Making sure that the Deepwater Horizon won't happen again

by Vladimir Andreev, Founder, Balanced Solutions

Deepwater Horizon on fire after the explosions

INNOVATION QUOTE

The biggest threat to innovation is internal politics and an organizational culture, which doesn't accept failure and/or doesn't accept ideas from outside, and/or cannot change." Gartner Financial Services Innovation Survey, 2016.

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Deepwater horizon tragedy

At 9:45 P.M. CDT on 20 April 2010, during the final phases of drilling the exploratory well at Macondo, a geyser of seawater erupted from the marine riser onto the rig, shooting 240 ft (73 m) into the air. This was soon followed by the eruption of a slushy combination of drilling mud, methane gas, and water. The gas component of the slushy material quickly transitioned into a fully gaseous state and then ignited into a series of explosions and then a firestorm. An attempt was made to activate the blowout preventer, but it failed. The final defense to prevent an oil spill, a device known as a blind shear ram, was activated but failed to plug the well.

At the time of the explosion, there were 126 crew on board; seven were employees of BP, 79 of Transocean, there were also employees of various other companies involved in the operation of the rig. Eleven workers were presumed killed in the initial explosion. The rig was evacuated, with injured workers airlifted to medical facilities. Deepwater Horizon sank on 22 April 2010.

The resultant oil spill continued until 15 July when it was closed by a cap. Relief wells were used to permanently seal the well, which was declared "effectively dead" on 19 September 2010.

DNV GL were awarded a contract to undertake the forensic examinations, investigations and tests on the recovered Deepwater Horizon BOP on September 1, 2010. (Ref 1).

What was the cause of the tragedy?

There were numerous factors that had contributed to the tragedy taking place. To name the few extreme press on the drilling team to complete the well as soon as possible, inadequate quality of the cementing, misinterpretation of the readings from the well, etc. However, the main question is why the "last barrier" – Blowout preventer (BOP) had not been able to contain the blowout.

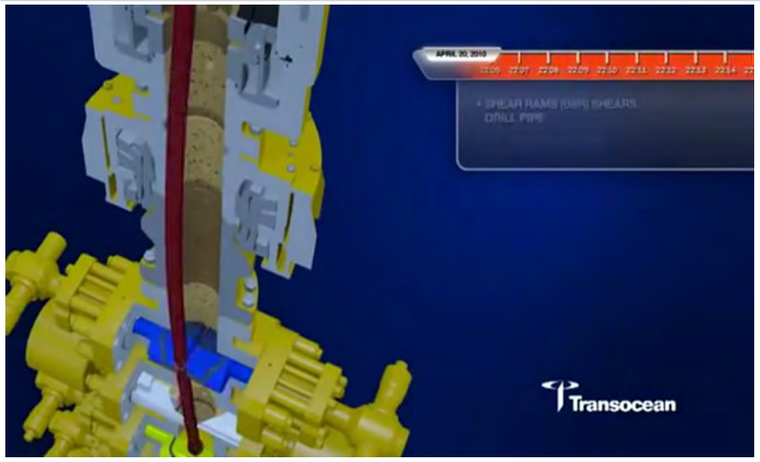
The DNV GL Report (Ref. 1) summarizes its following:

Primary cause of failure:

- The Blind Shear Rams (BSR) failed to fully close and seal the well due to a portion of drill pipe trapped between the blocks.

Contributing causes to the primary cause included:

- The Blind Shear Rams (BSR) were not able to move the entire pipe cross section into the shearing surfaces of the blades.
- Drill pipe in process of shearing was deformed outside the shearing blade surfaces.
- The drill pipe elastically buckled within the wellbore due to forces induced on the drill pipe during loss of well control.



Deepwater Horizon BOP - reconstruction of blowout (courtesy Transocean)

The DNV GL had also provided a set of recommendation for the industry to make sure that the Deepwater Horizon tragedy is not repeated. The recommendations related to the BOPs themselves were:

- Study of Elastic Buckling
- Study of the Shear Blade Surfaces of Shear Rams

losing effectiveness.

- The shape of the blades is such that it cannot effectively move buckled pipe into the area where shear blades can effectively cut the pipe.
- There is a limited amount of force can be applied to the cutters.
- Inability of the shear rams to establish a reliable pressure barrier in case of significant flow in the well during blowout.

For the years that have passed since the tragedy number it's been made significant advances in order to address the causes of the Deepwater Horizon BOP failure.

Cameron have improved their BOP controls, by introducing additional control pod in their Mark IV Subsea MUX BOP Control System (Ref. 2) in order to increase availability of BOP controls. In order to address increased shearing capacity, Cameron introduced a Subsea Pressure Intensifier as an option for new builds and retrofit (Ref. 3).

GE Hydril have introduced a wellbore pressure assisted actuation, thus addressing the issue with loss of effectiveness of the shear rams with increased wellbore pressure, in addition GE's BSRs features an automatic pipe centering capability (Ref. 4).

NOV have introduced Low Force Shear Ram with unique profile of the shear blades that in addition to self-centralization capability also provide unmatched shearing capability (Ref. 5). Also NOV have been working on the shearing gate valve concept that also utilizes metal seal.

Also, the major drilling companies had performed internal evaluations on whether or not their BOPs would be capable of the containing the well in the similar circumstances as were at Macondo well. The findings weren't altogether comforting for the majority of the BOPs:

- The BSRs at some combination of the type of drill pipe and wellbore pressure aren't capable to shear the drill pipe and seal the well.
- The BOP operating procedures don't address any mitigation measures of drill pipe buckling risk and therefore moving the drill pipe from the shearing surfaces of the blades.

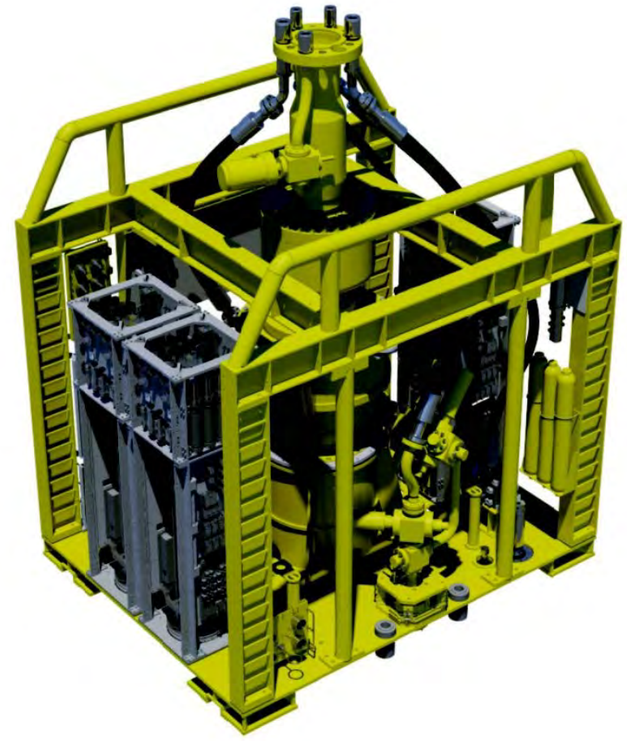
Industry response

In the wake of the disaster the industry had mobilized to the bridge the gap where BOPs aren't capable to provide a "last barrier".
The API had developed a revised specification for the BOPs.

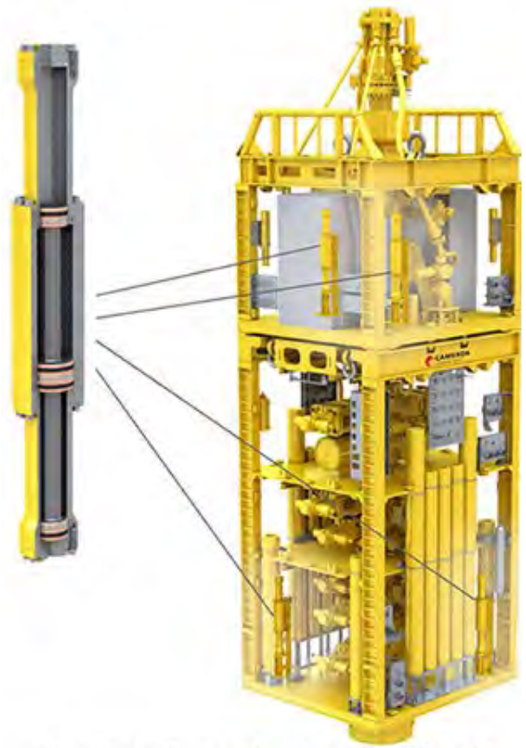
Major OEM's (Cameron, GE Hydril, NOV) had been working hard on the improvement of their products. New products have been introduced to dramatically improve shear & seal capabilities.

The efforts have been concentrating to address the following shortcomings of the traditional Shear Rams design:

- The Rams are working against wellbore pressure and therefore at high pressure are

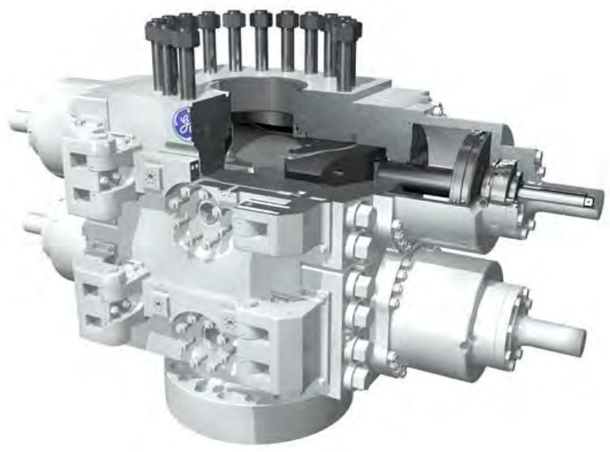


Mark IV Subsea MUX BOP Control System (courtesy Cameron)



The system requires two subsea pressure intensifiers to be installed on the stack (shown with additional mounting locations option on lower marine riser package).

Subsea Pressure Intensifier (courtesy Cameron)



Compact Ram BOP (courtesy GE Hydril)

In addition to major OEM's (Cameron, GE Hydrill and NOV) also smaller manufactures have been developing products that contribute to the industry efforts to BOP shortcomings. One of these manufacturers is Enovate have developed a shear & seal gate valve with bi-directional, metal-to-metal sealing under the trade name En-Tegrity™. The shearing capability of the En-Tegrity BOP is not affected by the increase of wellbore pressure and is capable to reliably seal the well with significant flowrate in the wellbore.

Unfortunately, none of the solutions that are available on the market addressing all of the identified shortcomings of modern BOPs. The solutions do provide an increase in potential shearing capability up to 40-50%, compared to the traditional design. Also, only Enovate and potential future product from NOV solution is capable to seal the flowing well and establish reliable pressure barrier with metal seals.

Therefore, there is still a need for the solution that is capable to address all of the shortcoming and in addition not being limited by the capacity of BOP controls.

The solution

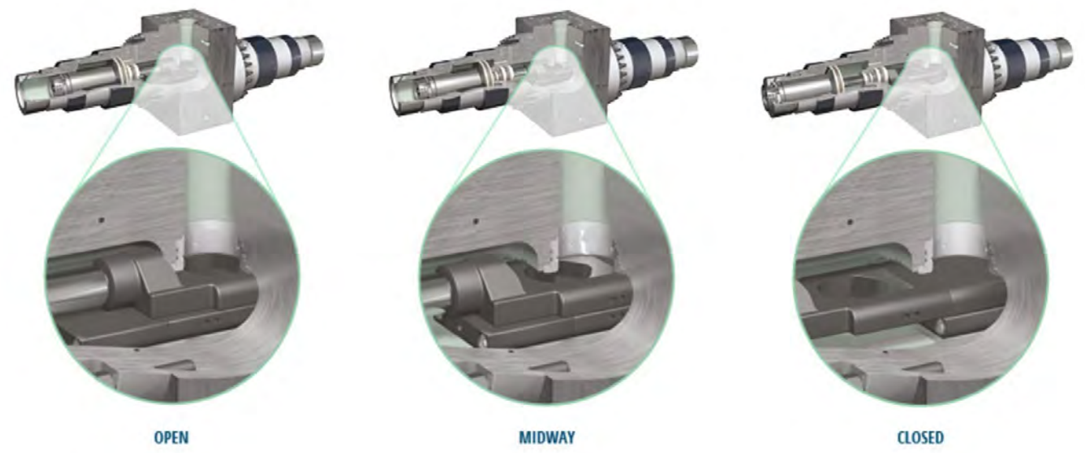
As a response to the challenges associated with the capability of the BOP to actually provide "last barrier", Balanced Solutions have developed a state-of-the-art solution under the name Pressure Balanced Double Acting (PBDA) Shear Gate Valve.

The PBDA Shear Gate Valve featuring following functionality:

- «Gates» with shear blades are simultaneously pushed and pulled by double acting cylinders – pressure compensated against well pressure & double shearing force.
- Pressure isolation provided by metal seals utilizing Double Piston Effect – effective double pressure barrier against hydrocarbons, no temperature degradation of seals.
- Accompanied by the Wellbore Pressure Actuation – Unlimited pressure source with shear pressures up to 1000 bar (15000 psi) or more.

Both PBDA Shear Gate Valve and Wellbore Pressure Actuation are patent pending.

The superior shearing capability of the PBDA Shear Gate Valve means, that it can cut practically anything that is going through the BOP, potentially even tool-joint. While the improved shear rams, when compared to the traditional design have increased capacity by 40-50% the PBDA Shear Gate Valve is capable to exert a shear force up to 200% higher than the traditional shear rams, in case when the wellbore pressure actuation is utilized the exerted shear force will be increased up to



En-Tegrity™ Shear & Seal Valve (courtesy Enovate)

Low Force Shear Ram (courtesy NOV)

1000% compared to the Deepwater Horizon Shear Rams.

What is also important to note that due to unique double acting hydraulic cylinders the shearing force is not transfer to the PBDA Shear Gate Valve body and therefore with increased pressure in cylinders the loading conditions of the body are unaffected; this feature ensures optimized low-weight design even for high shearing pressures that one would experience in case of Wellbore Pressure Actuation.

Due to the nature of the «Gate Valve Principle» the pressure barrier can be effectively established at any flowrate in the wellbore without risk of compromising the seals. In addition, the PBDA Shear Gate Valve is capable to two self-energizing pressure barriers with metal-to-metal seals.

The pressure-balancing feature of the PBDA Shear Gate Valve eliminates any need for mechanical piston locks thus greatly simplifying its construction and reducing risk of failure.

In comparison with traditional shearing solutions as well as the improvements that are available on the market to date, the Pressure Balanced Double Acting Shear Gate Valve provides a step change in the shearing capabilities. In case of well control accident, especially with flowing blowout the it "pushes" the certainty of cutting the drill string and establishing two reliable pressure barriers between well and the environment to practically 100%.

Balanced Solutions truly believes that the Pressure Balanced Double Acting Shear Gate Valve will make it sure that Deepwater Horizon won't happen again.

About the author

Vladimir Andreev,
Founder, Balanced Solutions.
Over 20 years of Commercial and Technical experience during involvement with Offshore Oil & Gas engineering and offshore construction projects. Has been holding senior technical positions with major offshore drilling and construction companies. During recent years working as independent consultant.
In 2016 has established a Balanced Solutions in order to develop and provide innovative products and services to subsea oil & gas development.

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