve attached to the wellhead and used during wireline operations to seal off the well bore and maintain well control (Schlumberger, 2017).

Wireline Ram (referring to a specific type of rams) – a type of valve consisting of two steel plates that seal off the well bore when closed, and feature a circular cut-out to accept a seal around a wireline cable (NOV, 2017a).

Workover - the insertion of a tool into a well bore for maintenance or remedial activities. Workover is typically used interchangeably with well intervention (Schlumberger, 2017).

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APPENDIX A WIRELINE OPERATIONS SURVEY QUESTIONS

The following questions were distributed to industry participants. In some cases, this set of questions was slightly modified or tailored to be more appropriate for certain companies based on their expertise.

Table A-1 Industry Survey Questions

#	Question
Test Pressure	
A1	What pressures are used for both routine and non-routine operations to test the wireline lubricator and wireline rams, if applicable (well bore or pump)?
A2	Is it acceptable to test with well bore pressure? If so, please explain and provide your operating procedures.
A3	If well bore pressure is allowed for testing, when will it be allowed and what safety precautions/barriers need to be in place?
A4	Is there a maximum pressure where you would not use well bore pressure?
A5	If it is acceptable to test with well bore pressure, how would you account for a safety factor?
A6	Is there any safety factor included in the pressure test above the expected pressure? If so, how do you calculate the higher pressure?
A7	If the well bore pressure is allowed for testing, how is the pressure released? Could you provide your operating procedures?
A8	Are the released fluids routed to a safe area, such as a flare stack?
A9	Please describe how the released fluids are routed.
Lubricator	
B1	Are lubricator tests being charted?
B2	What do you use as a guideline to chart pressure tests?
B3	What type of charts are you using?
B4	How/where do you store the charts?
B5	How long do you keep the charts?
B6	Do you use digital charts?
B7	The current regulations do not state that lubricator tests need to be charted. How are you verifying that the test is successful if the test is not being charted?
B8	How is the technique working for you?
B9	Are there alternative techniques you have considered? What are they?
B10	How long is a certified pressure test of the lubricator valid?
B11	Who is the one certifying it? What are their qualifications?
B12	Is there a low-pressure and high-pressure test performed? If so, what are the values?
B13	Do you always perform these low/high tests?

Wireline Ram	
C1	When are wireline rams used?
C2	What is the configuration of your wireline rams?
C3	When would you use blind shear rams?
C4	If wireline rams are used, is the related pressure test being charted?
C5	What do you use as a guideline to chart pressure tests?
C6	What type of charts are you using?
C7	How/where do you store the charts?
C8	How long do you keep the charts?
C9	Do you use digital charts?
C10	How long is a certified pressure test of the wireline rams valid?
C11	Who certifies? What are their qualifications?
C12	Is there a low-pressure and high-pressure test performed?
C13	How are the low- and high-pressure tests calculated?
C14	Do you always perform high/low-tests?
C15	Is a function test performed? A function test is defined as opening and closing the rams while not under pressure.
C16	What criteria do you currently use to determine whether a pressure test of the wireline rams is successful?
C17	What other criteria have you used in the past to gauge success?
C18	When testing the wireline rams, is a braided wireline used?
C19	If a smooth rod is used in place of a braided wireline, how can it be verified that the BOP will seal around the braided wireline?
Drilling BOP Limited Test Pressure	
D1	Most operators are requesting to lower their test pressure to 1,000 psi when stacked up on top of a BOP stack. This is a departure from the BSEE requirement to test to expected shut-in surface pressure when the lubricator is initially installed. Are the OEM's claims based on physical testing or modelling?
D2	What damage will the BOP incur if the pressure is greater than 1,000 psi?
D3	What type of damage do you expect the blind shear rams to suffer due to high-pressure testing greater than 1,000 psi?
D4	Is there a low-pressure test? If so, what would the recommended low pressure be?
D5	Is granting a departure from the requirement to test at expected shut-in surface pressure safe practice? Please explain your reasoning.
D6	Will the blind shear ram of the rig BOP shear and seal properly ~~on~~ after cutting the wireline rope?

D7	How is this known? Do the OEMs perform such a test?
D8	Is information publicly available on OEM specifications for blind shear rams? Is it possible to provide additional information that is not public? Please provide any documentation or website available
D9	If the wireline surface pressure equipment is not being tested to the maximum expected pressure, what alternatives are being used to alleviate this possible shortcoming, other than assuming the shear rams can cut the wireline and seal?
D10	Have you used any of their alternatives? How did they work?
Additional Questions	
E1	Are wireline pack-offs being pressure tested to handle the expected pressure?
E2	What is the criteria for testing wireline pack-offs?
E3	What procedure is being used to test a wireline pack-off?
E4	When is a grease injector tube (GIT) assembly used?
E5	How is a GIT assembly tested?
E6	Have you ever used a wireline cutting assembly? What are the criteria used for utilizing a wireline cutting assembly?
E7	Please list any additional requirements or procedures that are in place and implemented.
E8	Have you actually tested subsea test trees to shear wireline? If so, can you provide the acquiring documentation?
E9	Is there any new technology that you have used, or are considering using that we should investigate?