Guidance on How to Report Testing of BOP Shear Rams

Guidance and Clarification on How to Report Testing of Blowout Preventer (BOP) Shear Rams Used for Outer Continental Shelf (OCS) Oil and Gas Operations

Energy Systems Division

Report Authors

This report was prepared by the Global Energy Solutions (GES) Center team under the direction of Joe Braun.

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Used for Outer Continental Shelf (OCS) Oil and Gas Operations*

prepared by

Roy A. Lindley

Energy Systems Division, Argonne National Laboratory

Prepared for the U.S. Department of the Interior, Bureau of Safety and Environmental
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1.0 Introduction

The Bureau of Safety and Environmental Enforcement (BSEE) Well Control Rule (Subpart G)¹ was published on April 29, 2016, and became effective on July 28, 2016. This rule is part of BSEE regulations pertaining to well control equipment used for oil and gas operations on the U.S. Outer Continental Shelf (OCS).

In accordance with this new rule, BSEE seeks to obtain specific information from operators regarding the capabilities of shear rams in the Blowout Preventer (BOP). This information is required prior to beginning any operation involving the use of any BOP. Title 30 CFR 250.732(c)(2) of these regulations requires documentation of tests and associated engineering analyses and calculations to demonstrate the shearing and sealing capabilities of the BOP. Such documentation is consistent with and complementary to other documentation verifying the designs of individual components and the overall BOP system. Such verification is part of a testing process that demonstrates the performance and reliability of the equipment in a manner that is repeatable and reproducible.²

This document provides guidance concerning how to report BOP shear ram tests to support BSEE's regulatory role. The following information is suggested content:

1. Design and operational details about the specific shear ram(s) tested
2. Technical details on any tubulars and wirelines sheared
3. Description of the testing facility, test equipment, test equipment calibration, and certification
4. Testing procedures and methods used
5. Test results and acceptance criteria for the shearing tests and sealing tests
6. Design and operational details about the specific shear ram(s) for well control operations on the actual rig
7. Technical details on all tubulars and wirelines on the actual rig
8. Engineering calculations and analyses related to the testing and reconciliation of any technical differences between the testing and the actual intended operation
9. The quality assurance program(s) applied to the verification process

Moreover, a BSEE-approved verification organization (BAVO³) is to be used for certification, verification, and reporting of the BOP shear ram tests. (Please note that the BAVO requirements addressed in this document pertain only to BOP shearing and sealing.)

¹ Appearing in BSEE regulations at Title 30, Chapter II, Subchapter B, Part 250, Subpart G "Well Operations and Equipment."

² See Title 30 CFR §250.732 (b)(1)(ii) "....use of test protocols and analysis that represent recognized engineering practices for ensuring the repeatability and reproducibility of the tests, and that the testing was performed by a facility that meets generally accepted quality assurance standards."

³ See Title 30 CFR §250.732: BAVO requirements. BSEE is engaged now in developing BAVO acceptance criteria. BAVO information in this document will be updated when appropriate.

For high-pressure, high-temperature (HPHT) well conditions, there are additional reporting requirements. These requirements appear in a section of this document. In the event of a conflict between any regulation(s) and this document, the regulation(s) take precedence.

This document recommends a format and organization for the presentation of technical data. The actual submittal need not follow this template, but the content should be consistent with this document as shown beginning with Section 2.0. Conceptually, with documentation, the reported tests could be repeated with similar results without other input or knowledge.

2.0 General Information

2.1 Rig

At a minimum, provide the unique name and ownership of the drilling rig that is the reference of the report.

2.2 Well(s)

Provide the name(s) and lease identification details associated with the well(s) for which the shear ram verification is prepared. This shear report may pertain to several wells, all of which may not be known for the initial submittal of the report. Supplementary documentation or an amendment to this section may associate the drilling rig, drill pipe, and blind shear ram(s) with additional well(s). However, the additional wells should fall within the capabilities envelope of the blind shear ram testing.

2.3 HPHT Conditions

State whether HPHT conditions⁴ are anticipated for the wells associated with the report. If they are, regulations require supplemental information and assessments not required for nonHPHT wells. See Section 5.4 for more details.

⁴ See CFR Title 30, Volume 2 Section 250.804(b) for complete description.

3.0 Drilling Rig Equipment

3.1 Drilling Rig Shear Ram

Table 1 is a dual-purpose table that captures information for the rig shear ram(s) (similar to the tested shear ram in Section 4.2). When the actual rig equipment is not tested, multiple tables need to capture comparable information to support post-test engineering assessments. The table identifies whether the shear ram is actual rig equipment or representative equipment used for shear ram performance testing. In addition, the table (and other similar tables) includes consistent quality assurance information, including:

- quality assurance representative(s);
- other responsible individuals;
- individual affiliations and titles/roles; and
- date(s).

TABLE 1. BOP SHEAR RAM CONFIGURATION DATA SHEET

BOP and BOP System Equipment		
Identify whether information in this table pertains to actual rig equipment or representative equipment for the reported shear testing (check one).		
BSR Equipment: ☐ Actual rig BSR and actuator or ☐ Representative rig BSR and actuator		
Blowout Preventer (Shear Ram Only)	Value and Units	Comments and Notes
Manufacturer		
Description and Type		
Bore Size		
BOP Serial Number (s)		
Housing Manufacture Date		
Wellbore Rated Working Pressure		
Wellbore Rated Working Temperature		
Refurbishment and Inspection History		
Blind Shear Ram	Value and Units	Comments and Notes
Ram Manufacturer		
Description and Type		

Centering Feature ¹		
Ram Block Part Number(s)		
Ram Serial Number(s)		
Date of Manufacture		
Seal Manufacturer		
Seal Part Number		
Seal Durometer @ F		
BOP Blind Shear Ram Actuator	Value and Units	Comments and Notes
Manufacturer		
Description and Type		
Main Assembly Number(s)		
Serial Number(s)		
Date of Manufacture		
Rated Working Pressure (Main Actuator(s))		
Other Nameplate Information (e.g., Part Numbers, API Std, etc.)		
Manufacturer's Maximum Specified Shearing Pressure		
Piston Closing Area		
Piston Opening Area		
Piston Rod Area		
Piston Rod Stroke		
Closing Ratio (Pressure Ratio)		
Quality Assurance Record Information		
Preparer, Concurrence Name, Date, Affiliation, etc.		

3.2 Drilling Rig Shearable Tubulars and Wireline

Similar to Table 1, Table 2 captures information about tubulars and wirelines used for the wells identified in Section 2.2. Conceptually, the table would be prepared for each type of drill pipe on the rig identified in Section 2.1. The example table may not be suitable to communicate all information. For example, materials chemistry, quality inspections or certification records, and physical properties would need to be appended for completeness. To minimize confusion, a clearly identified single table is recommended for each tubular or wireline.

TABLE 2. SHEAR TEST SPECIMEN DATA SHEET

Test Specimen, Workstring or Tubing		
Identify whether the information in this table represents actual rig tubulars/wirelines or representative tubulars/wirelines (check box below). Provide a shear test specimen data sheet for any electric-, wire-, and slick-line sheared (information for each size and type of drillpipe, workstring, and tubing to be used in the well and not sheared to verify performance of shearing per 30CFR 250.732). For items not sheared in tests, similar information should be provided with calculations and engineering analyses.		
Type of Tubular or Line: ☐ Actual rig sample or ☐ Representative sample		
Description	Value and Units	Spec. Value and Units, Comments and Notes
Tubular Type (e.g., Drill Pipe or Wireline)		
Manufacturer		
Grade or Specification		
Nominal OD (in)		
Nominal ID (in)		
Weight per ft.		
Date of Manufacture		
Source (Specify Rig Name or Other)		
Physical Properties (as Specified in API 5DP)	Value and Units	Spec. Value and Units, Comments and Notes
Yield Strength (ksi)		
Tensile Strength (ksi)		
Elongation (%)		
Reduction of Area (%)		
Charpy (ft-lb at F)		
Hardness (HRC) and Location		
Chemical Properties	Value and Units	Spec. Value and Units, Comments and Notes
Chemistry		
Pipe Material Test Reports		
Quality Assurance Record Information		
Preparer, Concurrence Name, Date, Affiliation, etc.		

3.3 Drilling Rig Shear Ram Support Systems

Rig support systems for the blind shear ram include hydraulic supply pressure at the entry to the ram, the type of fluid required, the total volume required to close, and flow rates. The engineering systems analysis should be consistent with this information, and shear testing should represent anticipated field conditions.

3.4 Anticipated Well Conditions Pertinent to Shear Ram

3.4.1 Well Parameters

Anticipated well environmental conditions and ranges of conditions that are important to shear ram performance should be reported. These include, but are not limited to:

- location;
- water depth;
- total vertical depth;
- total well depth; and
- chemistry (hydrocarbons, drilling fluid, acids, H₂S, etc.).

3.4.2 Maximum Anticipated Surface Pressure (MASP)

The regulations at 30 CFR **250.734(a)(1)(ii)** require that at least one shear ram be capable of sealing the wellbore after shearing under maximum anticipated surface pressure (MASP)⁵ conditions as defined for the operation. Per 30 CFR 250.730(a), the working-pressure rating of each BOP component (excluding annular(s)) must exceed MASP as defined for the operation. For a surface BOP, MASP is to be calculated at the surface. For a seafloor BOP, MASP is calculated at mudline conditions.

Adjustment of shear pressure for MASP is mandatory for appropriate engineering comparisons of shearing requirements to hydraulic supply capabilities. Reported shearing pressure requirements with MASP adjustment must never exceed the rig's available hydraulic supply pressure (e.g., accumulator) or rated working pressure.⁶

⁵ MASP is defined in CFR §250.448(b).

⁶ API Standard 53 (4th ed. November 2012) at 6.5.10.7.5 : “Due to the variations in pipe properties and corresponding shear pressures, the maximum expected pressure for shearing pipe should be less than 90 % of the maximum operating pressure. An additional risk assessment should be performed if the shear pressure is higher than 90 % of the maximum operating pressure.”

3.4.3 Maximum Anticipated Well Pressures and Temperatures

Shear ram performance documentation includes maximum anticipated well pressures and temperatures. If these exceed HPHT thresholds, additional information is required per the regulations (see Section 5.4.)

4.0 Shear Ram Testing Information

4.1 Testing Facility Details

Document facts and details about the testing facility, as listed in Table 3 (or equivalent).

TABLE 3. TEST FACILITY INFORMATION

Test Facility	Comments/Notes (Attach Additional Pages as Needed)
General Information Required	Enter Information.
Facility Name	
Facility Physical Address	
Test Supervisor Name and Title	
Client Name and Address	
Client's Technical POC Name, Title, and Contact Information	
Witnesses (e.g., Third Party, BAVO, Client, etc.) Name, Title and Contact Information	
Hydraulic System (for Example)	Enter Information.
Pump Nameplate Make, Model, Size, HP, Rating, S/N, etc.	
Regulator Make, Model, Size, S/N, Test Setting (psig), etc.	
Maximum Manufacturer-Rated Working Pressure (psig)	
Maximum Rig Supply Pressure (psig)	
System Configuration (Attach P&ID)	
Test Hydraulic Fluid Product Trade Name and Mixture	
Data Acquisition System¹	Define and Characterize System.
Chart Recorders - Digital Acquisition System Manufacturer(s), Model(s), S/N, Calibrations and Validations	
Instrumentation¹	Define and Characterize System
Closing Pressure, Chamber Pressure Transducer Manufacturer, Model, S/N, etc.	E.g., Maximum Scale (25 – 75% of Full Scale), Accuracy (% of Full Scale) Records of Last Calibration, Measurement Frequency, etc.
Opening Pressure, Chamber Pressure, Transducer, and Location on BOP	“
Flowmeters	“
Backup or Secondary P-Transducers	“

Measuring and Examination	“
Quality System	Indicate Whether Measured or Specification.
Standard	Identify Standard, System Implemented, etc.
Last Audit (MDY) ¹	Audit Findings and Certification Period Coverage
Quality Assurance Record Information	
Preparer, Concurrence Name, Date, Affiliation, etc.	

¹ Include documentation of the measurement devices and sensors used, date of last calibrations and calibrated ranges, etc.

4.2 Shear Ram(s) Tested

Shear ram performance documentation must provide design and operational details about the specific shear ram(s) tested. If the equipment tested is not the actual rig shear ram (or one of the rig’s identical shear rams), Table 1 (above) has a dual purpose and can be used to capture the information for either piece of equipment (tested or rig shear rams). When the tested equipment is not the actual rig equipment, the table contains comparable information that supports post-test engineering performance assessments.

¹ Blind shear descriptions need to include the pipe-centering device, and that device should be part of the blind shear testing (30 CFR 250.734 (a)(16)). Per Subpart G, the centering device must be installed in the BOP no later than May 1, 2023.

BOP stack traceability shall include information about the quality system applied by BOP manufacturer(s). This includes QA certification by an entity meeting the requirements of 30 CFR 250.730 (d).

4.3 Test Setup

The testing documentation must present details of the actual shear ram placement in the facilities test setup. Important topics include the following:

- Interfaces with facility test system (hydraulic connections, instrumentation, etc.)
- Shear ram sensors and transducers and locations (and current calibration certificates)
- Test specimen support system hardware
- Test specimen constraints (mechanical apparatus features)
- Centering mechanism (if any)
- Leakage examination (procedure and acceptance criteria)
- Assembly and makeup of the shear ram assembly (photograph, manufacture requirements)

- Piping and instrumentation diagram (P&ID)
- Position of test specimen in bore

These subjects must be consistent with the test procedure.

4.4 Test Procedure/Protocol Followed and Acceptance Criteria

The procedure/protocol used for the shear ram must be documented. All steps of the test sequences, including any exceptions, must be listed. Also, a sound protocol should include acceptance criteria. Independent of protocol source or reference documentation, this must be a step-by-step description of test procedures, beginning with sample preparation and proceeding through ram block and operator function tests, pipe sample positioning, pipe shearing and sealing tests, and inspections.

Justification for off-center and side-load positioning and shearing of pipe must be informed.⁷ This is to be consistent with regulatory implementation schedules (see the individual sections of 30 CFR 250.700+ for effective dates of the Well Control Rule subsections).

Specific criteria and subjects are a component of documentation about testing that adequately supports BAVO organization verification roles (see **30 CFR 250.732**). Examples of these areas of BAVO verification include the following:

- Test equipment
- Facility and personnel qualifications
- Representation of test facility relative to actual rig and field conditions
- Shear and seal pressure and temperatures
- Data recording/capturing and reporting of test results

4.5 Test Specimen Selection

This section must inform how shear test samples were chosen and prepared and how the samples are typical of the rig tubulars (drill pipe, workstring, tubing, electric lines, wirelines, etc.) to be used in the well. This should address metallurgy, design specifications/standards, actual physical and chemical properties, size variations, sample preparation cutting methods, length of test

⁷ Conceivably these could be somewhat design dependent with regard to the most challenging shearing situation in terms of shearing force or post shear sealing. For such a circumstance, prudent engineering practice and risk management would address these distinctions.

sample, and position in test specimen section. For hot cutting, a heat-affected zone is shown outside the shear test plane on the test specimen and includes technical assurances regarding the extent of any heat affected zones.

4.6 Shear Ram Inspection Information

4.6.1 Pretest Shear Ram Inspection Report

Prior to testing a shear ram, there should be full physical inspection documentation as to the condition.

The scope of the inspection includes the following:

- Shear blades
- Ram blocks
- Sliding surfaces of the ram block
- Centering mechanism (as applicable)
- Seal surfaces
- Elastomers and seals
- Housing,
- Operator(s)

This documentation identifies the applicable manufacturer's specifications and indicates whether the shear ram assembly complies. If modifications occur during testing, the nature and extent of such should also be described. Finally, include BAVO verification of tested BOP shear ram assembly condition (third party prior to BAVO implementation).

4.6.2 Post-Test Shear Ram Inspection Report

As outlined in the paragraph 4.6.1, a post-test inspection is to be reported as part of the verification of general shear ram performance. This would include a qualified statement that the unit complies with applicable manufacturer's specifications and is suitable for subsea service (with possible parts replacements) as intended for the well conditions described in Section 2.2.

4.7 Test Results

Table 4 is a suggested format to summarize the results of each shear test. Actual recorded data should accompany such charts. This data could be plotted digital data or recorder charts with

notations of key events and visual documentation (photographs or video--see Section 4.8 for further details), including the following:

- BOP shear ram speed and pressures throughout the test (e.g., circular charts or other visual documentation)
- Start/end of test
- Initial specimen-ram blade contact, and point of shear¹
- Start/end of block travel
- End of test
- Indication of whether peak pressure exceeded manufacturer's specification or limitation of the BSR component
- Pressure test start
- Pressure buildup
- Hold pressure hold
- Pressure reduction
- End pressure test
- Operator hydraulic closing and opening areas
- NDE examination results (before, after, and as applicable during testing series)

TABLE 4. SHEAR TEST SUMMARY RESULTS

BOP Shear Test Results		
Identify whether the information in this table represents actual rig tubulars/lines or representative tubulars/lines (check one item per line below).		
Test Sample Orientation : ☐ Centered ☐ Off Center (unsecured) or ☐ Fixed To Wall (secured) or ☐ Other (explain)_____		
Test Sample No. (if more than 1): ☐ One ☐ Two ☐ Three or ☐ Other (No. _____)		
Test Data Summary	Value and Units	Comments/Notes
Date of Shear (DMY and Time of Shear)		Success or Failure:
Opening Pressure (psi)		
Opening Volume (gal)		
Peak Close Pressure (psi)		
Peak Close Volume (gal)		
Peak Shearing Force @ POS ¹ (kips)		

Sheared Specimen Description/ID		
Specimen Measured OD (in)		
Low Pressure Test (psi)		
High Pressure Test (psi)		
Ram Closure Time (sec)		
Upper Specimen, H x W (in.)		
Lower Specimen, H x W (in.)		
Visual Examination ¹		
Quality Assurance Record Information		
Preparer, Concurrence Name, Date, Affiliation, etc.		

¹ Visual examination to include photos of test specimen, shear blades, ram packers, and other critical components prior to and after testing and be made part of the report.

4.8 Photographic and/or Video Records⁸

The general objective of this documentation should be to capture the testing from setup to post-test assessments and inspections.

4.8.1 Facility and Test Setup

Photography of the facility test system and test setup (Figure 1, Figure 2, Figure 3, and Figure 4) accompanies piping and instrumentation diagrams (P&ID)s and includes details of the actual shear ram tested. Photographic documentation is marked to positively associate the information with other information in the shear ram performance assessment report (for example, the shear ram, client, date, and time).

4.8.2 Shear Results—Tubulars

⁸ Note: the pictures and figures in this report do not have associated copyright release.

The report contains photography of sheared specimens (as in Figure 5). This documentation should be marked for positive association with other tables, charts, and narrative in the shear report.

4.8.3 Shear Ram Condition (Before and After) Tests

Provide photographic documentation of the shear ram cutting and sealing mechanism before and after test shears (Figure 6 and Figure 7). Identify and characterize any repairs or alterations performed between tests. Logically this would include examinations verifying conformance with the manufacturer's specifications.

FIGURE 1 PLACEHOLDER FOR SHEAR RAM TEST SUPPORT SYSTEMS AT (NAME) FACILITY (IMAGES, FIGURES, AND/OR DRAWINGS OF CONTROL, DATA ACQUISITION, AND MECHANICAL EQUIPMENT)

This is visual documentation of the blind shear ram test setup including supporting systems and controls as detailed in Table 3. This may require several images, figures, and/or drawings. Part or all could be a video or video monitor screen shots.

FIGURE 2 EXAMPLE PHOTOGRAPHS OF SHEAR RAM READY FOR SHEAR TESTING

This is visual documentation of the BOP shear ram test setup prior to testing. This may require several images to document beyond the examples provided here. Part or all could be a video.

Above pictures reproduced courtesy of Bastion Technologies, Inc.

Figure 3 Placeholder for Tubular Specimen and Specimen Support Apparatus (Images, Figures, Sketches and/or Drawings)

This is visual documentation of how the tubulars (listed in Table 2) are supported for the shear tests including any constraint hardware in the bore area. This may require several images, figures, sketches, and/or drawings. Part of documentation could be video.

FIGURE 4 PLACEHOLDER FOR SHEAR SPECIMEN IN BORE OF SHEAR RAM JUST PRIOR TO SHEAR TEST (IMAGES)

This is visual documentation of tubulars (listed in Table 2) in the well bore ready to be sheared. This may require several images to illustrate different tubulars and the test conditions defined in the regulations. Part of documentation could be videos.

FIGURE 5 PLACEHOLDER FOR RAM BLOCKS BEFORE AND AFTER SHEAR AND SEAL TEST(S) (IMAGES)

This is visual documentation of the ram blocks/shear blades before and after shear testing. Logically this includes information about shear cutting edge condition, restoration, or shear blade replacement during the test sequence.

FIGURE 6 EXAMPLE PHOTOGRAPH OF SHEARED TUBULAR (IDENTIFICATION) SHOWING SHAPE DISTORTION (UPPER AND LOWER SHOWN)

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FIGURE 7 PLACEHOLDER FOR SHEAR RAM SEAL ASSEMBLY (BEFORE AND AFTER SEAL TESTING-IMAGES)

This is visual documentation of the BOP shear ram seals –pre and post testing.

FIGURE 8 PLACEHOLDER FOR SHEAR RAM INSPECTION UNDERWAY (IMAGES/DIAGRAMS)

Good practice is to verify that the shear ram assembly complies with manufacturer's specifications particularly before the test. Post-test verification is logical in the interest of safety independent of whether the tested assembly is placed into service after testing.

5.0 Engineering Analyses and Assessments

Sections 2.0, 0, and 0 document information about the well, the drilling rig and rig support systems for BOP(s), the specific BOP(s) used by the drilling rig, the BOP shear ram actually used for shear tests, the rig drill pipe and wire, and shear test results. Through all this, the simplest case is when the rig's BOP is used for actual shear testing with tubular and wire samples from rig stock. In this instance, there are the fewest concerns regarding how representative test results are of actual subsea operations and field conditions. On the other extreme, a tested BOP shear ram could be markedly different from a rig BOP shear ram, as could the tubulars and wires actually sheared. For such situations, there are technical concerns and uncertainties regarding the predicted performance of the actual BOP. In addition to the normal adjustments associated with BOP testing in a controlled environment (as compared to a subsea one), a thorough engineering analysis would identify and quantify performance differences between the actual rig BOP and the tested equipment. The ultimate goal is to demonstrate that shearing can occur with certainty and that there is adequate design margin to do so. The following section 0 identifies key areas of such engineering comparisons and analyses.

5.1 Theoretical Shear Calculations

A comparison of current test results to historical experience can be useful to address issues such as whether the rig BOP support system has adequate supply pressure to shear all tubulars.

5.1.1 Calculation Basis

There are engineering methods and formulas for predicting shear force for a given tubular and shear ram combination. Some methods could arise from fundamentals, while others may be empirical (such as a correlation of data collection). Independent of the basis, documentation should provide formula(s), values for constants, definitions of variables and associated units, and narratives about whether a particular formula is specific to the shear blade designs of the situation and whether the formula results represent the average or some other portion of supporting data. Conceptually, a formula or mechanics model could even be purely theoretical, but some level of actual validation is necessary. The formula or predictive method(s) must be referenced sufficiently to enable BSEE personnel (based on the reference) to request and inspect the validation information and protect intellectual property.

5.1.2 Calculation Results

Normal documentation includes shear prediction calculations for the actual and sheared (if different from actual) tubulars. These need to be representative of the tubular and shear blade/actuator design combination tested. Complete supporting documentation shows the formula, variables and units, constant values, calculated results, and notes about whether the prediction pertains to actual rig equipment or tested equipment. A thorough presentation links the calculated results to the summary tables presented previously (or equivalent).

5.1.3 Compare Calculations to Test Results

Shear force calculations are one means to interpret shear test results. If a correlation is intended to capture 95 percent of or all data, yet the actual shear results are greater than the correlation, there would be considerable cause for concern, and an explanation would be necessary. If the test results fall substantially below a correlation producing an average force estimate, there is a lesser concern. Nevertheless, a technical/statistical explanation is still appropriate to quantify possible variances in the shear test results and the associated shear testing acceptance criteria adopted for the testing.

5.2 Shear Ram Support Systems Capability Assessment

The hydraulic system for shear testing should resemble field conditions and capabilities, but there may be differences out of practicality. Potential differences are the following:

- Hydraulic fluid type
- Supply pressures and pump flow rate at shear ram manifold
- Fluid temperature
- Regulatory set points,
- Different valves and line resistance
- Hydraulic head
- Volume of fluid available

The document should include an assessment of these and other differences regarding the performance of the actual subsea BOP shear ram. Presumably, the system should be able to power the shear actions based on the worst-case and most conservative shear requirements, whether they are calculated or actual test results.

5.3 Certainties Assessment

5.3.1 Expected Variation in Test and Calculated Shear Pressures

Since any shear test can be unusually high or low and since possible variance is large when sample size is small, the relative certainty of test results is important. A statistically significant number of shear tests is unlikely to support shear performance because of the time and cost. The next best option is to compare calculations and data and know and show expected variances of that data. In so doing, conservative requirements can be determined for the shear ram support systems with a degree of certainty.

5.3.2 Comparisons of Rig Versus Tested Equipment

A shear and seal test performed at an onshore test facility (e.g., OEM test facility) cannot exactly duplicate in-field equipment, applications, and conditions (even if the rig's BOP and test specimen were used in the test at the onshore facility). Thus, a documented systems engineering assessment is necessary to evaluate substantial technical differences and similarities. These assessments must support the technical argument that the tests performed onshore reflect equipment, applications, and conditions in the field sufficiently to certify that the rig's shear rams, control system and components, and accumulator will shear all tubulars and lines in the hole. Some typical considerations are the following:

1. Adjustments to required shearing pressures (heads, mechanical losses, MASP, etc.)
2. Hydraulic fluid type and characteristics, including viscosity and thermal stability. Define and document technical specifications and capabilities of the entire hydraulic system supplying pressurized fluid to shear rams for shear testing (hydraulic fluid, pumps, valves, hoses, piping, regulator(s), etc.). Comparative assessments should include a risk assessment if shear pressure exceeds 90 percent of system capability.⁹
3. Physical, mechanical, and chemical pipe properties prior to shearing.¹⁰ In addition to the physical and mechanical properties (e.g., the wall thickness (in.), hardness (HRC), and outside diameter (in.)) identified in Table 2, which are required to be measured prior to shearing at the three locations along the pipe length, a placeholder line has been included for the pipe's chemical properties. Preferably, these chemical properties (as per pipe manufacturer) characterize significant variations between that from the pipe manufacturer and that measured prior to shearing as part of the sample preparation. This physical information can support technical explanations for certain variations or deviations.
4. Physical properties of sealing elastomers and temperature variations. The shear and seal tests may be conducted at 70°F, but actual conditions could vary from near freezing to something considerably higher. Further, there are possible issues of chemical compatibility for a sealing elastomer with the anticipated fluids that may be present.

⁹ See API Standard 53 (November 2012), at Sections 6.5.10.7.5 and 7.6.11.7.5 for details.

¹⁰ 30 CFR §250.732 (b)(1)(v)

5.3.3 Available Maximum Hydraulic Pressure for Adjusted Peak Shear Pressure

A fundamental issue is whether the rig or field hydraulic system has adequate pressure capability to shear the rig tubulars and wires. While other limits may exist, one comparison should be the available supply pressure at the shear ram operator input based on the maximum hydraulic pressure required during the shear process. Normally, this is greater than the pressure required at the time of shear.

5.4 HPHT Specific Requirements

The *Verification Test Report* (this document, including clearly referenced supplements or addenda) shall contain additional information if the BOP stack is expected to experience HPHT environment. Certain verifications must be documented and submitted before beginning HPHT operations.¹¹ The HPHT requirements include the following:

- Certification that the third-party verification organization conducted a detailed review of the BOP package design to ensure that all critical components and systems meet recognized engineering practices
- Verification that the designs of individual components and the overall system have been proven in a testing process that demonstrates the performance and reliability of the equipment in a manner that is repeatable and reproducible¹²
- Verification that the BOP equipment will perform as designed in the temperature, pressure, and environment that will be encountered
- Verification that the fabrication, manufacture, and assembly of individual components and the overall system uses recognized engineering practices and quality control and assurance mechanisms
- Complete material and quality control over contractors, subcontractors, distributors, and supplies at every stage in the fabrication, manufacture, and assembly process¹³

¹¹ See 30 CFR §250.732 (c)

¹² Identification of all reasonable failure modes and evaluation of design verification tests. See CFR §250.732 (c)(2)(i) and (ii) for complete regulatory language

¹³ 30 CFR §250.732 (c)(4)

6.0 Statement on Shear Ram and System Fitness for Service

This section is a consolidated summary and conclusion from the testing and engineering analyses conducted for the proposed well drilling. This section clearly identifies the BAVO¹⁴ (once the requirement goes into effect), per 30 CFR 250.732.

6.1 Shear Ram

Specifically state and attest that the rig shear ram performance, as configured in the BOP system on the actual rig, is adequate to shear any and all rig tubulars and wire.

6.2 Support System

Specifically state and attest that the BOP support system on the rig is adequate to assure required performance of the subsea shear ram. Local supply pressure is a key consideration, but other technical issues should also be addressed if there is an expected limitation or constraint.

6.3 Caveats and Limitations

List any and all caveats and limitations associated with the statements on shear ram performance, associated support systems, and overall fitness for service. This would include any operational or compatibility areas found in the assessments (based on testing and engineering considerations) to perform at the proposed location, including the maximum environmental and operational conditions that the MODU is designed to withstand, as explained in 30 CFR 250.713 and 30 CFR 250.734.

¹⁴ See Title 30 CFR §250.732 BAVO requirements. BSEE is engaged now in developing BAVO acceptance criteria. BAVO information in this document will be updated when appropriate.

7.0 References

List all references cited in the report. The information should be complete enough that BSEE can acquire the information from open sources or, if there are proprietary issues, request the information from sources not generally available to the public.

Appendices

A: Quality Assurance Program(s)

Testing Activities

Provide summary of QA program or reference program documentation available to BSEE upon requests and explain applicability relative to testing facility. Topics include the following:

- Facility test equipment
- Data recording equipment
- Procedures
- Protocol process
- Audits
- Responsible personnel
- Quality documentation

Use API Spec Q1, 8th edition equivalent as a minimum (officially incorporated by reference at 30 CFR 250.198) or later edition, based on justification per regulations. Also, complete documentation is expected to identify BAVO principals performing, reviewing, and approving the report content, along with their organizational affiliation and dates.

Engineering Analyses

Provide summary of QA program or reference program documentation available to BSEE upon requests and explain applicability relative to testing facility. Topics include the following:

- Procedures
- Peer reviews
- External (third party or BAVO) review
- Audits
- Responsible personnel
- Quality documentation

Use API Spec Q1, 8th edition equivalent as a minimum or a later edition if officially incorporated by reference at 30 CFR 250.198). Also document the BAVO principals performing, reviewing, and approving the report content along with their organizational affiliation and dates.

B: Personnel Qualification and Credential Records

BAVO Certifications

Professional and Engineering Qualifications/Registrations

Other Pertinent Qualifications

C: Miscellaneous Information

Manufacturer's Specifications

Special Test Requirements

Procedures as Applicable

Tubular or Wire Chemistry

Tubular or Wire Physical Property Reports

Pre- and Post-Test Inspection Reports

Raw Shear Test Data or Recording Charts

Energy Systems Division

Argonne National Laboratory
9700 South Cass Avenue, Bldg. *#362
Argonne, IL 60439

www.anl.gov

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