Testing improves surface BOP equipment reliability

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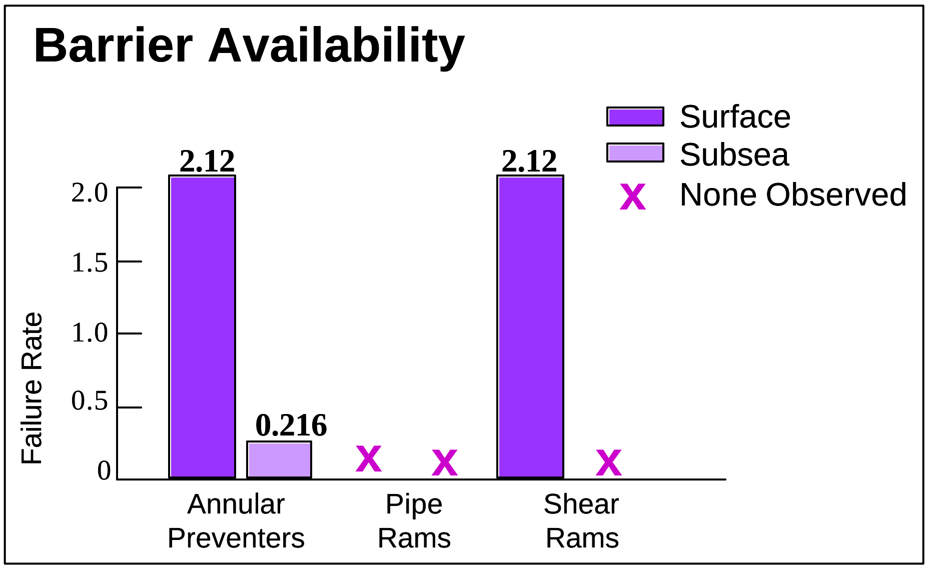
Several fairly simple testing procedures can significantly improve the reliability and availability of surface blowout preventer (BOP) equipment. The reliability of surface BOP equipment has largely been assumed satisfactory, considering the relative infrequency of blowouts. But recent data indicate surface BOP reliability is only one-tenth that of subsea BOP equipment. Thus, a company's possible exposure to blowouts may be significantly reduced by an improvement in the reliability of BOP equipment. BOPs are used to prevent an uncontrolled release of reservoir fluids. Most operators and drilling contractors immediately assume this critical safety equipment will work when needed. Many companies recognize that good safety performance can affect the financial bottom line, and therefore test and inspect the BOPs regularly.



Aside from human error, the possibility of a blowout has two main variables-the likelihood of a kick and the availability of the BOP system to function properly. In this article, only the equipment variable of the well control system will be considered.

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AVAILABILITY

Reliability is defined as how often the equipment is expected to work, and availability is defined as how often the equipment will be operable (available) when needed. The Foundation for Scientific & Industrial Research at the Norwegian Institute of Technology (Sintef) has published several reports documenting the reliability of both surface and subsea BOP equipment in

Norway. One set of data reports the equipment failures recorded on three surface BOP stack installations between 1987 and 1991. Another set describes similar subsea stack equipment failures based on 47 exploration wells drilled from 1987 to 1989. Both studies focused mainly on the failures found during the periodic testing during drilling operations. This approach was taken because of the link between undetected failures that occur before blowouts yet after successful tests. Of all detected failures, only those, which were deemed critical, namely those that would result in loss of well bore containment, are considered in this article. The Sintef data show a failure rate for surface BOPs to be ten times greater than that for subsea BOPs (Fig. 1). Failures detected while testing before drilling began and those detected during the initial installation were not included because of a lack of information on failure type. If the BOP stack was just taken out of service and a barrier failure subsequently detected on the stump, was the equipment available to work just before it was taken out of service? It is probable that this barrier would not have worked during the final stage of drilling the previous well. Most importantly, it is just at that stage of the well when BOP equipment availability is most critical. Additional data come from WEST Hou Inc.'s acceptance testing, an auditing process in which the BOP equipment and related systems are inspected and tested to ensure suitability for service. These tests are part of an overall quality system used to ensure equipment readiness. These data were taken from three consecutive trip reports from jack up drilling rig audits in 1992. These three were the most recent data, sequentially chosen to be representative and not handpicked to influence the study. The WEST Hou data differ from the Sintef data because the former are not related to elapsed time, but are "snapshots" of the equipment condition at the time of the audit. Therefore, a failure rate cannot be derived. Rather, conditions that would have resulted in loss of containment were taken as a percentage of the total equipment reviewed. External leakage and failure to seal in the closed position are the only deficiencies addressed (Fig. 2). The Sintef data did not address ram locking systems. The WEST Hou study found that 28% of the pipe ram locking systems and 33% of the shear ram locking systems surveyed were inoperable. These were included in the barrier availability determination. Other problems with well control systems were recorded in both studies but not addressed here.

These problems, although serious enough to require repair and sometimes suspend drilling, did not result in an immediate loss of barrier. The additional systems with problems included BOP control systems, diverters, valves on the BOP stack, and the choke and kill manifold. After a review of these data, several questions are suggested: Why is the reliability of surface BOP equipment so low, particularly relative to subsea equipment? What can be done to improve surface BOP equipment reliability?

LOW RELIABILITY

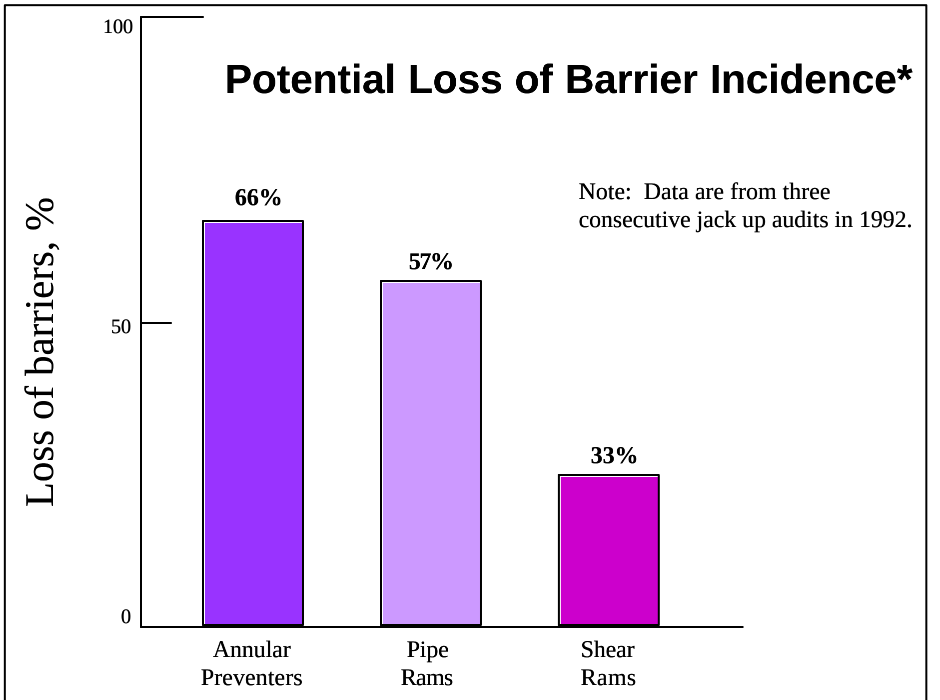
The reliability of surface equipment is lower than that of subsea equipment because of the following:

- Financial impact of drilling downtime. Total time and well costs, even while drilling, are relatively low, particularly compared to subsea downtime. Thus, the cost incentive for keeping subsea equipment reliable is greater than that for surface equipment.
- Skill levels of the people performing maintenance on the equipment. The problems include the lack of a dedicated individual responsible for BOP equipment, such as the subsea engineer on floating drilling operations, and the competency level of maintenance personnel servicing BOP equipment and control systems.
- BOP stack handling and testing capabilities. BOP maintenance on some rigs is unsafe or impossible between wells because the handling system may be inadequate to move the

entire stack without disassembly. Additionally, many rigs do not have a test stump and proper testing equipment.

- Rigs operating in Norway are required to have a test stump; therefore, the Sintef data on those rigs should show lower failure rates than for rigs without a test stump.
- Preventive maintenance programs. Experience has shown that the maintenance programs for surface BOP equipment generally emphasize preventive maintenance less than comparable programs for subsea equipment. Thus, surface BOP maintenance programs are often lower in quality and less comprehensive than programs for subsea equipment.
- BOP system availability and safety. Because no data were previously available, the reliability of surface equipment was presumed high.

Given that surface BOP equipment contains fewer redundant barriers to blowouts than do subsea stacks, the reliability of individual components is even more critical. For example, surface stacks may have three rams versus four on a subsea stack, one annular versus two, and a single hydraulic control system versus two independent, parallel control systems.



For surface BOP equipment

IMPROVING RELIABILITY

To improve BOP reliability, an operator should perform the following as part of a total quality system:

- Specify to the contractor the minimum acceptance standards for the BOP equipment and related systems.
- Audit to ensure that specifications have been met and that any required repairs were satisfactorily completed.
- Verify that the personnel responsible for maintaining and testing have the required skills.
- Upgrade preventive maintenance programs.
- Improve testing techniques.

ACCEPTANCE STANDARDS

Many operators often prepare documents for tender for rigs

with only a minimal reference to their expectations of BOP requirements, leading to several problems: equipment of unknown quality and operability, potential conflicts with the owner about the required testing, and the assignment of financial responsibility for delays from testing and unscheduled repairs. Including minimum acceptance standards in the tender documents is the first step toward eliminating these problems. Auditing surface and subsea BOP equipment to prescribed standards increases equipment reliability. Acceptance testing of subsea well control equipment (auditing to ensure minimum acceptance standards have been delivered) has been a common practice for some operators for the past several years. However, the driving force behind acceptance testing has been the high costs associated with drilling downtime on floating rigs. BOP-related problems are the third leading cause of drilling downtime for floating drilling rigs (following stuck pipe and weather), averaging 4% throughout the industry. After using expert acceptance testing, several operators have independently documented a drop in this downtime to less than 1%. Therefore, the decision to cut well costs by decreasing the BOP downtime through acceptance testing was often based on economics. The intrinsic benefit of increased safety was not considered by most operators in the economic analysis. However, some operators have stated that the safety incentive was their primary reason for using acceptance and annual audits.

PERSONNEL SKILL

In the mid-1970s, the position of subsea engineer became common because of the financial implications of subsea BOP stack failures. The use of specific personnel for subsea stack maintenance was the single largest reason for significant improvements in subsea BOP stack reliability. A similar solution is not recommended for surface BOP equipment, however, because of the lower costs of BOP-related downtime. In this situation, BOP availability can be increased by: Assigning BOP responsibility to a single person, even if only on a part-time basis Training the maintenance staff to ensure minimum specified standards of competence Auditing the equipment using a specialist at critical times in the drilling program. Each company's reliance on any of these measures and the extent of development must be individually determined based on the company's risk acceptance criteria.

MAINTENANCE PROGRAMS

The countries around the North Sea have some of the most stringent offshore regulations. Norwegian regulations, in particular, have required maintenance of BOP equipment at specific intervals since before 1980. These practices include a between-well maintenance system and annual and major surveys. The major surveys are mandatory every 4 years. In 1985, the U.K. began requiring similar maintenance schedules for operations in the U.K. sector of the North Sea. In U.S. waters, the Minerals Management Service specifies a maintenance system, but it does not specifically require either annual or major surveys. Other operating areas, such as parts of southeast Asia and the C.I.S., have no regulatory requirements for maintenance of equipment. A 4-year major survey verifies that critical wear limits have not been exceeded, ensures that dynamic and static surface finishes meet specified criteria, and provides a good opportunity to replace the elastomeric seals. These surveys are easily conducted offshore or on location on a land rig. However, many operators choose a repair facility for this work if they expect welding or machine work will be necessary. The following example illustrates the importance of regular inspection and testing. The movement of the ram blocks wears both the presenter body and the rams, and wear can occur rapidly considering the weekly function and pressure test requirements. The ram preventers must be checked for accumulated wear and any change in critical dimensions. When critical dimensions are exceeded for ram cavities, the low pressure integrity of the preventer is lost. Good testing techniques and dimensional inspection can detect when the critical dimensions have reached allowable safe limits.

At low pressures, ram body and block wear makes well bore pressure testing difficult. The preventer relies solely on the extrusion of the elastomeric seals from the force exerted by the operating piston to make this low pressure seal. Because the allowable tolerance between the ram block and the cavity is in the order of only 0.060-0.095 in. for various rams manufacturers, only a small amount of wear will result in low pressure test failures. In such situations, a BOP with new ram packers and top seals may not pass a lost pressure test.

TESTING

Many advanced testing techniques are available to determine the reliability of BOP equipment. However, one must enter the testing program with the attitude of finding the problems that exist, and not just achieving a straight line on a chart recorder. An examination of the basic pressure testing procedure is a good place to start the evaluation of a testing program. If the procedure is limited to pumping up the BOP stack and watching the chart for 5-10 min, then a good test is very likely. However, this criterion should not be the only defining factor for acceptable BOP equipment. On the other hand, if someone physically examines the stack for leaks, potential failures can be observed. In the proposed second edition of API Specification 16A, the standard for new drill through equipment, a good pressure test is defined by the phrase, "there shall be no visible leaks." Because of the large volumes of current BOP stacks and the high pressures used in many applications, a small leak can pass undetected unless the stack is visually examined by someone who knows where to look and who can ensure that the equipment works. The fundamental design feature of all ram-type BOPs is the necessity to maintain ram packer pressure higher than well bore pressure to ensure well bore containment. This seal is achieved by a design using well bore pressure to energize the ram blocks. Thus, the well bore pressure provides additional sealing force, which maintains the necessary differential pressure. If a drilling location must be evacuated because of inclement weather, well control problems, or fire, the rams must close, and the manual locking system must be engaged. After the rams are closed and the manual locking system is engaged, the locking system is supposed to maintain the ram packer pressure in the event that operating pressure is lost. For subsea BOPS, operating pressure loss occurs when the lower marine riser package is disconnected. For surface BOPS, operating pressure can be lost after emergency shutdown or after a simple hydraulic hose failure. Can one depend on this critical locking device if it may never have been tested? API Specification 16A, the standard for the design, manufacture, and testing of ram preventers, does not require testing of manual locking devices in the manufacturing facility when the equipment is new. API RP 53 is the recommended practice for the testing and maintenance of BOP equipment in the field. This recommended practice also does not require this test. (Ram locking devices are not even mentioned in this booklet.) Prudent drilling contractors and operators purchase rams to API Specification 16A and test them weekly per API RP 53. Successful tests may give them "warm and fuzzy" feelings about the safety of their installations based on these standards, but the locking systems may never have been tested. Each operator and drilling contractor should develop procedures for regular testing of the ram locking systems.

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Additional Data Shows Bigger Surface Subsea Gap

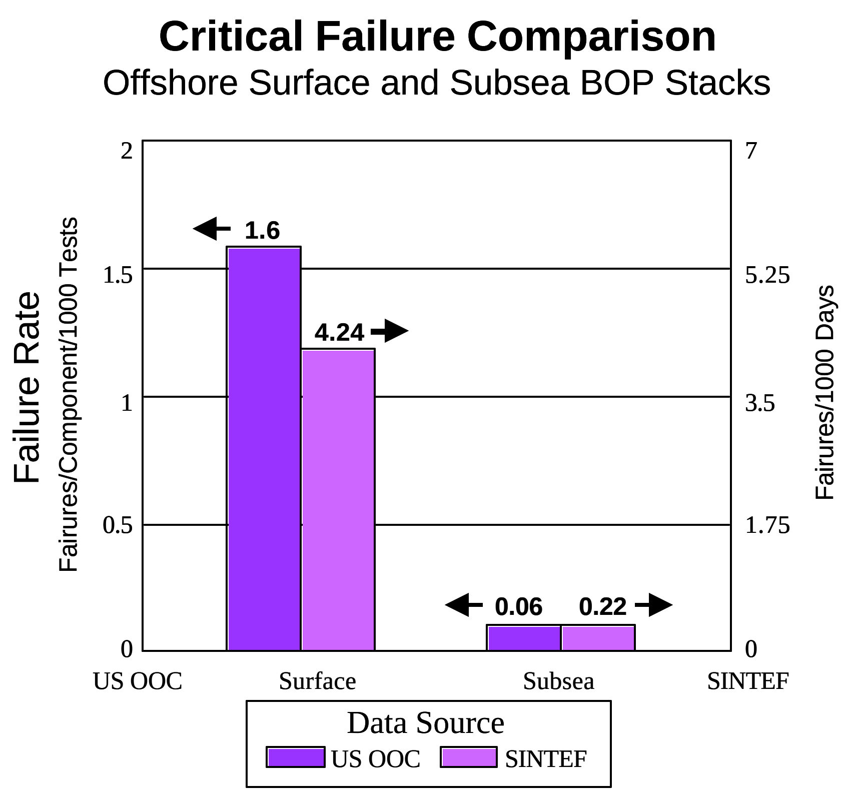
Since the publication of the above titled June 14, 1993 Oil & Gas Journal Article, an additional source of offshore reliability data was received. This data increases the previously reported spread between subsea and offshore surface BOP stack reliability from a factor of 19 to one of 27.

The chart below gives a graphical comparison of the SINTEF data presented in the original article and the data from the US OOC (US Offshore Operators Committee). The US OOC is an industry group which works with regulatory bodies, among others, to help them understand operating practices and concerns. The data graphed was represented in a June 1992 letter to the MMS (Minerals Management Service) regarding the proposed rule change on BOP testing intervals.

Note that the US OOC data and SINTEF data are graphed with differently scaled Y-axes. This was done because of the different bases of the data. Rather than make assumptions to directly compare the data, the graph was constructed to show the relative reliability of stacks in the two types of service.

The scales were selected to show the subsea data at the same height for both data sources. Although the US OOC units are failures per component per thousand tests and SINTEF data are failures per thousand service days, in both cases the data shows subsea reliability to be between 19 and 27 times that of offshore surface BOP components.

The addition of this third independent data source solidifies the conclusions drawn in the earlier paper, namely, that implementing certain policies and practices that have become standard on many floating drilling rigs would cost effectively and dramatically reduce your company's exposure to safety and environmental incidents.



Data from US Offshore Operators Committee and
SINTEF Failure rates Calculated on different bases