Capping stack: An industry in the making

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Abstract: This paper gives an overview of recent development of the marine well containment system (MWCS) after BP Macondo subsea well blowout occurred on April 20, 2010 in the Gulf of Mexico. Capping stack, a hardware utilized to contain blowout well at or near the wellhead is the center piece of MWCS. Accessibility to the dedicated capping stacks is gradually becoming a pre-requirement to obtain the permit for offshore drilling/workover, and the industry for manufacturing, maintenance, transportation and operation of the capping stack is in the making.

Key words: marine well containment system; capping stack; offshore drilling/workover; blowout

1 Introduction

The BP Macondo subsea well blowout occurred on April 20, 2010 in the Gulf of Mexico (GoM). It is evidenced that the offshore drilling/workover incident may result in huge damages to human lives, economies and marine environments. Much greater attention were paid to the offshore oil and gas industries, regulation institutions and publics after the Macondo incident. The offshore oil and gas industries have put more efforts in offshore drilling incident preventions and incident responses. The governments have imposed stricter rules on permit application and process monitoring. The publics have put more pressures on both the industries and governments on the prevention and incident responses.

After the Macondo disaster, the USA regulators require that operators seeking offshore drilling/workover permits need to demonstrate that they can control an offshore blowout. Targeted for GoM, two organizations, Marine Well Containment Company (MWCC) and Helix Well Containment Group (HWCG), were created to cooperatively provide those services. Different from the equipments that focus on blowout prevention, the marine well containment system (MWCS) focuses on the post blowout remediation including but not limited to debris removal, capping operation, delivery of dispersants and hydrate inhibitor, hydrocarbon capturing, transportation, process, storage and offloading, and well intervention.

2 MWCS

2.1 MWCS overview

The MWCS, as illustrated in Fig.1¹, is specifically designed to cap a blowout well and capture hydrocarbons from the damaged well without significantly increasing wellhead pressure to avoid further damage to well integrity. A typical well containment system usually comprises of 4 major sub-systems: a. subsea system including capping stack, subsea tool box such as debris cut and removal, subsea dispersant and hydrate inhibitor delivery system, subsea hydraulic power unit (HPU) and subsea deployment/running tools; b. flowline, riser, umbilical and manifold; c. modular capture vessel or capture vessel; d. modular topsides or topsides.

The capping stack is capable of making shut-in well, venting or diverting wellbore fluids to sea with oil dispersant chemical, re-directing wellbore fluids to be captured via surface vessels, and providing means for wellbore intervention.

Subsea application of dispersant at/near the wellhead is an integral part of capping operations. It can create safer surface working conditions for response personnel and enhance the degradation of the oil. The

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subsea dispersant kits include dispersant wands, associated manifolds and hoses, and debris clearing equipment with cutting, grappling and dragging tools to gain access to the blowout preventer when necessary. If the well cannot be shut-in, the capping stack should capture and redirect the flow through risers and flexible jumpers to capture vessels on the surface. Capture vessels can be floating production storage and offloadings (FPSOs), production test vessels, or tankers operated in the GoM during normal times with pre-built provisions that can be outfitted and integrated with process modules and other MWCS provided equipment after blowout incident.

Fig. 1 Typical MWCS (for illustration only)

2.2 MWCS operation companies

There are only two such complete MWCSs in the world. One is built and operated by MWCC, and the other is built and operated by HWCG. MWCC system is a more comprehensive and costly system while HWCG may be the only largely field tested system.

2.2.1 MWCC

The MWCS of MWCC is illustrated in Fig. 1. The major design parameters are: (a) fluid process capacity: 100,000 barrels of fluid per day; (b) gas flaring capacity: 200 million standard cubic feet of natural gas per day; (c) design shut-in wellhead pressure for the capping stack: 15,000 psi (1 psi = 6.895 kPa); (d) design pressure for flowline and riser system: 10,000 psi; (e) six month minimum uninterrupted full service at the maximum flow capacity, 25 year overall design life, design water depth: 500-10,000 ft (1 ft = 0.3048 m).

MWCC has 10 member companies: Anadarko, Apache, BHP Billiton, BP, Chevron, ConocoPhillips, ExxonMobil, Hess, Shell, Statoil. Member companies are committed to deepwater drilling in the U.S. GoM. Each member company has an equal share and an equal vote, and each contributes to the company’s overall operating costs as well as the overall cost of the expanded containment system, which is more than one billion dollars. Initial formation of the company was completed in March 2011, but membership remains open to all oil and gas operators in the U.S. GoM. System equipment and services are available to members and non-members. Non-members can enter into agreements to cite MWCC system in their permit application. MWCC charges a per-well fee to support some of the costs for developing and maintaining the system.

2.2.2 HWCG

The MWCS of HWCG is illustrated in Fig. 2. In the aftermath of the deepwater horizon event, 24 deepwater energy companies joined to form HWCG with the mission of developing a comprehensive and rapid deepwater containment response system.

3 Capping stack

3.1 Capping stack overview

Among the components/subsystems comprising MWCS, capping stack, an amalgam of connectors, pipes, valves and blowout preventers (BOP) may be essential but it may take longer to obtain in case of an blowout incident. From the view of functions, capping stack may be viewed as a combination or hybrid of the subsea tree and BOP. Therefore, capping stack is gradually becoming a pre-requirement to obtain the permit for offshore drilling/workover. The components of capping stack may vary with projects. As illustrated in Fig. 3, major components include but are not limited to wellhead connector, gate valve, choke, ram, re-entry connector, remotely operated vehicle (ROV) panel, frame, convertor and piping.
3.2 Capping stack operation companies

As shown in Table 1, there are at least 16 capping stacks in service or on order by industry organizations and operators. It is obvious that the capping stack is growing into an industry. The major capping stack system manufacturers are Trendsetter Engineering and Cameron at present.

3.2.1 MWCC

MWCC has three capping stacks. Fig. 4 shows a MWCC 15,000 psi capping stack supplied by Trendsetter. In addition, MWCC has completed a plan to cap a well under a floating structure (TLP/spar). Capping a well in this case requires a plan to move the structure out of the way to allow access to install the capping stack or pull the stack underneath structure for installation. All of this activity has been defined and planned before a well is drilled from a floating structure. This Shell-designed unit for tighter spaces—the footprint of the 9 ft × 9 ft device is about one-third the scale of the typical capping stack. This capping stack is under construction by Trendsetter. The capping stack under construction by Aker is also underway.

Table 1 List of capping stacks

<table>
<thead>
<tr>
<th>Organization</th>
<th>Specifications</th>
<th>Locations</th>
<th>Serving area</th>
<th>Supplier</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWCC</td>
<td>15,000 psi</td>
<td>Houston, TX, USA</td>
<td>GoM</td>
<td>Trendsetter</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10,000 psi with 9 ft × 9 ft footprint for tight spacing</td>
<td>Houston, TX, USA</td>
<td>GoM</td>
<td>Trendsetter</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>15,000 psi</td>
<td>Houston, TX, USA</td>
<td>GoM</td>
<td>Aker Solutions</td>
<td>1</td>
</tr>
</tbody>
</table>
### HWCG

HWCG has two capping stacks. Fig.5 shows a MWCC 15 000 psi capping stack supplied by Trendsetter.

### SWRP

SWRP is a non-profit initiative among nine major oil and gas companies, working together to enhance the industry’s capacity to respond to subsea well incidents. It was launched in May 2011 on the recommendation of the International Association of Oil & Gas Producers (OGP) and comprises experts from, and is resourced by the 8 major oil and gas companies; BG Group, BP, Chevron, ConocoPhillips, ExxonMobil, Shell, Statoil, and Total.

The initially targeted serving area is worldwide except GoM. Later the coverage was expanded to the worldwide since the capping system is transportable by sea or air. The integrated intervention system includes well capping and dispersant equipment that can be deployed internationally in the event of a subsea well control incident. SWRP has four capping stacks. Two are 10 000 psi capping stacks as shown in Fig.6 and two are 15 000 psi capping stacks as shown in Fig.3. Both were supplied by Trendsetter. Equipment will be stored and maintained across four locations.
3.2.4 Oil spill prevention and response advisory group

In November 2010, Oil & Gas UK’s Board took the decision to proceed with procurement and funding of a well capping device which could close off a well in the event of a major well control incident, enhancing the UK’s capability to respond to a major, sustained release of oil.

The design development was overseen by Oil Spill Prevention and Response Advisory Group’s (OSPRAG) technical review group (TRG), working with BP, which agreed to manage the detailed project design, procurement and construction phases. The device as shown in Fig. 7 was commissioned by the industry’s specialist organization, Oil Spill Response Ltd. It was built by Cameron Ltd. in Leeds and was unveiled at Offshore Europe 2011 in September.

The cap works by shutting in and holding pressure on an uncontrolled well and uses a choke and a series of valves which close down and stop the flow of hydrocarbons into the marine environment. It can quickly be deployed; a. at the widest possible range of wells and oil spill scenarios which could occur in the UK continental shelf, including West of Shetland; b. to various points of the subsea stack; c. at water depths of between 100 m and 3 048 m (328–10 000 ft); d. in wave heights of up to 5 m (16 ft) depending on the vessel/rig used; e. from a wide variety of multi-service vessels or drilling rigs; f. to wells flowing up to 1 034 bar (15 000 psi) in pressure and 121 °C (250 °F) in temperature; g. even where there is a high content of hydrogen sulfide present; h. on to a well flowing up to 75 000 barrels a day.

3.2.5 Wild Well Control Inc. (WWC)

WWC’s well containment equipment includes capping stack, subsea tool box such as debris removal, subsea dispersed system, and subsea HPU. The components of well contained will assist operators in the prevention, preparation, response and recovery from a deepwater well control event. The capping stack, as shown in Fig. 8, consists of an 18-3/4" 15K CIW, Single Ram, Type TL BOP, an 18-3/4" 15K CIW, Double Ram, Type TL BOP, an 18-3/4" 15K drilling spool with double valves, chokes, etc. The complete capping stack is modular and allows for flexibility in the arrangement of the rams and drilling spool. The stack can be deployed on a wireline or drillpipe. The equipment covers the critical aspects for well capping, containment, and collection designed for 10 000 ft water depth. As shown in Fig. 9, the equipment is transportable by sea/air, and is staged in Aberdeen, Scotland and is prepared for rapid deployment globally.

3.2.6 BP

Some international companies, such as BP and Shell, have internal standards for offshore operations requiring capping stacks available around the world, which many countries are coming to expect. They responded with caps of their own in addition to being part of industrial groups such as MWCC, SWRP and OSPRAG (BP). By comparing with the potential loss of uncontrolled or slowly contained marine well, this extra spending can be viewed as insurance.
As shown in Fig. 10, BP owns a capping stack, which based in Houston can be broken down into two pieces and flown where BP is working offshore. The lower section (left) is a modified horizontal production tree with a choke and a hub and weighs 70 t. The upper part (right) weights 37 t and contains two 5 ⅛ in gate valves able to shut in the well. BP also owns a 15 000 psi capping stack, located in Angola, mainly serving its offshore operations in West Africa.

3.2.7 Shell

Shell is another company along with BP and owns its own capping stack in addition to participating the industrial organizations. It owns three capping stacks: a. 10 000 psi for arctic condition of extreme cold and shallow waters with ice hazards, located in Alaska, USA; b. 10 000 psi, transportable by sea or air, located in Aberdeen, Scotland; c. 15 000 psi, transportable by sea or air, located in Singapore. As shown in Fig.11, Shell’s arctic capping stack is tall enough to be accessible if used on a well where the subsea equipment is recessed into a cellar dug into the seafloor to keep equipment below the threat of Arctic ice.

4 Conclusion

Capping stack is a safety feature that may never be used. However, as insurance, it is the kind of equipment that must be ready for deployment at any time. With the rapid expansion in offshore drillings, the capping stack is gradually growing into an industry.

References

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