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Supplement
WCE Subunit Boundaries

SafeOCS

About the Bureau of Transportation Statistics

Leadership

Patricia Hu, *Director*
Rolf R. Schmitt, *Deputy Director*

About This Report

Produced under the direction of:

Allison Fischman, *Director, Office of Safety Data and Analysis*

Major Contributors

Frank Adamek, Demetra Collia, David Gallander, Tony Hogg, Susan Lajeunesse, Amanda Lemons

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Abstract

This supplement provides descriptions of the various subunits comprising well control equipment (WCE) systems, including the blowout preventer (BOP) stack system, BOP controls, riser system, diverter system, and choke manifold system. These subunits and their components fall within the scope of the SafeOCS WCE failure reporting program.

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Notice

Table of Contents

INTRODUCTION **1**

DESCRIPTIONS OF WCE SUBUNITS **2**

1.1. BOP Stack System 2

1.1.1. The Subsea BOP Stack *2*

1.1.2. The Surface BOP Stack *2*

1.2. BOP Controls 3

1.2.1. The Subsea BOP Control System *3*

1.2.2. The Surface BOP Control System *4*

1.3. Riser System 4

1.4. Diverter System 5

1.5. Choke Manifold System 5

APPENDIX A. EXAMPLE SCHEMATICS **6**

LIST OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS **15**

List of Figures

Figure 1. Example Subsea BOP Stack 6
Figure 2. Example Surface BOP Stack and Controls 7
Figure 3. Example Subsea Shear Ram Control System Arrangement 8
Figure 4. Example Subsea Primary Control System – Shear Ram 9
Figure 5. Example Emergency Deadman/Autoshear Control 10
Figure 6. Example Secondary Acoustic Control System 11
Figure 7. Example Riser Joints 12
Figure 8. Example Diverter System 13
Figure 9. Example Choke Manifold 14

Introduction

Well control equipment (WCE) systems comprise a combination of several subunits serving to control the flow of wellbore fluids during oil and gas drilling and other well operations. API Standard 53 lists the subunits required for such operations, including blowout preventers (BOPs), choke and kill lines, choke manifolds, and control systems.[1] These subunits and their components, as well as the diverter and riser systems, fall within the scope of the SafeOCS WCE failure reporting program.

This supplement provides descriptions of each of the following WCE subunits:

- BOP stack system
- BOP controls (primary, emergency, and secondary)
- Riser system
- Diverter system
- Choke manifold system

Example schematic drawings are included in Appendix A.

This supplement has been revised to reflect updates to the SafeOCS equipment component schema.

[1] API Standard 53, Blowout Prevention Equipment Systems for Drilling Wells, Fourth Edition, section 1.1.2. Auxiliary equipment, which comprises the drill string valves, gas separation equipment, test equipment, and top drive equipment, is also described in Standard 53 but is excluded here as less relevant to well control.

Descriptions of WCE Subunits

1.1. BOP STACK SYSTEM

1.1.1. The Subsea BOP Stack

The subsea BOP stack (Figure 1) shall provide a means to do the following:[2]

- Close and seal on the drill pipe, tubing, casing, or liner and allow circulation.
- Close and seal on an open hole and allow volumetric well control operations.
- Strip the drill string.
- Hang-off the drill pipe on a ram BOP and control the wellbore.
- Shear the drill pipe, tubing, or wireline in use.
- Disconnect the riser from the BOP stack.
- Circulate across the BOP stack to a choke manifold.

Subsea BOP stacks shall be a minimum Class 5 (10,000 psi or greater maximum anticipated wellhead pressure (MAWHP)) or greater with:

- A minimum of one annular preventer.
- A minimum of two pipe rams.
- A minimum of two sets of shear rams, one of which must be able to seal. (Moored rigs can have a minimum of one set of shear rams after conducting a risk assessment.)

The subsea BOP stacks in use in the Gulf of Mexico Outer Continental Shelf (GOM OCS) today are equivalent to Class 8-A2-R6 with two annular preventers and six sets of rams.[3]

Subsea BOP stack mounted choke and kill lines provide redundancy as well as multiple access points to the BOP stack and allow for well control operations as follows:

- Circulating down one line and up the other line.
- Circulating down the drill pipe and up either or both lines.
- Pump down one or both lines.
- Allow well pressure monitoring.
- All outlets connected to the stack shall have two valves, and all are remote controlled.

1.1.2. The Surface BOP Stack

The surface BOP stack (Figure 2) shall provide a means to do the following:

- Close and seal on the drill pipe, tubing, casing, or liner, and allow circulation.
- Close and seal on an open hole and allow volumetric well control operations.
- Strip the drill string.
- Shear the drill pipe or tubing when blind shear rams are installed.
- Circulate across the BOP stack to a choke manifold.

[2] All shall statements refer to API Standard 53 requirements.
[3] Subsea BOP stack classifications are described in section 7.1.2 of API Standard 53.

Jack-up rigs, which operate in the shallow water GOM (<400 m), typically use a Class 4-A1-R3 (one annular preventer and three ram-type preventers) BOP with a maximum anticipated surface pressure (MASP) of 10,000 psi.[4] Surface BOP stack choke and kill systems provide access points to the BOP stack and allow the following:

- Circulating down the kill line and up the choke line.
- Circulating down the drill pipe and up the choke line.
- Pump down the kill line.
- Allow well pressure monitoring.
- All outlets connected to the BOP stack shall have two valves, one of which must be remote controlled.

1.2. BOP CONTROLS

1.2.1. The Subsea BOP Control System

Subsea BOP control systems shall have the following, unless otherwise noted:

- Redundant control pods
- An autoshear emergency control system
- A deadman emergency control system
- An ROV intervention secondary control system
- An acoustic secondary control system (optional for all subsea systems)
- An emergency disconnect sequence (EDS) (mandatory for all stacks run from a dynamically-positioned (DP) vessel but optional for moored vessels)

Figure 3 shows a typical example of a control system arrangement for the shear rams. The shear rams in the example can be closed from seven different sources.

The API Standard 53 minimal requirements do not specify the full range of equipment components available and in use today. Not only do current systems allow for full control from various panels, but they also provide readbacks in the form of position, inclination angles, flow meter readings, pressures, temperatures, alarms, and various system fault messages, both live and logged. Much of this information is also sent through secure communications to the shorebases for further monitoring or troubleshooting purposes.

1.2.1.1. The Primary BOP Control System

The primary BOP control system (Figure 4) includes all the functions that can be operated or monitored from any one of multiple panels on the rig (e.g., the driller's control panel, toolpusher's control panel, or subsea maintenance panel). Each of these panels can operate all the BOP stack functions. Any one of these panels can send a signal to the two identical control pods, each of which receives the signal but only the active pod responds to it. The other pod is fully redundant to the active pod and on standby for immediate use if required. These control pods, mounted on the lower marine riser package (LMRP), decode the multiplexed signals from the surface, and send the hydraulic fluid at the required pressure to the commanded function. The control pods each have independent MUX (multiplex) control cables from the surface

[4] Surface BOP stack classifications are in accordance with API Standard 53, section 6.1.2.

panels. The BOP stack also has at least two independent hydraulic supplies, adding to the levels of redundancy throughout.

Although the two control pods and multiple panels provide full redundancy of control to the BOP stack, there are some events that could prevent the rig personnel from affecting those controls. In anticipation of such circumstances, the subsea BOP stacks are outfitted with additional control equipment, including the emergency and secondary control systems.

1.2.1.2. The BOP Emergency Control System

The emergency control system (Figure 5) includes the automated deadman and autoshear controls, which are independent of the primary control system components. The autoshear system will automatically shut in the wellbore if the LMRP is disconnected deliberately or accidentally. The deadman system will shut in the wellbore if power and signals to both control pods are simultaneously lost.

1.2.1.3. The Secondary BOP Control System

The secondary control system includes BOP stack mounted interface control panels such that the remotely operated vehicle (ROV) can connect to the BOP stack to operate certain functions externally. The secondary control system (Figure 6) also includes an optional acoustic control interface with a standalone control pod.[5] This secondary control system allows for the operation of selected BOP stack functions via one of two redundant transponders that send and receive coded audio signals transmitted through the water from either the rig or a portable control unit.

1.2.2. The Surface BOP Control System

The BOP control system for a surface BOP stack (Figure 2) is usually a closed loop direct hydraulic system. The hydraulic power unit (HPU) pressurizes the hydraulic fluid from the reservoir tank, which it stores in the surface accumulator. The accumulator feeds a pressure regulator, which then directs the fluid to a control manifold. This manifold supplies the individual valves for each function which then direct the fluid directly to the BOPs and valves. When a function such as opening the annular is operated, the fluid on the close side of the annular is returned to the reservoir. Other than having two remote control panels to operate the manifold directional control valves, the individual control circuits do not have redundancy. The surface shear ram has only one close supply line, but it is always physically accessible. Redundancy is accomplished by having multiple sets of rams in the BOP stack.

1.3. RISER SYSTEM

The marine drilling riser system includes all components from the top of the BOP stack to the bottom of the diverter. On a subsea system, this includes a quantity (string) of riser joints to suit the rig. A 12,000-foot capable rig that uses 75-foot joints will have 160 joints of riser, plus a set of “pup” joints which have similar specifications but are a mixture of shorter lengths to allow the correct overall measurements to be reached.

Figure 7 shows an example schematic for a riser joint. Each joint has a “pin” on one end and a “box” on the other. The pin end has male stabs for the main tube and all auxiliary (choke, kill,

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[5] Optional, in this case, refers only to the installation of the equipment. If an acoustic control system is installed and mentioned on the permit to drill, then it is expected to be fully functional.

mud boost, and hydraulic conduit) lines. The box end is the female side of the connections and contains individual redundant seals for each line. The pin is stabbed into the box and then, depending on the style of riser there may be bolt, dogs, or a breech lock to join the joints together. Most deep-water riser joints will be enclosed in buoyancy modules to reduce the "wet" weight of the riser and help to keep the riser string in tension.

Above the riser joints is the telescopic joint. This is used how it sounds, a special joint of riser with a larger bore outer barrel at the bottom and an inner barrel at the top with two redundant sealing units in the middle. The outer barrel connects to the riser string, and the inner barrel connects to the diverter completing a sealed conduit from the BOP stack to the mud treatment equipment on the rig.

1.4. DIVERTER SYSTEM

The diverter equipment (Figure 8) is mounted underneath the rig floor rotary table and provides the interface between the drilling riser on a subsea system, or the BOP stack in the case of surface systems, and the drilling fluid (mud) systems. The components include the diverter housing, the diverter assembly, overboard and flowline valves, controls, and pipework. The use and operation of the diverter systems are similar for both subsea and surface WCE systems.

In the event of a shallow gas kick or a blowout, the diverter packing unit would be hydraulically closed to prevent the flow from immediately reaching the rig floor. Activating the packer to the closed position automatically starts a sequence to remotely close the flowline valve and to open the overboard lines simultaneously to prevent a closed system because the diverter is, by definition, not a blowout preventer. Rather, it is a safety device intended to give the people on the drill floor vital minutes to evacuate in case of an emergency.

1.5. CHOKE MANIFOLD SYSTEM

The choke manifold system (Figure 9) is an arrangement of piping, valves, chokes, and instruments used to control pressurized fluids coming out of the well. The boundaries of the choke manifold system are from the drape hoses to the top of the vent pipe in the derrick. The manifolds are designed to allow wellbore fluids to be evacuated from the well and safely directed to the proper location. During a well kill operation, this could involve drawing heavy mud (drilling fluid) from the mud pits via the standpipe manifold and pumping it down the kill line. With a BOP closed, the gas-cut mud, or simply the lighter mud, is directed up the choke line and back to the manifold. When the fluid reaches the manifold, it is directed through a remotely adjustable choke designed to restrict the flow and thus control the pressure coming out of the well.

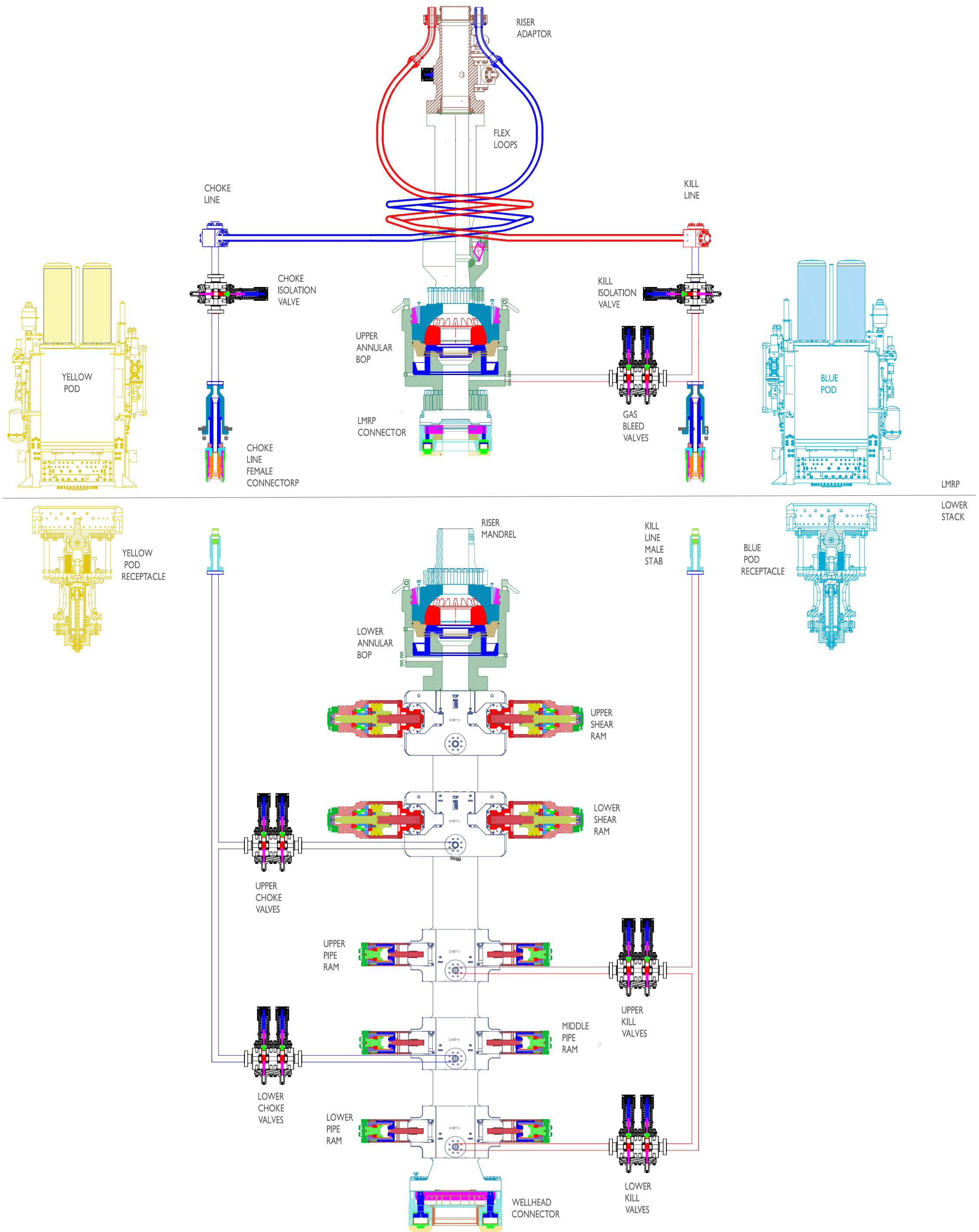
All choke manifolds must have at least two adjustable chokes for redundancy purposes.[6] If the choke becomes blocked during a well kill operation, it is relatively easy to redirect the flow through an alternate choke with minimal disruption. The functional requirements for the choke manifold are essentially the same for both subsea and (≥10,000 psi) surface systems. However, the surface systems are often less versatile in the possible routings through the manifold.

[6] API Standard 53, sections 6.2.1.3 and 7.2.2.6.

Appendix A. Example Schematics

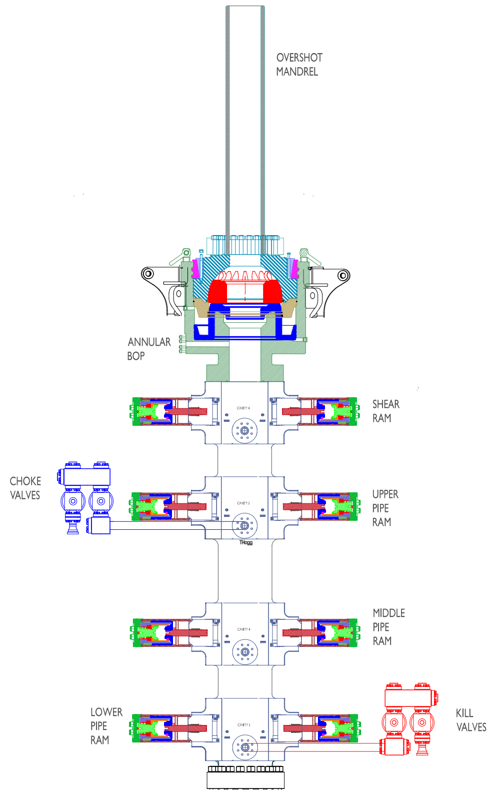
The following pages present example schematics referenced in the subunit descriptions.

Figure 1. Example Subsea BOP Stack



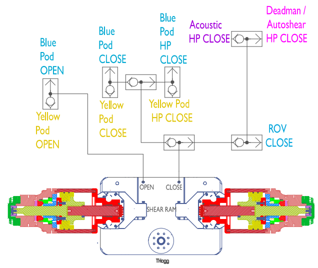
BOP = blowout preventer; LMRP = lower marine riser package.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS.

Figure 2. Example Surface BOP Stack and Controls



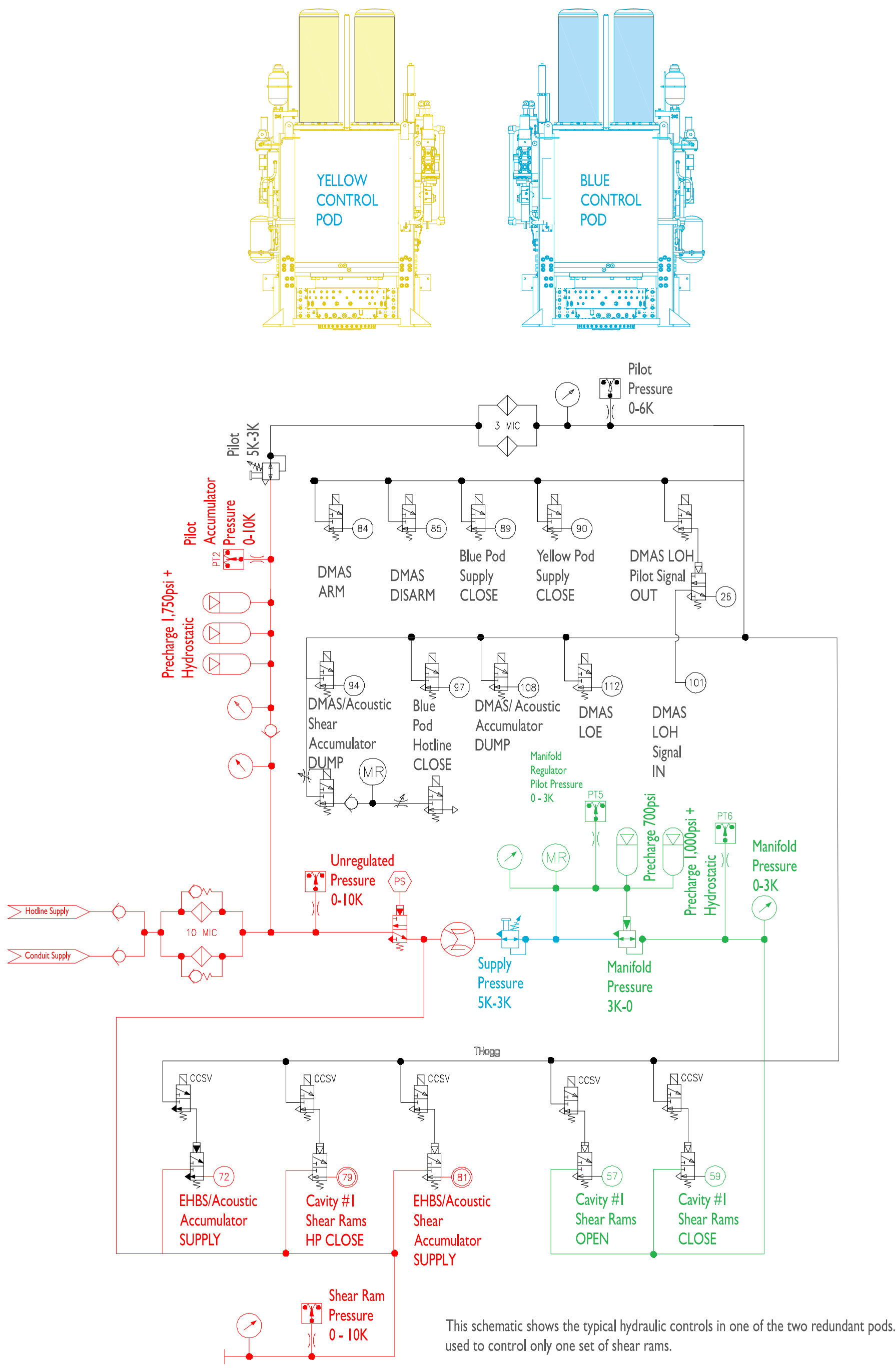
BOP = blowout preventer.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS.

Figure 3. Example Subsea Shear Ram Control System Arrangement



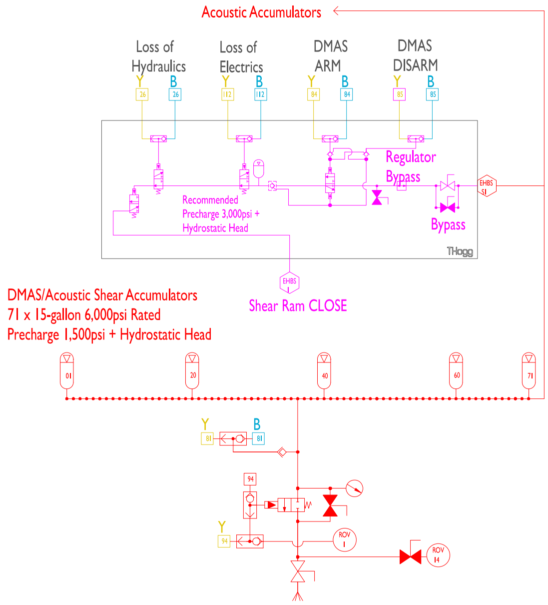
HP = high pressure; ROV = remotely operated vehicle.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS.

Figure 4. Example Subsea Primary Control System – Shear Ram



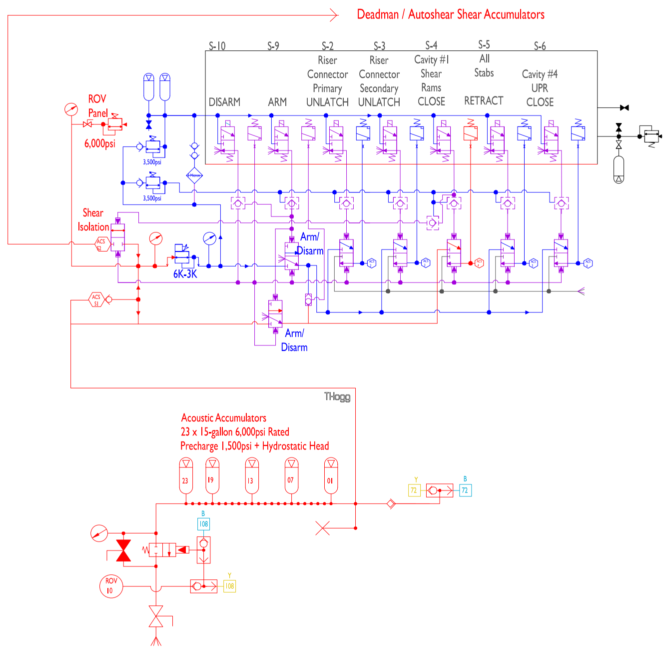
BOP = blowout preventer; DMAS = deadman/autoshear system; LOH = loss of hydraulics; LOE = loss of electrics; EHBS = emergency hydraulic backup system; HP = high pressure. Source: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS.

Figure 5. Example Emergency Deadman/Autoshear Control



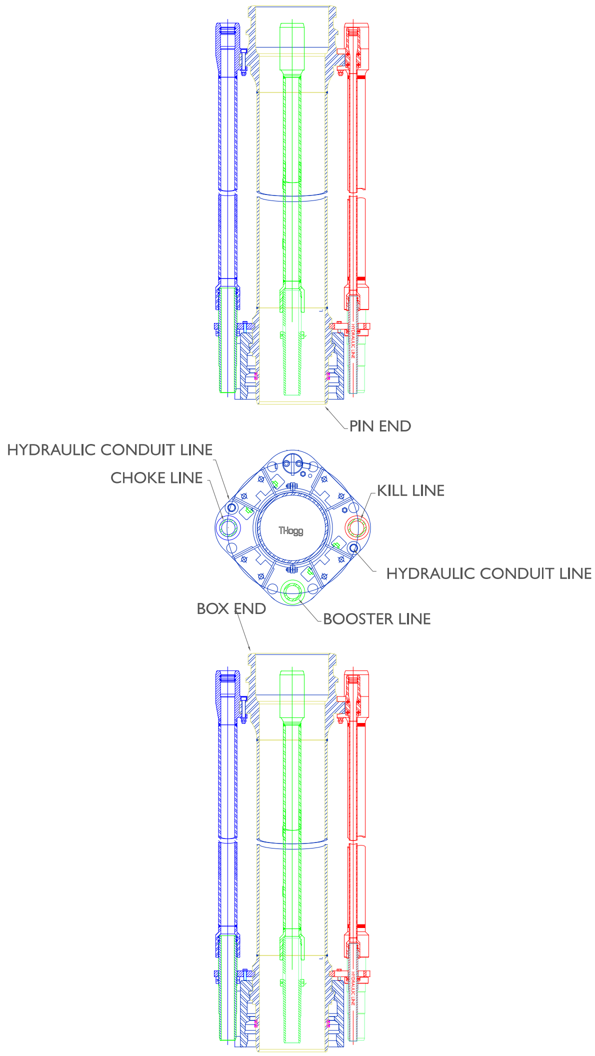
Y = yellow; B = blue; DMAS = deadman/autoshear system; EHBS = emergency hydraulic backup system.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS.

Figure 6. Example Secondary Acoustic Control System



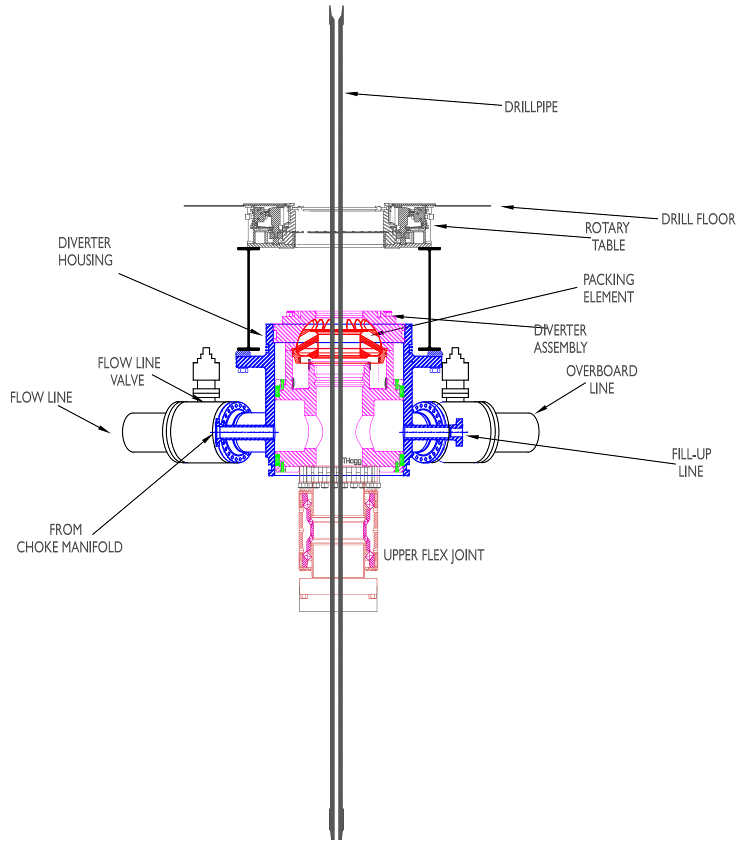
ROV = remotely operated vehicle; UPR = upper pipe ram; Y = yellow; B = blue.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS.

Figure 7. Example Riser Joints



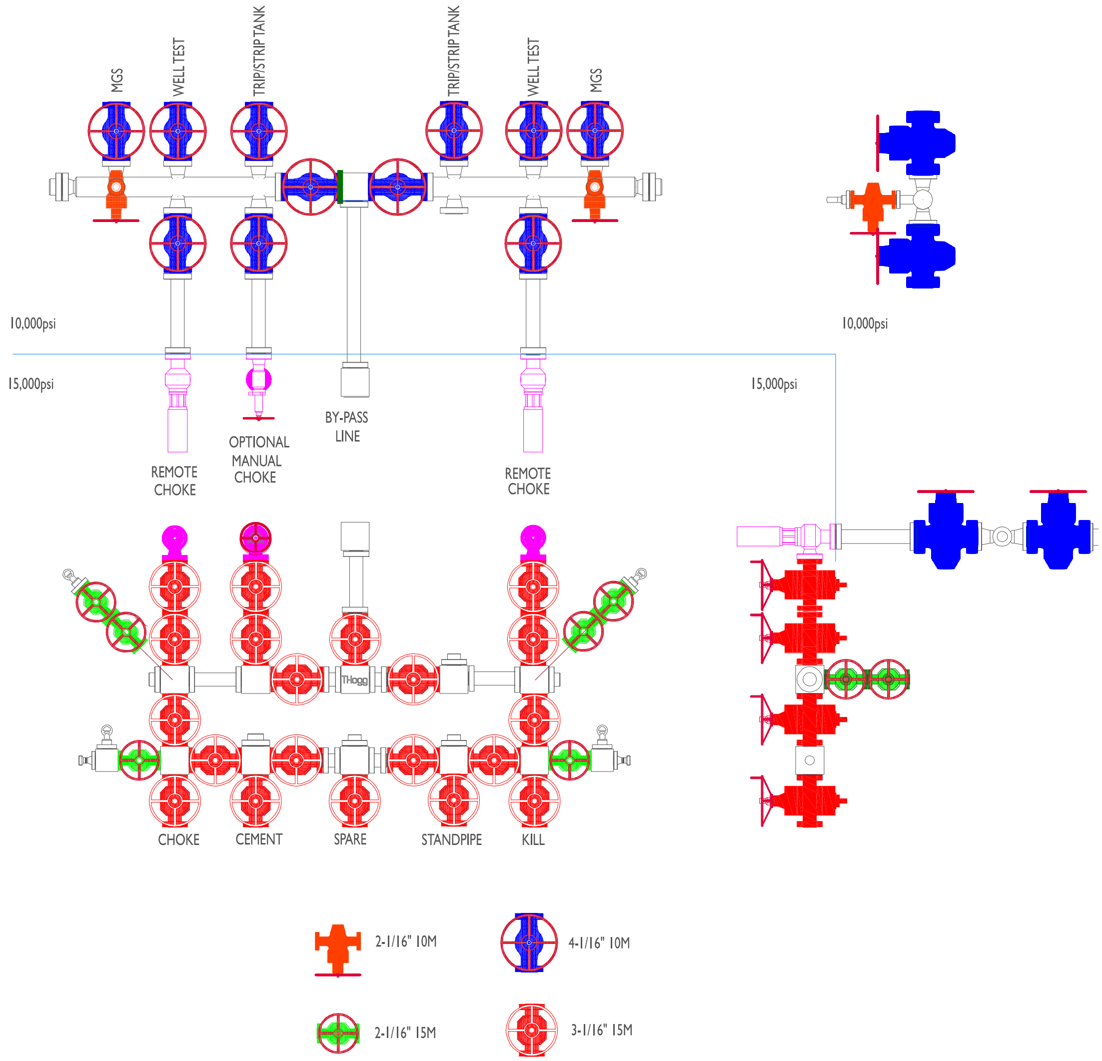
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS.

Figure 8. Example Diverter System



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

Figure 9. Example Choke Manifold



MGS = mud gas separator.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, SafeOCS.

List of Abbreviations, Acronyms, and Initialisms

API	American Petroleum Institute
BOP	blowout preventer
BTS	Bureau of Transportation Statistics
DMAS	deadman/autoshear system
DP	dynamic positioning
EDS	emergency disconnect sequence
EHBS	emergency hydraulic backup system
GOM	Gulf of Mexico
HP	high pressure
HPU	hydraulic power unit
LMRP	lower marine riser package
LOE	loss of electrics
LOH	loss of hydraulics
MASP	maximum anticipated surface pressure
MAWHP	maximum anticipated wellhead pressure
MGS	mud gas separator
MUX	multiplex
OCS	Outer Continental Shelf
ROV	remotely operated vehicle
UPR	upper pipe ram
WCE	well control equipment