Blowout Prevention System Safety

2017 Annual Report

U.S. Department of Transportation
Bureau of Transportation Statistics

2017 Annual Report

Blowout Prevention System Safety

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EXECUTIVE SUMMARY

The 2017 Annual Report: Blowout Prevention System Safety, produced by the Bureau of Transportation Statistics (BTS), summarizes blowout prevention (BOP) equipment failures on marine drilling rigs in the Gulf of Mexico (GOM) Outer Continental Shelf (OCS). It includes an analysis of equipment component failures and other key information such as root causes of failure events, follow-up response to failures, and opportunities to improve data quality. The terms "notice," "notification," "report," and "event" refer to a reported equipment component failure and are used interchangeably in this report.

BTS, a principal federal statistical agency, entered an interagency agreement with BSEE in 2013 to develop, implement, and operate the SafeOCS program for the collection and analysis of data to advance safety in oil and gas operations on the OCS.[1] In 2016, under a memorandum of understanding with BSEE,[2] the SafeOCS program was expanded to include the confidential reporting of equipment failure data required under the Well Control Rule (WCR),[3] published by the Bureau of Safety and Environmental Enforcement (BSEE), Department of the Interior. The confidentiality of all SafeOCS data, individual reports, and pre-decisional documents is protected under the Confidential Information Protection and Statistical Efficiency Act of 2002 (CIPSEA) (44 USC 3501 note)[4].

To review equipment failure notifications, BTS retained subject matter experts (SMEs) in drilling operations, equipment testing, equipment design and manufacturing, root cause failure analysis, quality assurance and control, and process design. BTS also consulted with an external technical review team including representatives of the International Association of Drilling Contractors (IADC), contractors, and operators.

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[1] Interagency Agreement Between Department of the Interior Bureau of Safety and Environmental Enforcement and Department of Transportation Bureau of Transportation Statistics for Development and Operation of a Confidential Near Miss Reporting System (Aug. 15, 2013), available at https://www.bsee.gov/newsroom/partnerships/interagency.

[2] Memorandum of Understanding Between U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement and U.S. Department of Transportation, Bureau of Transportation Statistics (Aug. 18, 2016), available at https://www.bsee.gov/newsroom/partnerships/interagency.

[3] 81 Fed. Reg. 61,833 (Sept. 7, 2016).

[4] For more information on CIPSEA, refer to Appendix A.

In 2017, the first full year of WCR reporting, 18 of 25 operators associated with rig operations in the GOM reported 1,129 equipment component failure events. The reported events occurred on 45 of the 59 rigs operating in the GOM during this period.[5] Based on information sent to BSEE, the 18 reporting operators account for 90.2 percent of new wells drilled. Both types of BOP stacks (subsea and surface) were associated with component failures and the majority of notifications were associated with the more complex subsea BOP stacks (92.5 percent).

Other key findings include:

- The top four reporting operators represented 81.8 percent of reported component events and 32.7 percent of wells spud[6] in the Gulf of Mexico for 2017.
- There was a decrease in overall reporting from 2016 to 2017. The event reporting rate adjusted for rig activity (defined as events per 1,000 BOP days) decreased from 122.3 in 2016 to 59.8 in 2017.
- There was an increase in reporting equipment component failures while not in operation for rigs with subsea BOP stacks. The percent of subsea, not-in-operation reports for 2017 was 86.4 as compared to 79.8 percent for 2016.
- There was a decrease in the rate of unplanned stack pulls[7] for rigs with subsea BOP stacks. In 2016 the rate was 7.2 percent and in 2017 it was 5.6 percent.
- Based on follow-up documents submitted to SafeOCS, only 12 of the 18 components involved in unplanned stack pulls were sent to shore for further analysis by the original equipment manufacturer (OEM) or a third party, despite the expectation of a root cause failure analysis (RCFA) for every stack pull.

[5] Other rigs may have been associated with unreported failures.

[6] Begin drilling operations at the well site. (30 CFR 250.470(c)(1)) (Appendix B).

[7] An unplanned stack pull occurs when the subsea BOP is removed from the wellhead or the LMRP is removed from the lower stack to repair a failed component (Appendix B).

- Of 1,044 subsea events in 2017, one reported loss of containment of synthetic oil based mud (drilling fluid) during in-operation rig activity. No surface stack events resulted in loss of containment.
- Leaks remained the most frequently reported observed failure and wear and tear remained the most frequently reported root cause of failure events in 2017 as they were in 2016.

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INTRODUCTION

The 2017 Annual Report: Blowout Prevention System Safety, published by the Bureau of Transportation Statistics (BTS), provides information on equipment component failures occurring during drilling and non-drilling operations on rigs in the Gulf of Mexico (GOM) Outer Continental Shelf (OCS). The reporting of such events is mandated by the Well Control Rule (WCR), published by the Bureau of Safety and Environmental Enforcement (BSEE), Department of Interior.

About SafeOCS

BTS, a principal federal statistical agency, entered an interagency agreement with BSEE in 2016 to develop, implement, and operate the SafeOCS program. BTS began collecting notifications of equipment component failures as required by BSEE's WCR, which went into effect July 28, 2016. This report is based on information submitted to SafeOCS. The confidentiality of all individual notifications and pre-decisional documents is protected under the Confidential Information Protection Efficiency Act of 2002 (CIPSEA). For more information on CIPSEA, refer to Appendix A. The terms "notice," "notification," "report," and "event" refer to a reported equipment component failure and are used interchangeably in this report.

About the BSEE Well Control Rule

The WCR defines an equipment failure "as any condition that prevents the equipment from meeting the functional specification" and requires reporting of such failures[8]. More specifically, pursuant to 30 CFR 250.730 (c), operators must do the following:

(1) *Provide a written notice of equipment failure to the Chief, Office of Offshore Regulatory Programs, and the manufacturer of such equipment within 30 days after the discovery and identification of the failure.*

(2) *Ensure that an investigation and a failure analysis are performed within 120 days of the failure to determine the cause of the failure. Any results and corrective action must be documented. If the*

[8] 30 CFR 250.730(c)(1).

investigation and analysis are performed by an entity other than the manufacturer, the Chief, Office of Offshore Regulatory Programs and the manufacturer receive a copy of the analysis report.

(3) If the equipment manufacturer sends notification of any changes in design of the equipment that failed or the operator changes in operating or repair procedures as a result of a failure, a report of the design change or modified procedures must be submitted in writing to the Chief, Office of Offshore Regulatory Programs within 30 days.

(4) You must send the reports required in this paragraph to: Chief, Office of Offshore Regulatory Programs; Bureau of Safety and Environmental Enforcement; 45600 Woodland Road, Sterling, VA 20166.

Per the agreement between BSEE and BTS, all notifications related to equipment failure should be submitted to BTS. Refer to the 2016 SafeOCS Annual Report: Blowout Prevention System Events and Equipment Component Failures for more information on the WCR.

Collaboration and Participation

This report is a product of a wide range of collaboration by key stakeholders in the oil and gas industry and government. They include:

- **The Joint Industry Project (JIP) on BOP Reliability Data**: In early 2016, the International Association of Drilling Contractors (IADC) and the International Association of Oil and Gas Producers (IOGP) created a Joint Industry Project (JIP) to develop a BOP reliability database, building on prior industry efforts. BTS collaborated extensively with the JIP in the deployment of SafeOCS in 2016, specifically in the design of the data collection system and supporting documentation. In 2017, members of the JIP lent their expertise by serving on the technical review team and the disclosure review team. They also made substantial contribution to the development of this report. The SafeOCS program continues to receive extensive input from the JIP.
- **External Technical Review Team**: BTS's SafeOCS staff also consulted with an external technical review team with members representing the IADC–IOGP BOP Reliability JIP, original equipment manufacturers (OEMs, which include integrators and component manufacturers), drilling contractors, and operators. The review team provided input to BTS on how to improve the data collection and reporting process. They also collaborated with BTS on areas of common interest, such as improved data sharing and development of analytical tools to facilitate trend analysis of equipment failure data on an industry-wide level. BTS will continue to work with such teams on SafeOCS upgrades to inform and improve the safety of drilling and well operations.

- **Internal SME Review Team**: SafeOCS retained subject matter experts (SMEs) in drilling operations, production operations, subsea engineering, equipment testing, well control equipment design and manufacturing including BOPs, root cause failure analysis, quality assurance and quality control, and process design. The SMEs assisted in developing the data collection forms and process and reviewing notification data for accuracy and consistency. They assisted with validation and clarification of BTS and BSEE data and provided input to this report.
- **BSEE**: BSEE provided BTS with data reported to BSEE on Well Activity Reports (WARs), population and exposure data on production levels, rig activity, and ranges and types of facilities and structures. BSEE provided data was used for data validation and benchmarking.
    - **Well Activity Reports (WAR)**: Well activity reporting in the Gulf of Mexico (GOM), Pacific, and Alaska OCS regions is required daily or weekly (depending on the region), per 30 CFR 250.743. Well activity includes drilling and non-drilling operations such as pre-spud operations[9], drilling, workover operations, well completions, tie-back operations, recompletions, zone change, modified perforations, well sidetracking, well suspension, temporary abandonment, and permanent abandonment. WARs must be submitted for well operations performed by all drilling rigs, snubbing units, wireline units, coil tubing units, hydraulic workover units, non-rig plug and abandonment (PA) operations, and lift boats. BTS's SafeOCS staff and SMEs reviewed WAR data submitted to BSEE for the reference period (January 1, 2017, to December 31, 2017) to provide context for the equipment component failures reported to SafeOCS – specifically, to determine the amount of rig activity (measured in BOP days[10]). WAR data also typically provided daily activity summaries, which were used to cross reference information on type and time of equipment component failures reported to SafeOCS.
    - **Well Spud Data**: BSEE provided BTS with data on wells spud in the GOM in 2017. This information was used to provide context on the scope of rig operations during 2017 in the GOM.

[9] The period of time preceding the start of drilling activities (Appendix B).

[10] To measure rig activity, the BSEE WAR database was analyzed to calculate the number of days each rig was active. The final measure, *BOP days*, offers an approximate measure of "rig activity", or the time period (in days) when an equipment component failure could have occurred. For more information on BOP days measure, see page 10 of the 2016 Annual Report.

ABOUT THE REPORT

The interagency agreement between BSEE and BTS requires BTS to publish a report on the status of SafeOCS, modifications made to the data collection process, lessons learned, and emerging trends based on collected data. This report includes an analysis of reported equipment component events and other key information such as root causes of failures, follow-up response to failures, and opportunities to improve data quality. The data analyzed includes failure notifications submitted directly to BTS through SafeOCS, as well as notifications reported to BSEE and provided to BTS[11]. To provide context for the failure notifications, additional BSEE-provided data was analyzed as described above.

The report summarizes BOP equipment component failures that occurred from January 1, 2017 to December 31, 2017 on marine drilling rigs (platform, bottom-supported, and floating) within the GOM OCS, reported to SafeOCS or BSEE. For 2017, a total of 1,158 equipment component event notifications were received. Of all reported events, 1,129 occurred on marine drilling rigs and 29 occurred on non-rig units. Non-rig units, such as snubbing units, coiled tubing units, and intervention vessels cannot perform drilling operations like rigs; their capabilities lie within pre- and post-drilling operations and well support measures. The differences in operational capabilities led to the separation of rigs and non-rigs for the analysis in this 2017 annual report. Due to the limited number of notifications associated with non-rig units, this year's report covers equipment component events on drilling rigs only.

The report begins by analyzing aggregate equipment component failure data and then, in separate sections, presents statistics on the reported events for the two major types of BOP stacks (subsea and surface). This separation was necessitated by the differences in complexity as impacted by the number of components[12], accessibility of equipment, and environmental conditions for each type of stack. These

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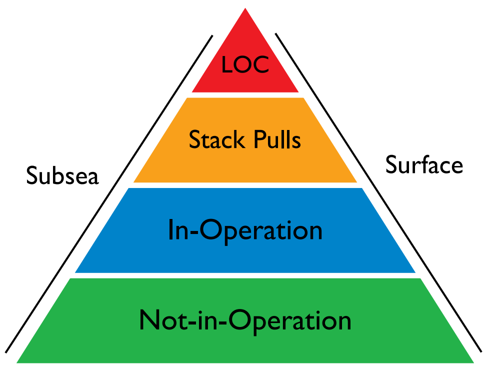
[11] Although BSEE has strongly encouraged companies to submit well control equipment failures directly to SafeOCS, some reports were submitted to BSEE during the reporting period. BSEE provided these to BTS for analysis. BSEE has proposed a regulatory revision to clarify that BSEE may require companies to submit these reports to its designee. See Proposed Rule, 83 Fed. Reg. 22,128, at 22,137 (May 11, 2018). Data submitted directly to BTS is protected under CIPSEA (Appendix A), while data submitted to BSEE is not.

[12] There are approximately 4,000 components for a typical subsea stack and approximately 480 for a typical surface stack. Exact counts vary by operator, rig, and individual BOP stack configurations.

differences lead to different operational practices (e.g., as they affect pre-deployment inspection and testing protocols) and result in varying reporting outcomes. Within each BOP stack type section, event data were analyzed by when the event occurred (while not in operation or while in operation) and whether an in-operation event caused a stack pull or loss of containment (LOC). Appendix B contains a glossary with detailed definitions of technical terms.

Event Impact Pyramid



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

The '*Event Impact Pyramid'* graphic, shown to the left, will be used throughout the report to indicate the focus of each section in the report. Each level of the pyramid represents the expected risk for an adverse event related to an equipment component failure. The bottom level (not-in-operation) poses the lowest risk and the top level (LOC) poses the highest risk. The pyramid also reflects the observed frequency of equipment failures at each level.

The report concludes with a review of investigation and analysis of equipment failures, including results of root cause failure analyses (RCFA) performed by integrators or OEMs and other technical experts, as well as any follow-up action undertaken by OEMs or integrators. These analyses are used by the industry for improving operational efficiency, reliability, and safety of the equipment and associated processes.

Reported Equipment Component Events

Per 30 CFR 250.730 (c) (1), operators involved in drilling and non-drilling operations on the OCS (GOM, Pacific, and Alaska regions) are required to report any equipment failures experienced during these activities to SafeOCS. For 2017, SafeOCS received equipment failure notifications from one region, the GOM, which accounts for 98.0 percent of annual oil production on the OCS. In the GOM, there were 25 operators actively involved in drilling and non-drilling activities that resulted in 153 new wells. Of those, 18 operators, representing 90.2 percent of new wells drilled, submitted equipment failure notifications. The reported events occurred on 45 of the 59 rigs operating in the GOM during the reporting period.

Table 1: Numbers at a Glance

	2017	2016*
Active operators	25	20
Reporting operators	18	14
Total activity level†		
Wells Spud	153	165
BOP Days	18,886	6,711
Monthly event reporting	94.0	160.4
Adjusted event reporting‡	59.8	122.3
Total events reported	1,129	821
Subsea	1044	754
Not-in-operation	902	602
In-operation	142	152
Surface	85	67
Not-in-operation	44	32
In-operation	41	35
Top four operators' percent		
Events	81.8%	81.3%
Wells Spud	32.7%	40.0%

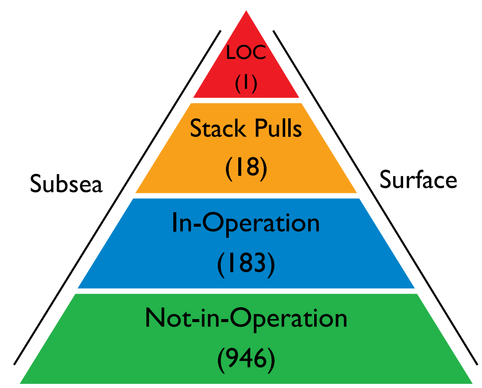
*2016 information is based on 6 months of reported data.

†Level of activity for all active operators in each year

‡Adjusted event reporting reflects the number of events per 1,000 BOP days, calculated as (1,129/18,886)*1000 = 59.8.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Figure 1: All Reported Events in 2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

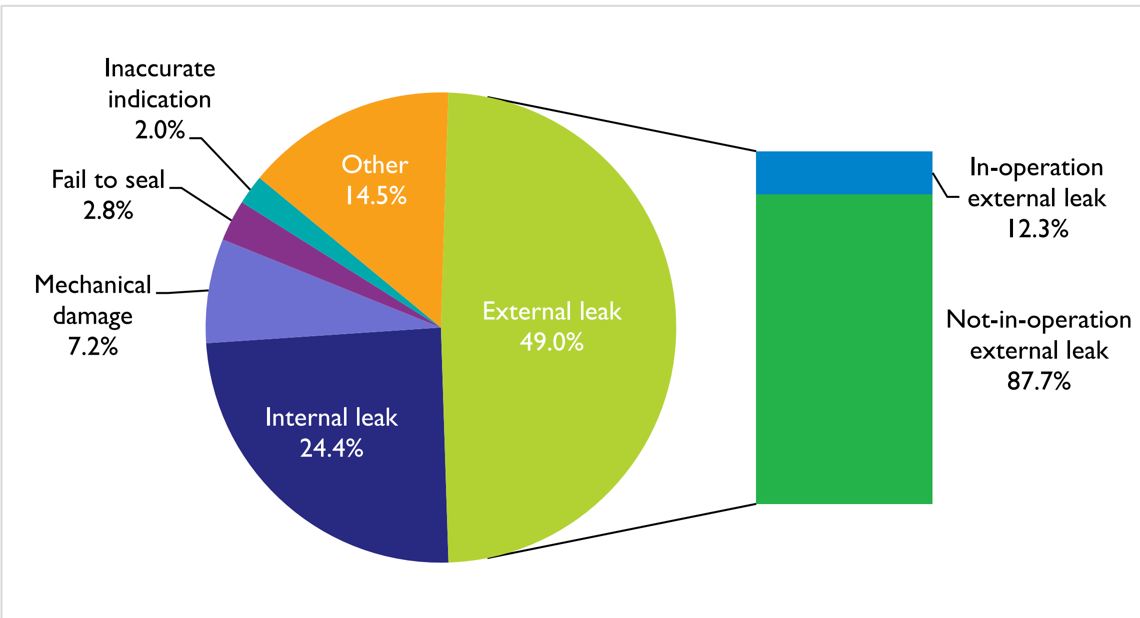
As shown in Table 1, the rate of event reporting adjusted for rig activity (measured in BOP days, see footnote 11) decreased from 122.3 in 2016 to 59.8 in 2017.

Figure1indicates that not-in-operation events were the most commonly reported events (83.8 percent). Of the in-operation events, 9.8 percent resulted in stack pulls and only one event (0.5 percent) resulted in a loss of containment.

What Was Reported

Reporting operators were asked to select the observed failure for each component from a list of options on the reporting form, which includes, but is not limited to, leakage, loss of pressure, failure to seal, mechanical damage, corrosion, or loss of communication between the control system and other components. As shown in Figure 2, external leaks, internal leaks, and mechanical damage remain the top three observed failures, consistent with results published in the 2016 report. Although, external leaks were the most frequently reported failures, only 12.3 percent of those occurred while in operation and involved control fluids rather than drilling fluids or wellbore fluids, which may contain hydrocarbons.

Figure 2: Distribution of 2017 Events by Observed Failure Type



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

An **external leak** means that a component (such as, an SPM valve, regulator, or control tubing) is leaking fluid from a contained space to an uncontained space—for example, into the atmosphere for surface components, or into the sea for subsea components. In-operation external leaks can have a more adverse impact on the environment for the following reasons:

- they can lead to a leak of wellbore fluids[13]
- they are more challenging to detect (particularly for subsea BOPs),
- it can be challenging to estimate contamination (particularly for subsea BOPs), and
- mitigation efforts may take more time depending on current operations.

An **internal leak** means that a component (such as a valve) is leaking pressurized fluid from one contained space to another without potential for fluid to escape to the environment and therefore have no direct environmental impact.

External leaks and internal leaks can happen while in operation or while not in operation; however, discovering leaks while not-in-operation is preferable for reasons stated above. External and internal leaks combined represent 73.4 percent of reported events, an increase of 6.4 percentage points from 2016. This increase is primarily attributed to an increase of not-in-operation external leaks in 2017. For the reporting period, 87.7 percent of external leaks were not-in-operation leaks, which represents a 5.8 percentage point increase from 2016.

Mechanical damage— such as component failures resulting in worn pistons or damaged bladders, springs, and bolts—was the third most reported observed failure (7.2 percent), a 1.7 percentage point decrease from 2016. These failures were mainly of BOP control components such as seals, seats, and actuating elements failing to seal, and did not have any direct environmental impact. Fail-to-seal (a form of internal leakage) cases were reported at approximately the same rate in 2017 (2.8 percent) as 2016 (2.6 percent). All but one of these failures were ram block seals that failed pressure tests and none resulted in external leaks.

Failures captured in the "other" category in Figure 2 include, but are not limited to cases where there was a failure such as spring cracking, hose/piping rupture, ground faults, loss of communication or electrical failure. Each failure categorized in "other" represented less than 2.0 percent of total observed failures. It is worth noting that occasionally, infrequently observed failures can lead to significant events, such as a stack pull. For example, only 4 events reported ground fault as the observed failure; however, one of those events led to a stack pull.

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[13] For the definition of wellbore fluids, refer to Appendix B.

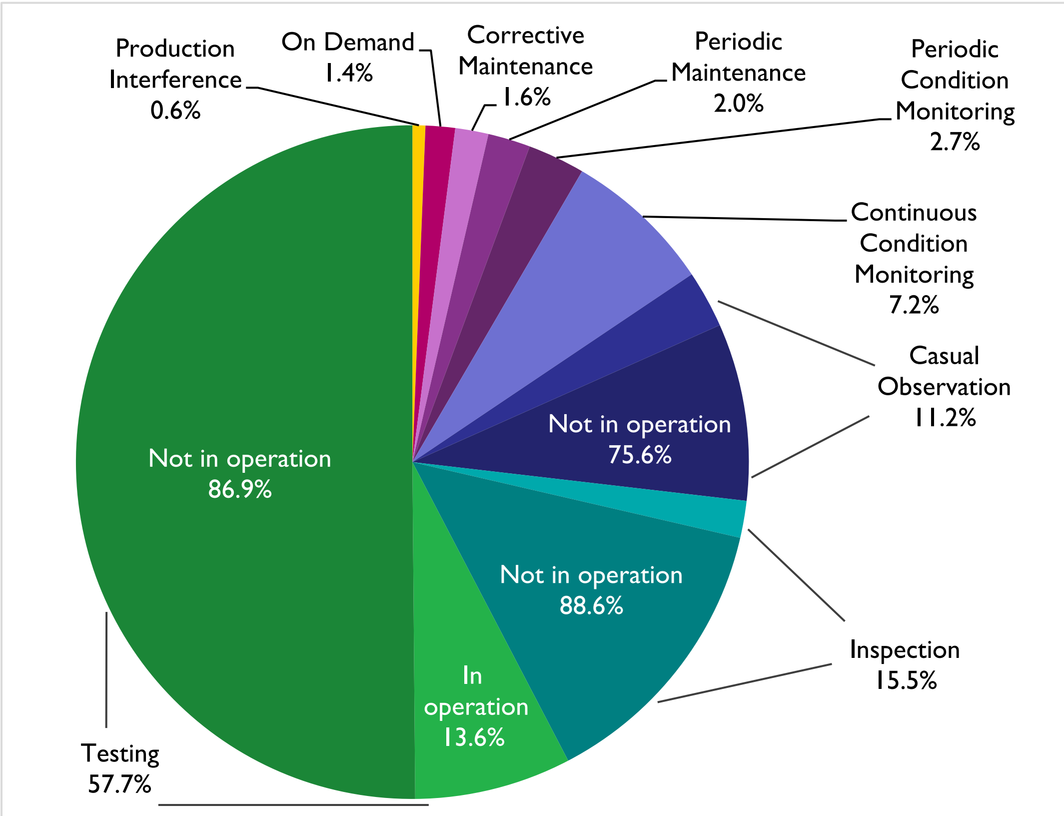
How Events Were Detected

Understanding how equipment component events are detected can be important for increasing early detection and reducing consequences of failures. Component events are detected via several methods:

- **Testing**: applying pressure (pressure testing) or commanding equipment to function (function testing) to determine if the equipment performs properly or maintains integrity, often performed on a schedule.
- **Inspection**: visual observation, which may involve some disassembly, or electronic observation via a camera on a remotely operated vehicle (ROV). Such inspections are often performed on a schedule.
- **Casual observation**: visual observation not requiring disassembly and not on a schedule.
- **Continuous condition monitoring**: continuous monitoring with automated sensors and gauges, often with predetermined alarm settings.

Figure 3 shows that the majority of equipment failures (57.7 percent) were detected through pressure and function testing conducted both while in operation and not in operation. Furthermore, detection of failures via testing while not in operation increased from 78.5 percent in 2016 to 85.4 percent in 2017. This represents a significant increase in failures found during not-in-operation testing from 2016 to 2017 and indicates a practice of preemptive effort at increased testing on deck and/or during deployment, potentially leading to reduced failures while in operation. The majority of failures found during inspection (88.6 percent) and casual observation (75.6 percent) also occurred while not in operation.

Figure 3: Distribution of 2017 Events by Type of Detection Method



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

SUBSEA EVENTS

There were 1,044 subsea events (92.5 percent of total events) reported to SafeOCS, approximately the same percentage as reported in 2016 (91.8 percent of total events). Of those events, 86.4 percent occurred while not in operation (i.e., on deck, during deployment, or during retrieval), an increase in not-in-operation events from 2016[14] to 2017. Of the in-operation events, 8 led to stack pulls, and one of the 8 resulted in a loss of containment event.

Key Statistics

- Over eighty-five percent (86.4%) of reported failures on subsea stacks occurred while not in operation, a 6.6 percentage point increase from 2016.
- The percentage of subsea in-operation events leading to a stack pull was 5.6 percent, a 1.6 percentage point decrease from 2016[15].

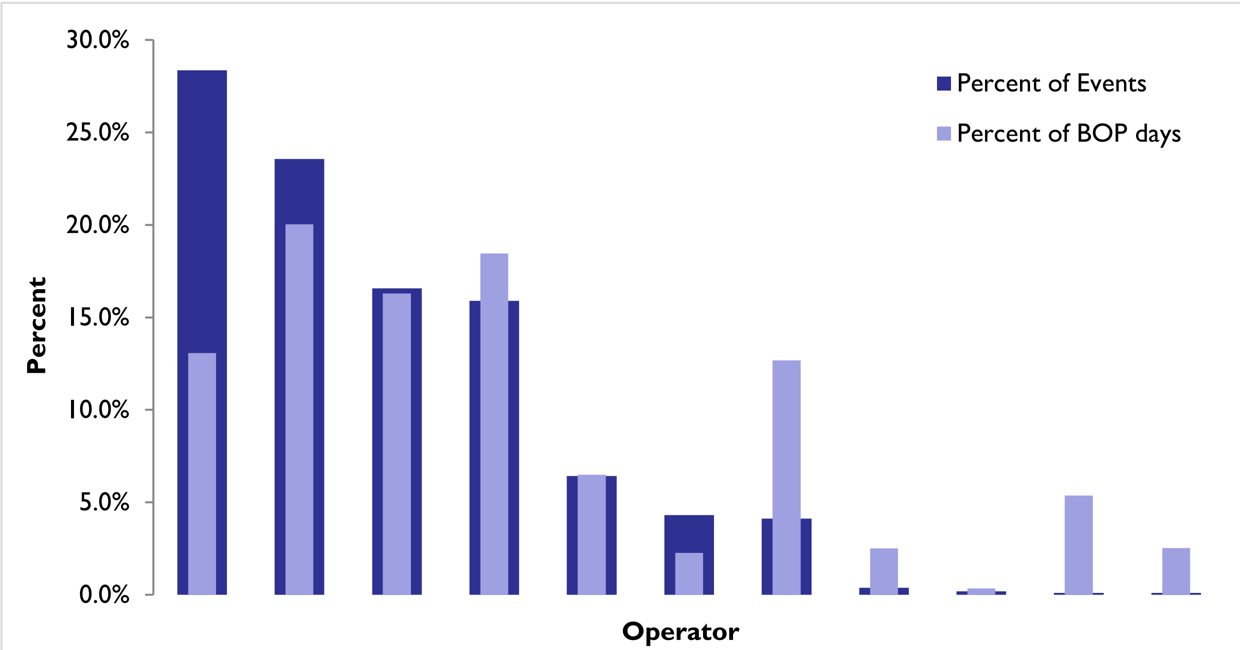
Who Reported Equipment Events

Of 18 reporting operators, 11 reported events that occurred on rigs with subsea BOP stacks. Subsea rig activity (measured in BOP days) and subsea events by operator are shown in Figure 4. Each individual operator's reporting activity and rig activity are represented by two bars: dark purple for percent of events and light purple for percent of rig activity. The data are sorted by percent event reporting for each operator. The top four reporting operators submitted 84.4 percent of subsea notifications and accounted for 67.8 percent of subsea rig activity, measured in BOP days.

[14] The percent of subsea, not-in-operation events reported in 2016 was 79.8 percent.

[15] Based on updated 2016 data, the percent of subsea, in-operation events leading to a stack pull in 2016 was 7.2 percent.

Figure 4: Distribution of Subsea Rig Activity and Reported Events by Operator

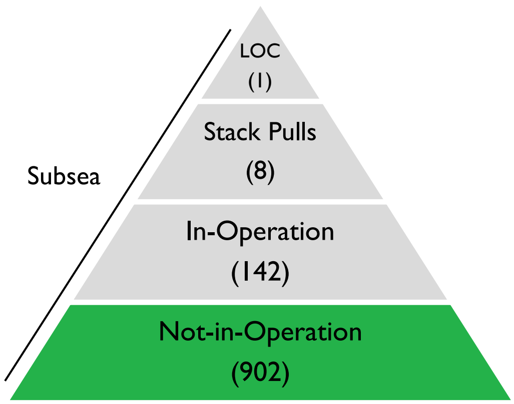


NOTE: BOP days are based on rigs that were associated with at least one equipment component failure.

NOTE: Operator names have not been disclosed to preserve confidentiality.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Not-in-Operation Events



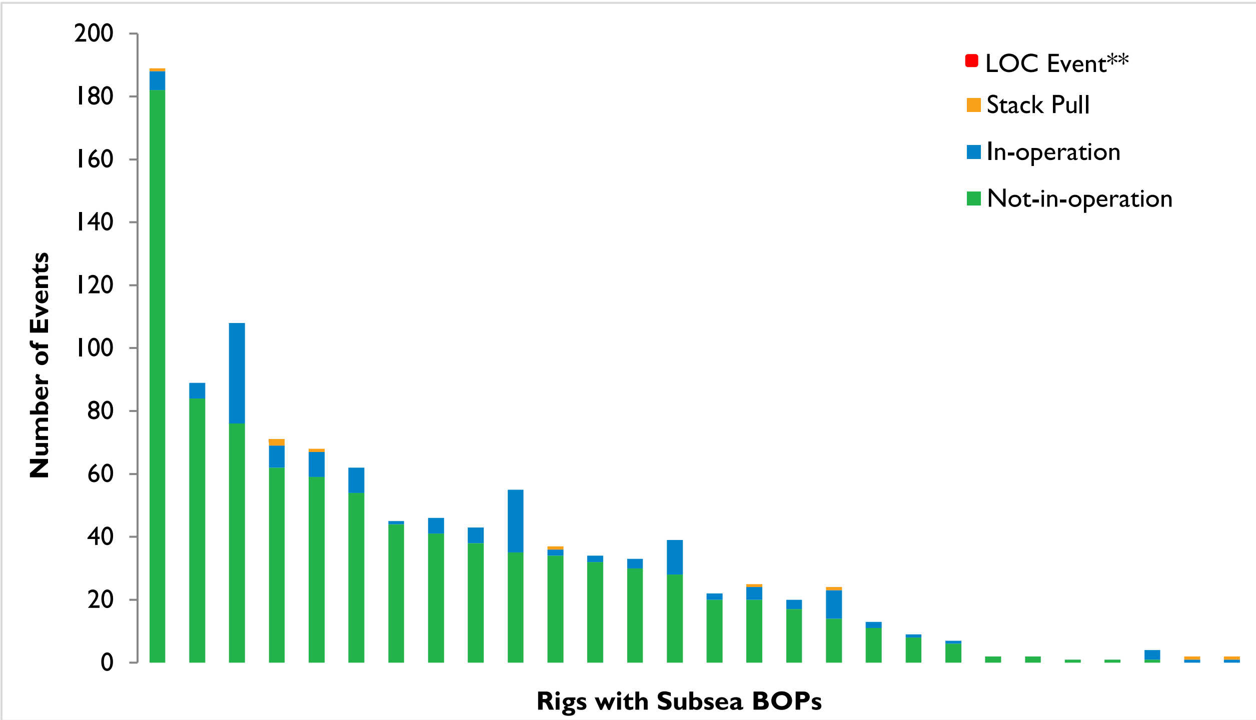
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Subsea not-in-operation failures occur when the BOP is not on the wellhead, the lower marine riser package (LMRP) is not on the BOP, or the BOP and LMRP are on the wellhead but initial subsea testing has not been completed. (See definitions in Appendix B). Failures discovered while not in operation are important for identifying potential issues with the equipment as a preemptive measure before it goes in-operation. These failures are found via testing, inspection, and routine maintenance conducted on deck, during deployment, and during initial testing, as well as other monitoring.

Figure 5 compares the events that occurred while not in operation, while in operation, and those that resulted in a stack pull for rigs with subsea BOPs in 2017. Based on 2016[16] and 2017 data, the number of failures found while not in operation has an inversely proportional relationship to the failures found while in operation. This indicates that rigs with a higher incidence of not-in-operation failures tend to have fewer failures while in operation.

[16] For 2016 results, see page 24 of the 2016 Annual Report.

Figure 5: Reported Events by Rigs with Subsea BOPs



NOTE: **The equipment failure that led to an LOC event is shown as a stack pull to preserve operator confidentiality.

NOTE: Rigs are sorted by highest number of not-in-operation events.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

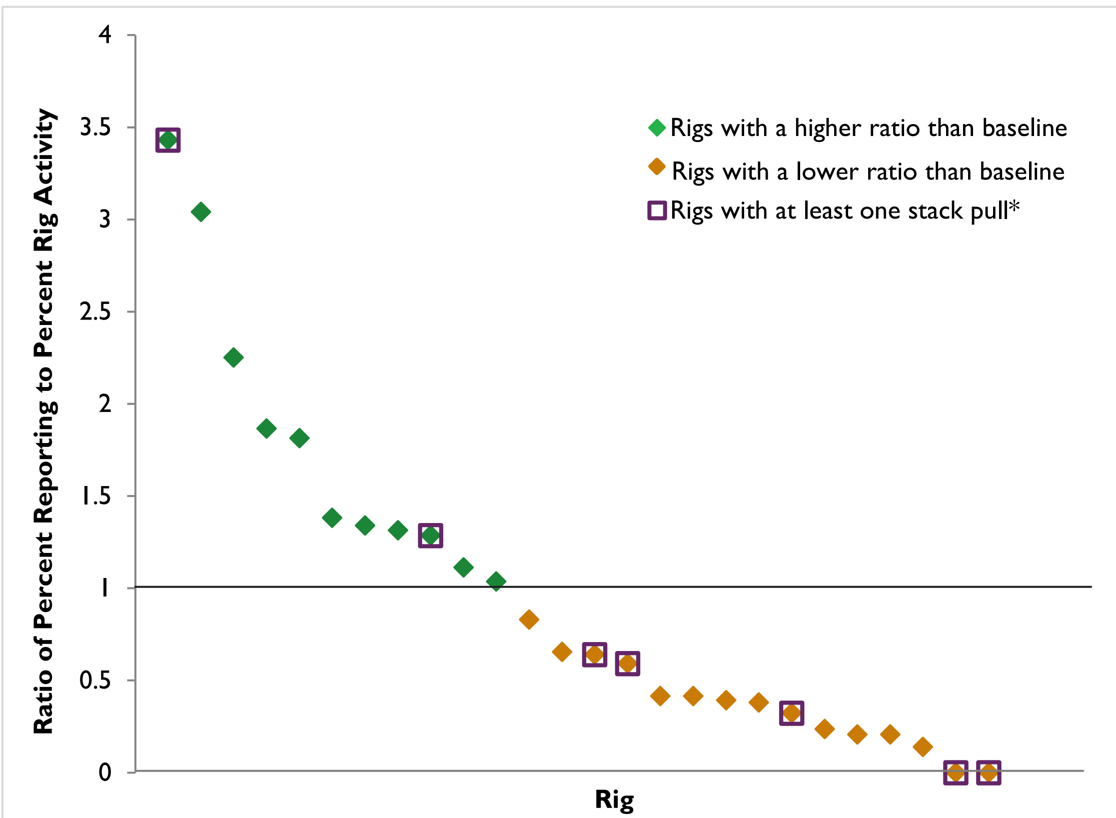
Presumably, rigs with higher rig activity (measured in stack runs[17]) have a higher likelihood of having more not-in-operation failures. Figure 6 shows the percent of not-in-operation events for rigs with subsea BOPs adjusted for the level of 2017 rig activity. Not-in-operation events are those occurring during on deck testing, between-well maintenance, while deploying, and during initial latch-up testing. The number of stack runs is used as a surrogate exposure measure (denominator) for rig activity to normalize the percent of equipment failures while not-in-operation. The line intersecting the graph at the value of 1.0 represents the baseline where the percent reporting activity[18] of a rig is equal to the

[17] For the definition of a stack run, refer to Appendix B.

[18] Percent reporting activity is estimated as the number of reported subsea not-in-operation failure events for an individual rig divided by 902 (the total number of subsea not-in-operation failure events in 2017).

percent rig activity[19] for that rig. As shown in Figure 6, of the 11 rigs above the baseline (shown in green), 2 had stack pulls (9.1 percent, stack pull rate) and of the 15 rigs below the baseline (shown in yellow), 5 had stack pulls (33.3 percent, stack pull rate). Rigs above the baseline report a higher percentage of not-in-operation events and exhibit a lower rate of stack pulls. Conversely, rigs below the baseline report a lower percentage of not-in-operation events and exhibit a higher rate of stack pulls. This suggests an inversely proportional relationship between not-in-operation events and occurrence of a stack pull (i.e., more not-in-operation events found might lead to fewer stack pulls).

Figure 6: Adjusted Percent Reporting of Not-in-operation Events by Rig



NOTE: *One stack pull event that was not associated with BOP component failure was excluded from this chart.
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

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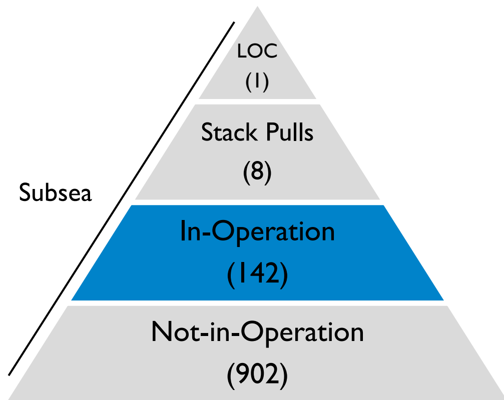
[19] Percent rig activity is estimated as the number of stack runs for an individual rig divided by 160 (i.e., the total number of subsea stack runs for 2017).

In-Operation Events



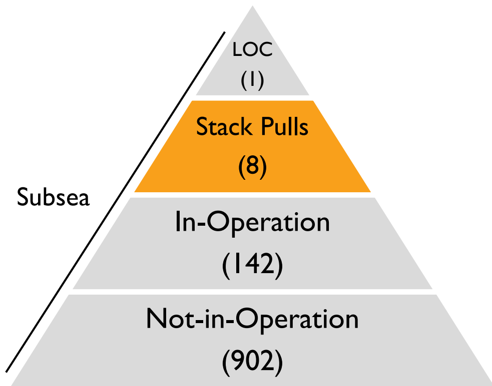
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Subsea in-operation events are well control equipment failures that occur after the BOP is latched on the wellhead and the initial latch-up tests are successfully completed. Despite the prevailing component redundancy[20], in-operation failures are considered more critical than not-in-operation failures because of the potential for a well control event. In 2017, 13.6 percent of subsea failures occurred in operation, a 6.6 percentage point decrease from 2016.

Though considered more critical, in-operation events can often be monitored, corrected, isolated, and/or bypassed in a safe and timely manner until the subsea stack can be pulled to surface to repair the failed component. In addition, some events do not disable the component in its entirety, and the system can still perform its necessary safety function. For example, a hydraulic valve can have a slight leak when it is commanded to open, but it still has the ability to close when needed. When a failure completely disables the component or inhibits a barrier (such as an annular preventer or shear ram preventer) from fully performing its safety function (i.e., to prevent loss of containment), it is deemed more severe and must be addressed before operations can continue.

[20] Notwithstanding components that can result in single-point failures, such as failures associated with the wellhead connector, most of the remaining components rely on redundancy to mitigate failures.

Stack Pull Events



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Stack pulls can be planned or unplanned. Planned stack pulls are scheduled at the end of well activities (between wells) or prior to anticipated severe weather conditions (e.g., a hurricane). Unplanned stack pulls occur when either the BOP is removed from the wellhead or the LMRP is removed from the BOP stack to repair a failed component. Unplanned stack pulls cause operational delays in addition to potential risk for environmental impact. When a component fails, an assessment is made on whether the remaining components and BOP equipment meet both operator and regulatory requirements for the upcoming planned operations. If the equipment does not meet those requirements, then a stack pull will be required.

The rate of unplanned stack pulls to in-operation failures was examined for both 2016 and 2017. In 2016, the rate was 7.2 percent, and in 2017 it was 5.6 percent. Table 2 lists the component and the associated system, as well as the observed failure, associated with each subsea stack pull in 2017. As expected, external leaks were the leading reason for events resulting in unplanned stack pulls. Of the 8 stack pull events, one failure occurred on the riser system above the LMRP and was due to a packing element failure on a telescopic joint. Due to design constraints of the system, the BOP and LMRP needed to be unlatched and lifted, so that the telescopic joint could be brought to surface and repaired on the rig floor. This stack pull illustrates that some failures can have an impact to operations and cause delays even though they have minimal effect on well control.

Unplanned stack pulls are caused by failed components that can affect safe operations of barriers, control systems, or other safety systems. As shown in Table 2, reported stack pulls affected **barriers** (annular preventer, pipe ram preventer), **control systems** (BOP control pod, BOP controls stack mounted), and **safety systems** (autoshear deadman EHBS); however, not all observed failures are of equal importance or have the same likelihood of occurring. External leaks can lead to different outcomes depending on the system, equipment component, and observed failure combination. For example, of the 14 external leaks of shuttle valves on the BOP Controls Stack Mounted, 2 were in-operation (14.3 percent) and only one resulted in a stack pull (50.0 percent). In comparison, of the 3 external leaks of the bonnet face seal on the pipe ram preventer, only one was in-operation (33.3 percent) and it also resulted in a stack pull (100.0 percent). The percentages shown above point to great variability in the rate of a stack pull depending on the system/component/observed failure combination as compared to the overall rates. The overall rates being: a) rate of 39 total events leading to 14 in-operation events (35.9 percent) and b) rate of 14 in-operation events leading to 8 stack pulls (57.1 percent). Due to the inherent variability in the data reported thus far, determining the likelihood for a stack pull based on currently reported information is premature.

Table 2: Components and Observed Failures Related to Unplanned Subsea Stack Pulls

Associated System	Failed Component	Observed Failure	Total Events	In-operation Events	Stack Pulls
Annular Preventer	Operating System Seal	Internal leak	9	3	1
	Packing Element	Leakage	4	2	1
Autoshear Deadman EHBS	Piping Tubing	External leak	4	1	1
BOP Control Pod	Interconnect Cable	Mechanical damage	1	1	1
BOP Controls Stack Mounted	Electrical Connector	Failure to transmit signal	2	2	1
	Shuttle Valve	External leak	14	2	1
Pipe Ram Preventer	Bonnet Face Seal	External leak	3	1	1
Telescopic Joint	Packer	External leak	2	2	1
Total			**39**	**14**	**8**

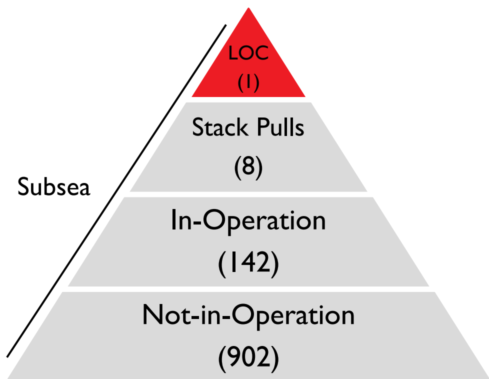
NOTE: The data in Table 2 represent all events that occurred on the identical system and component combination, with the same observed failure that lead to the stack pull. For example, of 14 failures involving externally leaking shuttle valves on the BOP Controls Stack Mounted, one resulted in a stack pull.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Considering the number of subsea stack deployments provides additional perspective on the underlying risk or likelihood for a stack pull. During 2017, 160 subsea BOP stack deployments occurred successfully and passed their initial latch up testing[21], and 27 additional stack deployments occurred but did not go into operation. Eight of the successful deployments experienced unplanned stack pulls for equipment repairs before planned operations were completed, resulting in a 5.0 percent unplanned stack pull rate per successful BOP subsea stack deployment.

[21] This number includes latch-ups where the BOP was being moved from on subsea location to another and stayed submerged.

Loss of Containment



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Loss of Containment (LOC)[22] events caused by equipment component failures represent the highest potential for risk to operations, crew, and the environment. However, during most operations, redundancy in BOP rams, control systems, and emergency systems reduce the risk of an LOC event. Furthermore, due to the unique nature of each failure, not every LOC event results in an adverse incident.

In 2017, during normal operations, one event, resulting in a stack pull, caused a loss of containment (drilling fluids leaked externally). This was a well control incident[23] that did not lead to a loss of well control[24]. A discharge of approximately 94 barrels (approximately 4000 gallons) of synthetic oil based mud (SOBM) into the environment occurred from a breached seal system on a BOP ram door on the pipe ram preventer. Through investigation, it was determined that the event was a result of the following factors:

1. The most critical factor was the existing BOP ram design that required unusual and time consuming cleaning procedures to prevent an excessive buildup of drilling debris in the RAM cavities,
2. Secondary factors that played a role in the event were;
    a. failure by the OEM to effectively communicate the level of effort needed to properly prevent debris buildup,
    b. failure by the OEM to communicate that improper cleaning can lead to loss of seal integrity, and
    c. failure by the operator to implement the initial recommendations specified by the OEM.

[22] For the definition of loss of containment, refer to Appendix B.

[23] For the definition of a well control incident, refer to Appendix B.

[24] For the definition of loss of well control, refer to Appendix B.

Even though thorough cleaning was recommended in the original OEM's notice for preventing the failure, the design issue was the primary cause, as the follow-up investigation revealed that even with more thorough cleaning, the debris buildup might still occur. For this event, the affected component was a bonnet face seal on the pipe ram preventer and the observed failure was an external leak. In 2016, SafeOCS received two notifications that involved the same component and reported external leak as the observed failure; however, those events were found while the BOP was not in operation and did not result in LOC events.

Alternative systems were available during this incident to allow for safe removal of the BOP. However, this event reinforces the criticality of communication paths between operators, equipment owners, and OEMs. The event was investigated and follow-up actions were documented in a full BSEE investigation report[25].

[25] U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE), 2017, *Accident Investigation Report*. Available at https://www.bsee.gov/sites/bsee.gov/files/gb-427-shell-offshore-7-jun-2017.pdf.

Surface Events

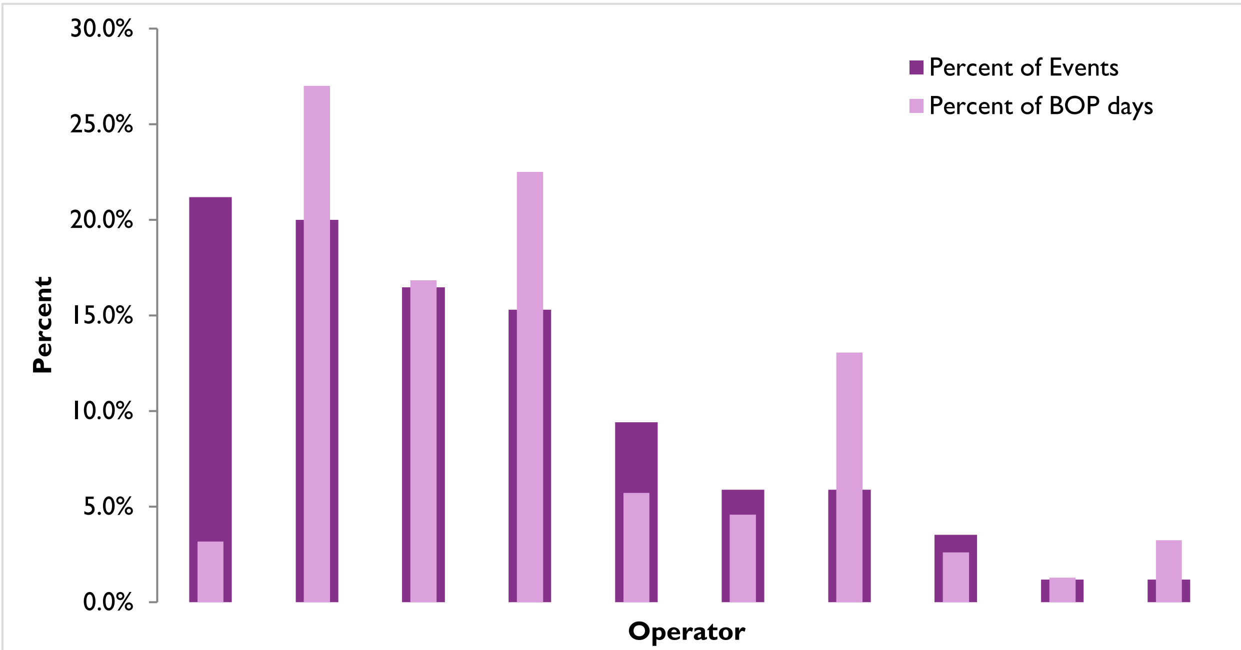
Surface BOPs perform the same functions as subsea BOPs but are less complex and tend to have fewer components. In addition, the equipment is readily accessible on the platform for installation and maintenance activities. Surface BOP stacks are normally used on fixed platforms, jack up rigs, spar platforms, and tension leg platforms (TLPs). Seventeen of the 45 rigs (37.8 percent) had surface offshore BOP stacks. However, surface stacks account for just 7.5 percent of the failure notifications.

Eighty-five equipment component events occurred on surface BOP stacks in 2017 (Table 1). Of those, there were 44 events while not in operation, 41 while in operation, and 10 stack pulls. The percentage of failures occurring while not in operation was higher for subsea stacks (86.4 percent) than on surface stacks (48.2 percent). This reflects the common field practice of conducting more thorough pre-deployment testing and maintenance on subsea stacks as compared to surface stacks. For 2017, there were no reported LOC events on surface stacks.

Who Reported Equipment Events

Of 18 reporting operators, 10 reported surface events. Reporting activity and rig activity (measured in BOP days) for operators with surface BOP stacks is shown below in Figure 7. Each individual operator's reporting activity and rig activity is represented by two bars: dark pink for percent of events and light pink for percent rig activity. The data are sorted by percent event reporting for each operator. The top four reporting operators submitted 72.9 percent of surface failure notifications and represent 69.5 percent of surface rig activity. However, the percent reporting activity and percent rig activity for each operator are not evenly distributed among the top four, as shown in Figure 7. For example, one operator shown in Figure 7 had less than 5.0 percent of total rig activity but reported more than 20.0 percent of total surface events.

Figure 7: Distribution of Surface Activity and Reported Events by Operator

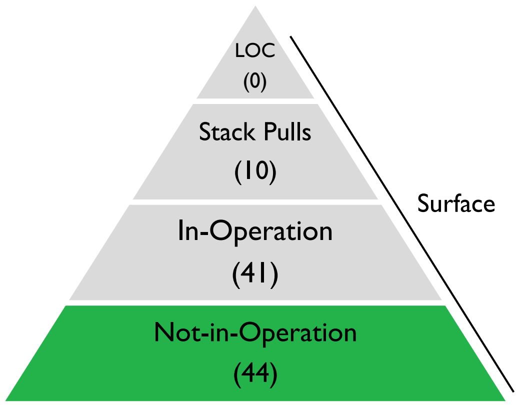


NOTE: BOP days are based on rigs that were associated with at least one equipment component failure.

NOTE: Operator names have not been disclosed to preserve confidentiality.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

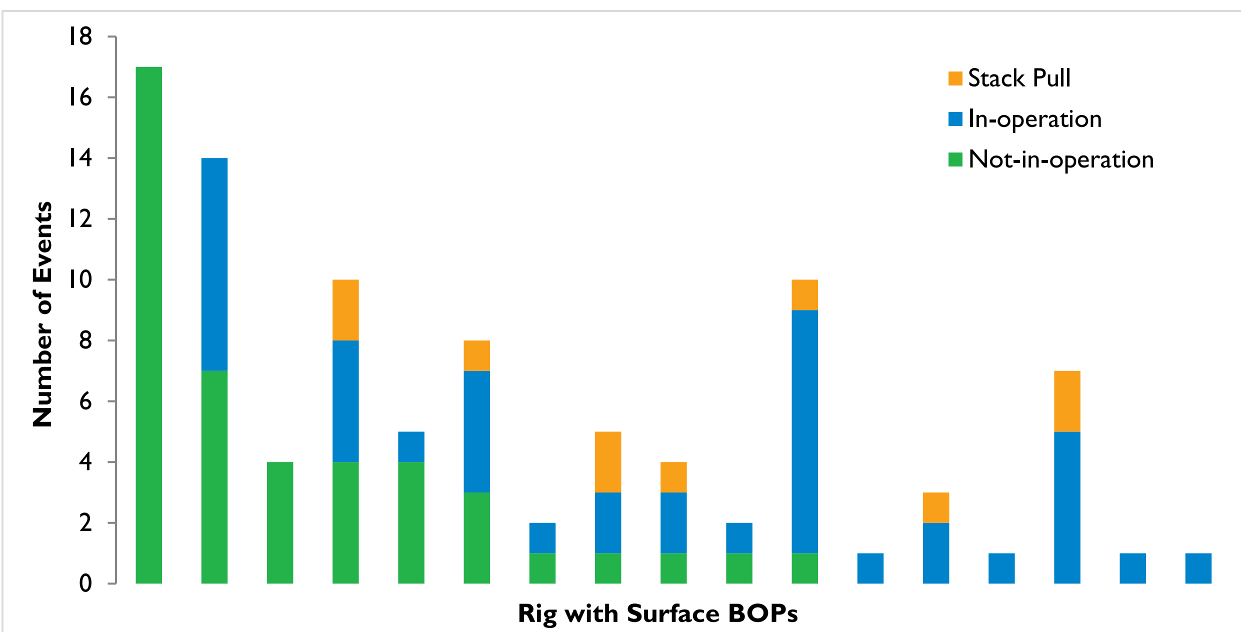
Not-in-Operation Events



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

SafeOCS received 44 surface not-in-operation failure notifications, which affected 24 different types of components on 14 different systems. Rigs with surface BOP stacks show a similar pattern to rigs with subsea BOP stacks with respect to not-in-operation failures and occurrence of in-operation failures and stack pulls. Based on 2017 notifications, rigs that experience more failures during not in operation appear to experience fewer failures while in operation. Figure 8 demonstrates this inversely proportional relationship between reporting of failures found while not in operation and reporting of in-operation failures leading to stack pulls. However, due to the limited sample size, generalizing this observed pattern to the industry is premature. BTS will conduct additional analysis as more data become available.

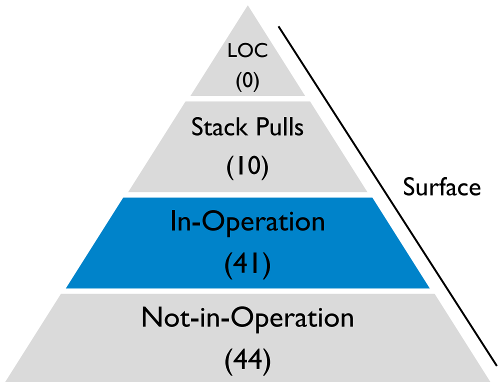
Figure 8: Reported Events by Rig with Surface BOPs



NOTE: Rigs are sorted by highest number of not-in-operation events.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

In-Operation Events



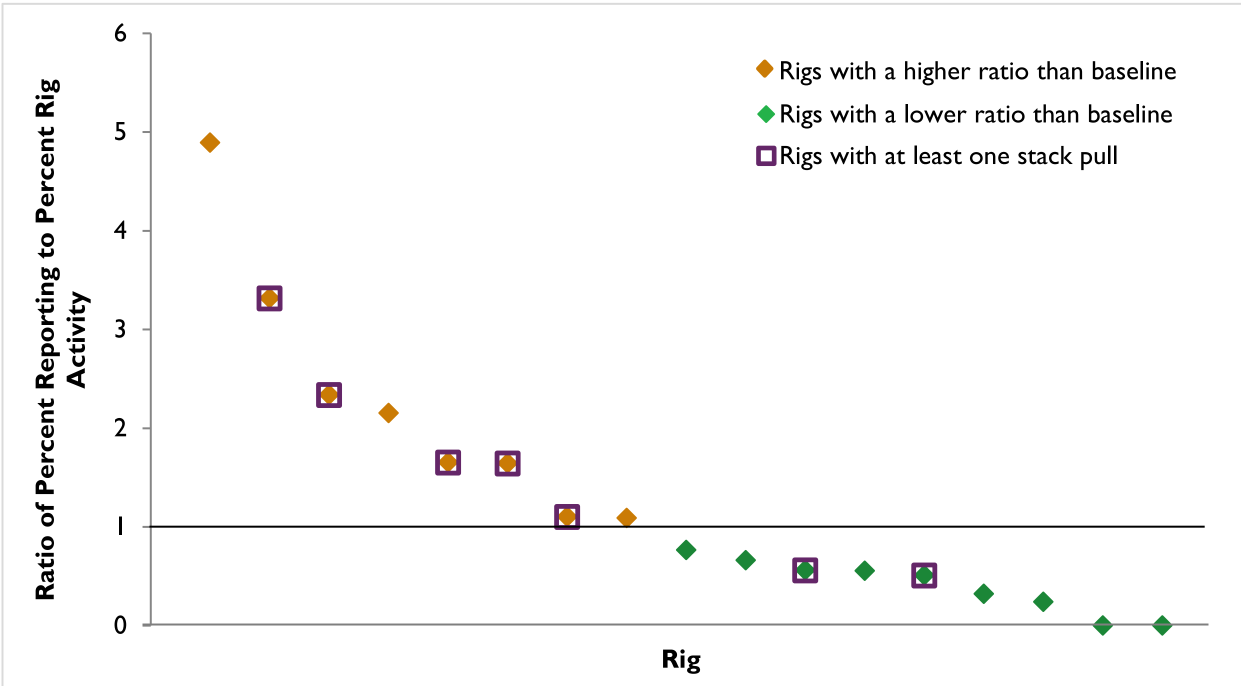
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS

Surface stack equipment, like subsea equipment, undergoes testing, inspection, and other monitoring while not in operation. Similar to subsea BOPs, surface BOPs are only in operation after they are attached to the wellhead and have completed a successful pressure test of the connection to the wellbore per the approved well plan. SafeOCS received 41 surface in-operation notifications.

Time in operation, as a measure of exposure for each BOP, was calculated based on the number of days a BOP was in operation as reported to BSEE in the WARs. The number of BOP days in operation is used as a surrogate measure (denominator) for rig activity to normalize the rate of equipment failures while in operation. In-operation events are those occurring after the BOP has been latched and has passed pressure testing, and during in-operation testing.

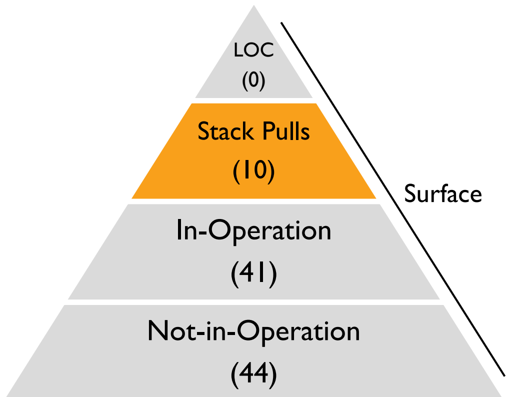
Figure 9 shows the percentage of in-operation events for rigs with surface BOPs adjusted for the level of 2017 rig activity. The line intersecting the graph at the value of 1.0 represents the baseline where the percent reporting activity of a rig is equal to the percent BOP days in-operation for that rig. Of the 8 rigs above the baseline (shown in yellow), 5 had stack pulls (62.5 percent, stack pull rate) and of the 9 rigs below the baseline (shown in green), 2 had stack pulls (22.2 percent, stack pull rate). Therefore, based on 2017 data, rigs above the baseline exhibit higher rates of stack pulls and rigs below the baseline exhibit lower rates of stack pulls. This points to a proportional relationship between in-operation events and occurrence of a stack pull (i.e., more in-operation events found might lead to more stack pulls). However, due to the limited sample size, generalizing this observed pattern to the industry is premature. BTS will conduct additional analyses as more data become available.

Figure 9: Adjusted Percent Reporting of In-Operation Events by Rig



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Stack Pull Events



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

By definition, a surface stack pull occurs when a BOP component fails while in operation and requires well conditioning and a mechanical barrier placement to make necessary repairs. Of the 41 in-operation failure events, 11 events had the unique system/component/observed failure combinations that led to 10 stack pulls, as shown in Table 3. For example, failure of a packing element on the annular preventer will not always lead to a stack pull. However, based on the reported data, a packing element failure on the annular preventer associated with leakage while in operation shows a 75.0 percent stack pull rate (i.e., 3 of the 4 in-operation failures led to a stack pull). Overall, the 11 in-operation events associated with the unique system/component/observed failure combinations identifed in Table 3 led to 10 stack pulls (90.9 percent, stack pull rate).

Table 3: Components and Observed Failures Related to Unplanned Surface Stack Pulls

Associated System	Failed Component	Observed Failure	Total Events	In-operation Events	Stack Pulls
Annular Preventer	Hardware_all other mechanical elements	External leak	1	1	1
	Packing Element	Fail to open	2	2	2
		Leakage	6	4	3
Pipe Ram Preventer	Ram Block Seal	Fail to seal	3	1	1
Shear Ram Preventer	Ram Block Seal	Fail to seal	6	3	3
Total			18	11	**10**

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Considering the number of surface stack deployments provides additional perspective on these stack pulls. During 2017, 119 surface BOP stack deployments occurred successfully, passed their initial latch up testing, and went into operation. Ten of these deployments resulted in unplanned stack pulls for equipment repairs before planned operations were completed, resulting in an 8.4 percent unplanned stack pull rate per surface BOP stack deployment.

INVESTIGATION AND FAILURE ANALYSIS

Per 30 CFR 250.730 (c) (2), operators involved in drilling and non-drilling operations on the OCS are required to ensure that an investigation and failure analysis (I & A) are performed within 120 days of the reported failure to determine the cause of failure. Understanding the root cause of equipment component failures is key to preventing reoccurrence and addressing any existing issues with equipment design, maintenance practices, and/or established procedures. Typically, the root cause of an event is determined through investigation and failure analysis performed by a technical representative, such as a subsea engineer on site, or through a more detailed root cause failure analysis (RCFA) involving the OEM or a third party.

Level of Follow-up

When an equipment component fails, operators and equipment owners have the option to dispose of the component, or when more detailed information is needed, send it to shore for analysis or repair. When root cause failure analysis is conducted on equipment, it provides an opportunity for OEMs to evaluate and improve the reliability of their products. Sending equipment for analysis, conducting follow-up failure analysis, and developing and implementing subsequent action constitute significant communication paths between OEMs, equipment owners, and operators regarding causes of equipment failures, improvements, and preventative measures across the industry.

For 2016 and 2017, the percentage of events that had more detailed I & A done is shown in Table 4. Overall, the rate of reports with I & A completed decreased from 12.4 percent in 2016 to 5.5 percent in 2017. This could be partially attributed to investigations that are still outstanding as they require more time for completion. A higher percentage of I & A were reported for failures on surface BOPs (29.9 percent and 17.6 percent for 2016 and 2017, respectively) than for subsea BOP failures (10.7 percent and 4.5 percent for 2016 and 2017, respectively).

Table 4: Investigation and Analysis by BOP Type

BOP Type	Year	Total Notifications	Notifications with I & A
Subsea	2016	755	82 (10.7%)
	2017	1044	47 (4.5%)
Surface	2016	67	20 (29.9%)
	2017	85	15 (17.6%)

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Root Cause Determined Through I & A

A number of factors can cause a component to fail: equipment reaching its expected service life (normal wear), a malfunction resulting from an equipment design issue, operation outside of the equipment limits, maintenance not being properly performed on the equipment, or other factors. Depending on the type of failure, the root cause may be easily determined, and the component is repaired or replaced without further investigation. Other failure events, due to their nature and complexity (e.g., failures leading to a stack pull), need a more thorough investigation, such as further I & A done on site by a subsea engineer, or an RCFA done by the OEM or third party. RCFAs provide specific information that can help prevent equipment failures.

Table 5 shows the distribution of reported root causes categorized by whether further I & A were conducted. For notifications without further I & A, the root cause of the reported failure was determined through an immediate evaluation. As the data shows, this was the case for the majority of the notifications (94.5 percent).

Table 5: Distribution of Notifications by Reported Root Cause

Root Cause	Notifications with Further I & A	Total Notifications
Wear and Tear	23	633
Maintenance Error	6	138
Design Issue	12	80
QA/QC Manufacturing	5	60
Procedural Error	4	17
Documentation Error	1	6
Other*	11	195
Total	**62**	**1129**

NOTE: *Root causes classified as "other" consist of failures where the root cause was not determined due to the nature of the failure, or the investigation and failure analysis are still pending.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Wear and tear generally means that the component has met its expected service life and needs to be replaced. Wear and tear was the most frequently reported root cause of failures (53.6 percent). Furthermore, notifications with wear and tear had the lowest percentage (3.6 percent) of I & A documentation sent to SafeOCS. Normal wear and tear is expected as an equipment component nears the end of its lifespan (number of cycles or hours). However, 53.6 percent may be an overestimate of the prevalence of "wear and tear" as the true root cause. This is evidenced by notifications listing "wear and tear" as the root cause and a) reporting low component usage (e.g., less than 50 cycles or hours reported) and/or b) reporting an installation date less than one month prior to the component failure. Further research on the citing of "wear and tear" as a true root cause of reported events is warranted.

Maintenance error is either the result of improper installation or repair of equipment, or lack of a complete or thorough maintenance plan for that equipment. Maintenance error was the second most frequently reported root cause for 2016 (16.2 percent) and 2017 (12.5 percent).

Design issue primarily indicates a design flaw or a discrepancy between expected operating conditions outlined by the integrator and actual operating conditions experienced by that component. It was the third most frequently reported root cause (6.4 percent) of equipment component failures. Notifications listing design issue are discussed in the next section of this report.

Based on the SafeOCS Guidance document[26], RCFAs by the OEM or a third party are expected to be done on events resulting in stack pulls and for reoccurring failures. There were 18 stack pulls reported in 2017. Two were reoccurring failures of the same component. Table 6 lists the components that failed, the associated system, and the root cause determined for the stack pulls. The root causes for the failures associated with stack pulls were design issue, wear and tear, procedural error, and maintenance error. Stack pull cases that resulted in follow-up action recommended by the OEM are discussed in the next section.

[26] U.S. Department of Transportation, Bureau of Transportation Statistics, A user Guide for Reporting Well Control Equipment Failure. As of the publication of this report, the latest version of the guidance is Rev. 2.00, dated November 30, 2017. The guidance is available at https://safeocs.gov.

Table 6: RCFA Results of Component Failures Leading to Unplanned Stack Pulls

BOP Type	Associated System	Failed Component	Root Cause	Stack Pulls
Subsea	Annular Preventer	Operating System Seal	Design Issue	1
	Autoshear Deadman EHBS	Piping Tubing	Design Issue	1
	BOP Control Pod	Interconnect Cable	Procedural Error	1
	BOP Controls Stack Mounted	Electrical Connector	Procedural Error	1
	Pipe Ram Preventer	Bonnet Face Seal	Design Issue	1
	Multiple	Multiple	Not reported to SafeOCS*	3
Surface	Annular Preventer	Hardware_all other mechanical elements	Procedural Error	1
		Packing Element	Design Issue	2
			Maintenance Error	1
			Wear and Tear	1
	Pipe Ram Preventer	Ram Block Seal	Wear and Tear	1
	Shear Ram Preventer	Ram Block Seal	Wear and Tear	3
	Multiple	Multiple	Not reported to SafeOCS*	1
Total Stack Pulls				**18**

NOTE: The 4 stack pulls where the root cause was not reported to SafeOCS included 3 notifications where the assessment is still pending and one where the root cause was not determined after further investigation and analysis. The affected systems on these events included: an annular preventer, BOP controls stack mounted, and a telescopic joint, and the affected components were: a packer, packing element, and shuttle valve.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

Though the root cause of failures leading to stack pulls can vary, cases where wear and tear was determined to be the root cause were analyzed further. For subsea stacks, equipment is expected to be deployed for extended periods of time, and therefore is tested, repaired, or replaced prior to a stack being deployed to the seafloor. As expected, there were no subsea stack pulls with wear and tear as the root cause. For surface stacks, the equipment is more readily available for maintenance and repair on the rig. Therefore, surface stack pulls due to wear and tear are more likely to occur as fewer proactive component replacements are done due the accessibility of equipment. Half of the 10 surface stack pulls were determined to be due to wear and tear, and ram block seals contributed to 4 of these failures. The range of reported age for these 4 components was 4 to 19 months, and the range of reported open and close cycles on the associated system was 57 to 133.

Lessons Learned

Per 30 CFR 250.730 (c) (3), if, as a result of a failure, the equipment manufacturer sends notification of any changes in design of the failed equipment or changes in operating or repair procedures, a report of the design change or modified procedures may be submitted to SafeOCS[27]. This section addresses the results of RCFA investigations involving the OEM or third party and subsequent action taken. These types of follow-ups have the potential to lead to findings with industry-wide impacts. For example, an identified design issue could lead to a design change for which an engineering bulletin or safety alert that affects multiple operators and/or equipment owners is issued.

Table 7 below shows follow-up actions resulting from RCFAs and confirmed in documentation submitted to SafeOCS. For example, 5 follow-up actions reflected design updates to the operating system seal. Reported follow-up actions included mitigation steps to improve training, documentation, and/or equipment source accuracy; equipment design changes; or long-term corrective actions for the OEM, operator, and/or equipment owner. Although there was limited information on learnings from RCFAs reported in 2017, the listed actions serve as examples on how RCFAs lead to improvements not only for an individual entity, but also for the entire industry. If the OEM discovers the need for an updated design of a component, this update will be implemented across the industry to prevent a reoccurring failure, which reduces risk and improves operations.

Since design issues can span across industry, a more in-depth review of notifications indicating design issue as the root cause is warranted. In 2017, 80 notifications listed design issue as the root cause and the affected component failures included the following: annular packing element seal failure, BOP ram door hinge seal leakage, Belleville spring corrosion or cracking, insufficient ball valve mounting bolts loosening, SPM seal plate scoring and cracking, choke and kill valve gate/seat cracking, and BOP ram retraction issues. Of these 80 notifications, further investigation and analysis were completed for 9, and 30 are still pending.

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[27] *As stated in BSEE press release titled, "BSEE Expands SafeOCS Program", October 26, 2016*

Table 7: Recommended Preventative Actions

Root Cause	Component	Follow-up Action	Count
Design Issue	Bonnet Face Seal	OEM to update design	1
	Operating System Seal	OEM to update design	5
	Ram Block Hardware	OEM to update design	1
	ROV Valve	OEM to update design	2
	Slide Shear Seal Valve	Upgrade component to the most recent OEM design change	2
	SPM Valve	OEM to update design	1
Documentation Error	SPM Valve	Update manuals and procedures	1
Maintenance Error	Locking Device	Update manuals and follow previous OEM recommendations	1
	Packing Element	Refer to previous OEM maintenance recommendations	1
	Piping Tubing	OEM to ensure proper training of welding technicians	1
Procedural Error	Interconnect Cable	Update rig manuals	1
	Ram Block Seal	Update rig manuals	1
QA/QC Manufacturing	Operating System Seal	OEM to ensure vendor sends correct components	1
Wear and Tear	Operating System Seal	Upgrade component to the most recent OEM design change	1
Total			**20**

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

NEXT STEPS: OPPORTUNITIES FOR IMPROVING DATA QUALITY

Collecting more detailed, accurate, timely and relevant equipment failure data can support a more in-depth statistical analysis on root causes of equipment failures and the development of predictive analytics of failure events. The industry can use this information to make changes to current practices and improve safety and equipment reliability. To that end, BTS continues to focus on improvement efforts in the following areas.

- Improving Data Processing

  With extensive technical input from the IADC/IOGP BOP Reliability JIP, SafeOCS/BTS has substantially improved the data collection process by allowing for simultaneous processing of multiple notifications, thereby optimizing data input and database updates. Currently, operators still submit notifications in several forms: handwritten forms, Excel summaries, and SafeOCS website forms, the latter being the preferred method for BTS. BTS intends to launch a training campaign to promote online reporting in an effort to improve data accuracy and minimize data entry errors.

- Data Collection Form Enhancements

  Currently, a small number of data fields (e.g., equipment sent to shore) appear to cause confusion and lead to inaccurate responses, primarily due to misleading definitions and unclear instructions in the WCR User Guide. Correcting these could improve paths of communication between OEMs, operators, and equipment owners. BTS is presently conducting a thorough review of the existing form, plans to issue a revised form, and offer training for data users no later than December 2018.

  The following is an example of apparent reporting inconsistencies found during the quality review of 2017 data: Table 8 shows that for the 232 failed components sent to shore for OEM or third party analysis (shown in the bolded section), operators submitted I & A documentation to SafeOCS for only 34. For example, 13 reports that had I & A completed originally noted that the equipment had not been sent to shore, which is a data inconsistency that needs to be further investigated. Another example of data inconsistency is the 15 reports that had I & A completed but had no information reported as to whether the equipment was sent to shore.

Table 8: Investigation and Analysis Conducted on Equipment Sent to Shore

Was the Equipment Sent to Shore?	Further I & A Conducted	Total Notifications
No	**13**	**783**
Yes	**34**	**232**
OEM Analysis	26	146
OEM Repair	6	78
Third Party Analysis	1	2
Third Party Repair	1	6
No Response	**15**	**114**
Total	**62**	**1129**

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS program.

- Improving Data Harmonization

  A comparison of the WCR database with the BSEE WAR database indicates inconsistencies between information in the daily summaries of WAR and WCR notifications. These inconsistencies can lead to inaccurate categorizations of data, such as whether or not the BOP was in or out of operation, potentially leading to under or over estimation of the number of failures that truly occur when the BOP is in operation. BTS will conduct a thorough review of both data sources and publish a report outlining recommendations for improving data harmonization.

- Collecting Additional Information

  Over 75 percent of the 2017 event notifications included the component installation date, cycles/hours information, and whether the component was new, repaired, or replaced. This data gives an indication of how long the equipment has been in operation and for most cases can be use a surrogate for estimating the age of the component or the time since the equipment was repaired or replaced. Over time, installation date data will be useful in benchmarking reliability. BTS will continue to work with the IADC/IOGP BOP Reliability JIP and other stakeholders to ensure this information is included in all equipment failure notifications and explore other age related information that can be added to the data collection form.

- Based on initial input from OEMs, SafeOCS plans to do a more extensive outreach and provide training on how to access aggregate statistics from the SafeOCS website.

Appendix A: Confidential Information Protection Efficiency Act of 2002 (CIPSEA)

The confidentiality of all data submitted to SafeOCS is protected by the Confidential Information Protection Efficiency Act of 2002 (CIPSEA). However, data submitted directly to BSEE are not protected by CIPSEA. Data protected under CIPSEA may only be used for statistical purposes. This requires the following: a) only summary statistics and data analysis results will be made available; b) microdata on incidents collected by BTS may not be used for regulatory purposes; and c) information submitted under this statute is also protected from release to other government agencies including BSEE, as well as protection from Freedom of Information Act (FOIA) requests and subpoenas.

APPENDIX B: GLOSSARY

Annular Preventer: A device that can seal around any object in the wellbore or upon itself.

Shear Ram (also, Blind Shear Ram): A closing and sealing component in a ram blowout preventer that first shears certain tubulars in the wellbore and then seals off the bore, or acts as a blind ram if there is no tubular in the wellbore.

Blowout Preventer (BOP): A device installed at the wellhead, or at the top of the casing, to contain wellbore pressure either in the annular space between the casing and the tubulars or in an open hole during drilling, completion, testing, or workover.

BOP Equipment Systems: BOP equipment systems consist of blowout preventers (BOPs), choke and kill lines, choke manifolds, control systems, and auxiliary equipment.

BOP Control Pod: An assembly of subsea valves and regulators hydraulically or electrically operated which will direct hydraulic fluid through special porting to operate BOP equipment.

BOP Control System (BOP Controls): The system of pumps, valves, accumulators, fluid storage and mixing equipment, manifold, piping, hoses, control panels, and other items necessary to hydraulically operate the BOP equipment.

BOP Stack: The assembly of well control equipment including preventers, spools, valves, and nipples connected to the top of the wellhead, or top of the casing, that allows the well to be sealed to confine well fluids. A BOP stack could be a subsea stack (attached to the wellhead at the sea floor), or a surface stack (on the rig or non-rig above the water).

BOP Stack Pull (Subsea): When either the BOP is removed from the wellhead or the LMRP is removed from the lower stack to repair a failed component. The BOP stack cannot be classified as a stack pull until after it has been in operation as defined above.

BOP Stack Pull (Surface): When a BOP component fails during operations and requires well conditioning and a mechanical barrier placement to make necessary repairs.

Control Fluid: Hydraulic oil, water-based fluid, or gas which, under pressure, pilots the operation of control valves or directly operates functions.

Disabled barrier: When a barrier is not able to perform its intended function (for example, a failure that causes an annular preventer to fail to seal, or fail to open or close).

Drilling Fluid: The fluid added to the wellbore to facilitate the drilling process and control the well. Various mixtures of water, mineral oil, barite, and other compounds may be used to improve the fluid characteristics (mud weight, lubricity, etc.). This is commonly called drilling mud, and it may contain drilling cuttings.

In-Operation (Subsea): A BOP stack is in-operation after it has completed a successful pressure test of the wellhead connection to the well-bore per approved well plan.

In-Operation (Surface): A surface BOP stack is in-operation after it has completed a successful pressure test of the wellhead connection to the well-bore per approved well plan.

Loss of Containment (LOC): An external leak of wellbore fluids outside of the "pressure containing" equipment boundary.

Loss of Well Control: A loss or well control is

- (i) Uncontrolled flow of formation or other fluids. The flow may be to an exposed formation (an underground blowout) or at the surface (a surface blowout);
- (ii) Flow through a diverter; or
- (iii) Uncontrolled flow resulting from a failure of surface equipment or procedures.

Non-Drilling Operations: Drilling rigs primarily perform drilling and completion operations, but can also perform operations typically performed by less expensive non-rigs such as well intervention, workover, temporary abandonment, and permanent abandonment. These activities are considered non-drilling operations and are typically performed by non-rig units such as coil tubing units, hydraulic workovers, wireline units, plug and abandon (P&A) units, snubbing units, and lift boats.

Not-in-Operation (Subsea): The BOP stack changes from in-operation to not-in-operation when either the BOP is removed from the wellhead or the LMRP is removed from the lower stack. When the BOP stack is on deck or is being run or pulled (retrieving), it is considered not-in-operation.

Not-in-Operation (Surface): A surface BOP changes from in-operation to not-in-operation when the well is conditioned and a mechanical barrier (i.e., packer/plug) is set in the wellbore.

Pipe Ram Preventer: A device that can seal around the outside diameter of a pipe or tubular in the wellbore. These can be sized for a range of pipe sizes (Variable Pipe Ram) or a specific pipe size.

Pre Spud: The period of time preceding the start of drilling activities.

SafeOCS User Guide: SafeOCS solicited input from the JIP to create a guidance document to assist operators in reporting BOP equipment failures.[28] The SafeOCS user guide provides detailed instructions and definitions to the OCS oil and gas industry operators for selecting and inputting data in the form. Updates to the guidance document will occur periodically.

Stack Run: The activity of deploying, or "running" a subsea BOP stack from the rig (or non-rig) floor to the subsea wellhead. During this time period (approximately 8 hours to 48 hours depending on water depth), activities may include: function testing, pressure testing, initial latch-up testing (during latching of the BOP to the wellhead).

Wellbore Fluid: The fluids (oil, gas, and water) from the reservoir that would typically be found in a production well, commonly referred to as hydrocarbons. During drilling, completion, or workover operations, drilling fluids may also be referred to as wellbore fluids.

Well Control Incident: A well control incident is (in drilling & completion and live well intervention) defined as a failure of barrier(s) or failure to activate barrier(s), resulting in an unintentional flow of formation fluid –

1. into the well
2. into another formation or
3. to the external environment.

Wells Spud: Begin drilling operations at the well site. (30 CFR 250.470(c)(1))

[28] https://www.safeocs.gov/forms/WCR_Guidance_Rev2.1.pdf

Appendix C: Acronym List

ANSI: American National Standards Institute

API: American Petroleum Institute

BOP: Blowout Preventer

BSEE: Bureau of Safety and Environmental Enforcement

BTS: Bureau of Transportation Statistics

CIPSEA: Confidential Information Protection and Statistical Efficiency Act

DOI: Department of the Interior

DOT: Department of Transportation

GOM: Gulf of Mexico

IADC: International Association of Drilling Contractors

IOGP: International Association of Oil and Gas Producers

JIP: Joint Industry Project: RAPID-S53-Reliability and Performance Information Database for API Standard 53

LMRP: Lower Marine Riser Package

LOC: Loss of Containment

OEM: Original Equipment Manufacturer

RCFA: Root Cause Failure Analysis

SafeOCS: Safe Outer Continental Shelf

SME: Subject Matter Expert

SOBM: Synthetic Oil Based Mud

WAR: Well Activity Report (per 30 CFR)

Appendix D: Relevant Standards

Industry Standards with Relevant Sections Incorporated by Reference in 3030 CFR 250.198

- API Standard 53, Fourth Edition, November 2012
- ANSI/API Spec. 6 A, Nineteenth Edition specification for Wellhead and Christmas Tree Equipment
- ANSI/API Spec. 16 A, Third Edition Drill Through Equipment
- API Spec. 16 C, First Edition specification for Choke and Kill Systems
- API Spec. 16 D, Second Edition specification for control systems for Drilling Well Control Equipment and Control systems for Diverter systems
- ANSI/API Spec. 17 D, Second Edition Design and Operate Subsea Production Systems, Subsea Wellheads and Tree
- API RP 17 H First Edition, Remotely Operated Vehicle Interface on Subsea Systems
- API Q1

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30 CFR 250.730 (a)(1) The BOP requirements of API Standard 53 (incorporated by reference in § 250.198) and the requirements of §§ 250.733 through 250.739. If there is a conflict between API Standard 53, and the requirements of this subpart, you must follow the requirements of this subpart.

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BSEE's former regulations repeated similar BOP requirements in multiple locations throughout 30 CFR part 250. In this final rule, BSEE is consolidating these requirements into subpart G (which previously had been reserved). The final rule will structure subpart G—Well Operations and Equipment, under the following undesignated headings:

- General Requirements
- Rig Requirements
- Well Operations
- Blowout Preventer (BOP) System Requirements
- Records and Reporting

The sections contained within this new subpart will apply to all drilling, completion, workover, and decommissioning activities on the OCS, unless explicitly stated otherwise.

Federal Register Volume 81, Issue 83 (April 29, 2016), Pages 26013 and 26015

For information about…	Refer to…
Application for permit to drill (APD)	30 CFR 250.subparts D and G
Oil and gas well-completion operations	30 CFR 250. Subparts D and G
Oil and gas well-workover operations	30 CFR 250. Subparts D and G
Decommissioning activities	30 CFR 250. Subparts G and Q
Well operations and equipment	30 FR 250. Subpart G

APPENDIX E: SCHEMATICS OF BOP SYSTEM BOUNDARIES

Figure 10: Example Choke and Kill Manifold for Subsea Systems

See Appendix C, Figure 18 in 2016 SafeOCS Annual Report.

SOURCE: Consult 2016 SafeOCS for schematic details and source.

Figure 11: Example Subsea BOP Stack with Optional Locations for Choke and Kill Lines

See Appendix C, Figure 19 in 2016 SafeOCS Annual Report.

SOURCE: Consult 2016 SafeOCS for schematic details and source.

Figure 12: Example Subsea Ram BOP Space-Out

See Appendix C, Figure 20 in 2016 SafeOCS Annual Report.

SOURCE: Consult 2016 SafeOCS for schematic details and source.

Figure 13: Example Surface BOP Ram Space-Out

See Appendix C, Figure 21 in 2016 SafeOCS Annual Report.

SOURCE: Consult 2016 SafeOCS for schematic details and source.