## Introduction

Preventing and, when prevention is not sufficient, responding to potential uncontrolled releases of oil or gas ("blowout") is critical to safe drilling operations. A kick is an influx of formation fluids into the wellbore. A blowout is an uncontrolled kick exiting the well at surface.

Well control is a process that begins with spudding the well and is not complete until the well is put on production and all drilling operations cease.

This chapter will examine equipment commonly used in well control and processes used to control kicks of oil or gas.

## Blowout preventer stack equipment

### *Annular blowout preventer*

The annular blowout preventer is installed at the top of the BOP stack (**Figure WC-1**) and has the capability of closing (sealing off) on anything in the bore or completely shutting off (CSO) the open hole by applying closing pressure.

The sealing device of an annular blowout preventer is referred to as the "packing element". It is basically a donut-shaped element made out of elastomeric material. To reinforce the elastomeric material, different shapes of metallic material are molded into the element. This keeps the elastomeric material from extruding when operating system pressure or wellbore pressure is applied to the bottom of the packing element. Since the packing element is exposed to different drilling environments (i.e., drilling fluid/mud, corrosive $H_2S$ gas and/or temperature of the drilling fluid), it is important to make sure that the proper packing element is installed in the annular preventer for the anticipated environment of the drilling operation.

During normal wellbore operations, the preventer is kept fully open by applying hydraulic pressure to position the piston in the open (down) position. This position permits passage of drilling tools, casing, and other items which are equal to the full bore size of the BOP. The blowout preventer is maintained in the open position by relaxing all hydraulic control pressures to the closing chamber and applying hydraulic pressure to the opening chamber. Application of hydraulic pressure to the opening chamber ensures positive control of the piston.

### *Close preventer operation*

In order for the annular BOP to close on anything in the bore or to perform a complete shut-off, CSO or open-hole closure, closing pressure must be applied. A CSO is typically limited to 50% of the annular rated working pressure, RWP. As the piston is moved to the closed position, the elastomer packer is squeezed inward to a sealing engagement with

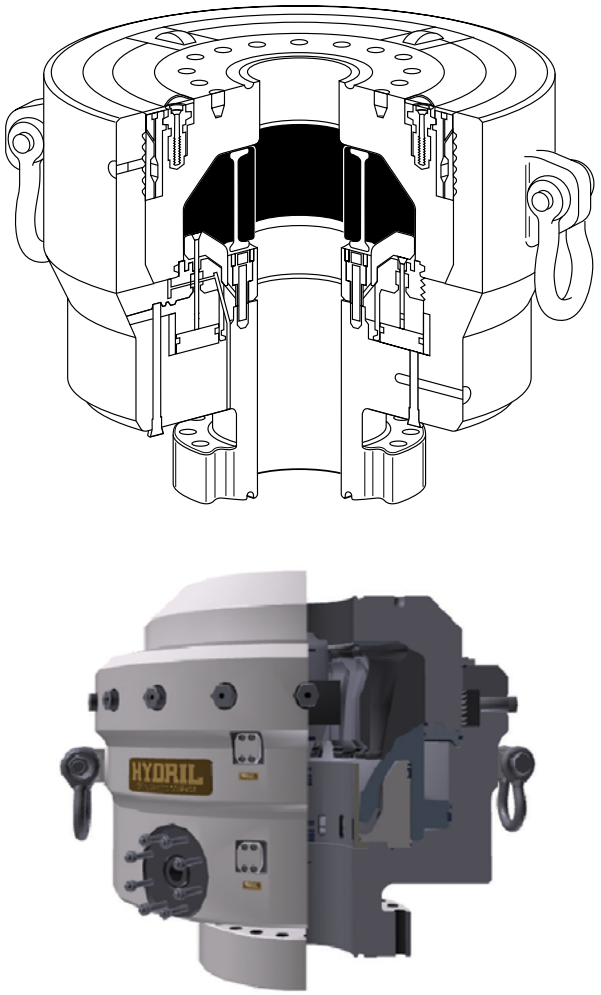


**Figure WC-1:** Schematic (top) and photo of annular blowout preventers. Photo courtesy GE Oil & Gas. Top image, IADC drawing.

anything in the bore or on the open hole. Compression of the elastomer throughout the sealing area assures a strong, durable seal off against almost any shape, even with a previously used or damaged packer.

The piston is moved to the closed position by applying hydraulic pressure to the closing chamber. Guidelines for closing pressures are contained in the operational section for each manufacturer's type of annular blowout preventer and in the Operator's Manual. The correct closing pressure will ensure long life, whereas excessive or deficient closing pressures will reduce packer life. The pressure regulator valve of the hydraulic control unit should be adjusted to the manufacturer's recommended closing pressure.

As the packing element rubber deteriorates, higher closing pressures may be required to effect a seal. Subsea applications may require an adjustment of closing pressure due to effects of the hydrostatic head of the control fluid and of the drilling fluid column in the marine riser. Some manufactur-

 

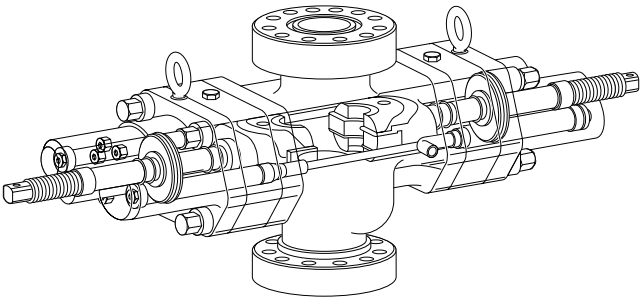

**Figure WC-2:** Schematic of ram-type BOP. IADC drawing.


**Video WC-1:** Animation shows internal BOP action. Courtesy National Oilwell Varco.

ers may also require limiting the closing pressure depending upon the diameter and wall thickness of casing or large diameter tubulars. The applicable operator's manual will explain these requirements.

## *Stripping with an annular BOP*

Drillpipe can be rotated and tool joints stripped through a closed packer while maintaining a full seal on the drillpipe. Longest packer life is obtained by adjusting the closing chamber pressure just low enough to maintain a seal on the drillpipe with a slight amount of drilling fluid leakage as the tool joint passes through the packer. The leakage indicates the lowest usable closing pressure for minimum packer wear and provides lubrication for the drillpipe motion through the packer.

A pressure regulator valve should be set to maintain the proper closing pressure. For stripping purposes, the regulator valve is usually too small and cannot respond fast enough for effective control, so a surge bottle is connected as closely as possible to the BOP closing port (particularly for subsea installations). The surge bottle is pre-charged with nitrogen, and is installed in the BOP closing line in order to reduce the pressure surge which occurs each time a tool joint enters the closed packer during stripping. A properly installed surge bottle helps reduce packer wear when stripping. Check manufacturer's recommendations for proper nitrogen precharge pressure for your particular operating requirements. In subsea operations, it is advisable to add an accumulator to the opening chamber line to prevent undesirable pressure variations.

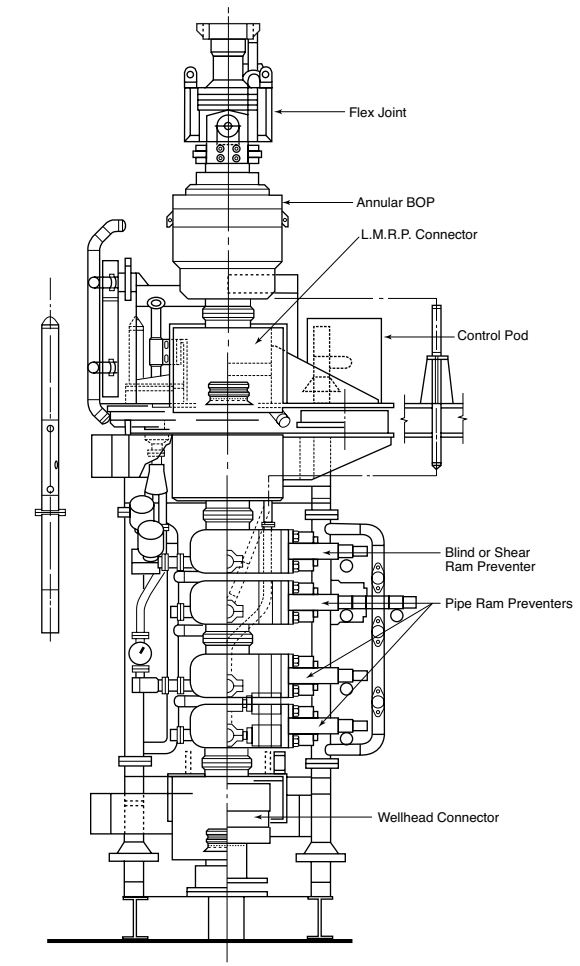


**Figure WC-3:** Schematic (top) and photo of typical subsea BOP stack. Photo courtesy GE Oil & Gas. IADC drawing at top.

 

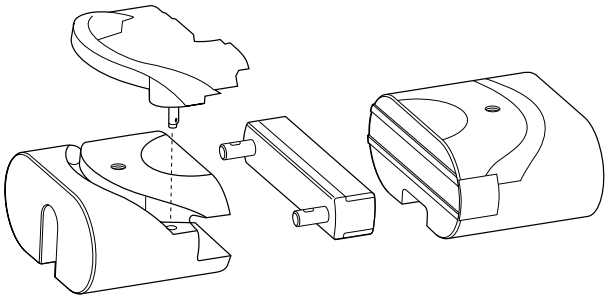

**Figure WC-4:** Blind rams. IADC drawing.

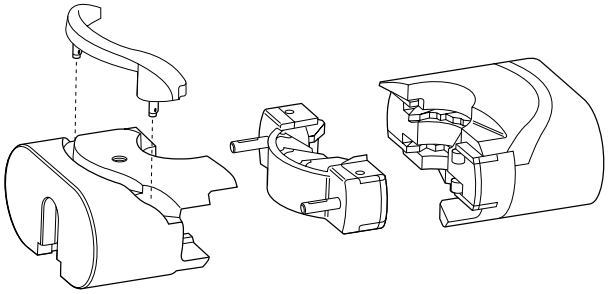

**Figure WC-6:** Variable bore rams. IADC drawing.

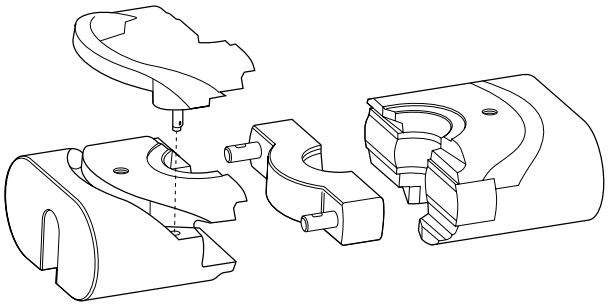

**Figure WC-5:** Pipe rams. IADC drawing.

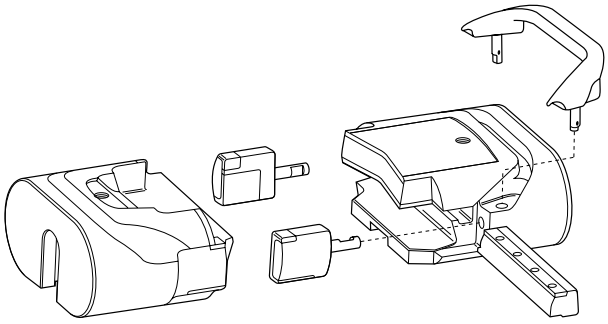

**Figure WC-7:** Schematic (top) and photo of Upper and lower shearing blind rams. Photo courtesy GE Oil & Gas. IADC drawing at top.

### *Ram-type blowout preventer*

A ram-type blowout preventer is basically a large bore valve (**Figure WC-2**). The ram blowout preventer is designed to seal off the wellbore when pipe or tubing is in the well. In a BOP stack, ram preventers are located between the annular BOP and the wellhead. (See schematic of a typical subsea BOP stack in **Figure WC-3**.) The number of ram preventers in a BOP stack ranges from one to eight depending on application and water depth. Flanged or hubbed side outlets are located on one or both sides of the ram BOPs. These outlets are sometimes used to attach the valved choke and kill lines too. The outlets enter the wellbore of the ram preventer immediately under the ram cavity.

Other than sealing off the wellbore, rams can be used to hang-off the drillstring. A pipe ram, closed around the drillpipe with the tool joint resting on the top of the ram, can hold up to 600,000 lb of drillstring.

Several different types of rams are installed in the ram type BOP body. The five main types of rams are blind rams, pipe rams, variable bore rams, shearing blind rams, and casing shear rams. Following is a brief description of each type:

- Blind rams: Rubber sealing element is flat and can seal the wellbore when there is nothing in it, i.e., "open hole" (**Figure WC-4**);
- Pipe rams: Sealing element is shaped to fit around a variety of tubulars with a particular diameter, which include production tubing, drill pipe, drill collars, and casing that will seal off the wellbore around it (**Figure WC-5**);
- Variable bore rams: Sealing element is much more complex and allows for sealing around a particular range of pipe sizes (**Figure WC-6**);
- Shearing blind rams: Blade portion of the rams shears or cuts the drillpipe, and then a seal is obtained much like the blind ram (**Figure WC-7**);
- Casing shear rams: Casing shear rams are typically shearing rams only and will not seal. They are specifically designed to cut large diameter tubulars that are incapable of being sheared by blind shear rams.

**Note:** Shear rams are also available that are capable of shearing multiple tubing strings and large diameter tubulars while maintaining a reliable wellbore pressure seal.

### Operation and use of pipe rams

As described earlier, pipe rams are designed to fit around certain diameter tubulars to seal off the wellbore (annulus) in a blowout situation. Most pipe rams are designed with re-

 