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Refurbishing the Wellhead Master Valves from IDDP 1 for the IDDP 2 Well at Reykjanes.

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ABSTRACT

During the Icelandic Deep Drilling Project, the two wellhead master valves on IDDP 1 well in Krafla both got stuck in open position on July 24, 2012. The valve stem broke in both valves. The valves had been in use for 2 years and 4 months, experiencing up to 142 bar pressure and 450°C. These two valves are 10 inches in diameter, expanding gate valves with Class 1500 body rating, but Class 2500 flange rating.

HS Orka borrowed the valves from Krafla (owned by Landsvirkjun) and refurbished them before they were installed on the IDDP 2 wellhead on Reykjanes in 2018. In the current paper, the broken parts and their probable failure mechanisms are described. Material selection for the new parts, and the completed modifications are outlined.

INTRODUCTION

The wellhead master valves on the IDDP 1 well in Krafla were purchased in 2008 by Landsvirkjun. The valves have a class 1500 body with class 2500 flanges. The valve actuation was by an electrical motor drive as can be seen on fig .1.

The first valve was installed in Krafla in July 2009. In March 2010 the IDDP 1 well was discharged for the first time. By July 2010 the wellhead temperature had reached 380°C. Master valve 2 was installed in May 2011 to reduce the stress on valve 1 by sparing frequent operations of the other. The valves had been exposed to 380 to 450 °C for up to 2 years and up to 142 bar pressure. For at least 7 months, during 2012, prior to the valve stem break (Markússon et. al, 2013), the valves were heated in open condition to 445 to 450°C, starting at about 0°C when the valves were opened. The temperature at the wellhead, when attempting to shut the well in using the master valves, was about 450°C. For the last 9 months of operation the wellhead temperature was recorded 440°C to 450°C and increasing. The valves had only been operated 9 times before the valves broke down (Markússon et. al, 2013).

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Figure 1: Expanding gate valve from IDDP 1 in the Krafla workshop in 2012 after removal from IDDP 1

Figure 2: Broken parts of the stem. From left to right: Broken stem shown in gate when dismantling the valve, broken bottom part of stem after cleaning, end of broken stem.

Figure 3: Gate and segment. a) Gate segments showing distortions b) Back side of gate and segment c) Gate after sandblasting.

Original valve description

The valves were manufactured by the TIX company in Japan in 2008. The valves are expanding gate valves size 10" with class 1500 body rating but with flanges class 2500. The valve body material is WC6 cast steel (low alloy steel containing chromium and molybdenum). The flow path of the valves was originally clad with type 309 stainless steel from the manufacturer. The bonnet and the opposite gate cave are unclad. The stem is 17 – 4PH (UNS 17400). The gate and gate segments are type 410 stainless steel (ss) as well as the seat skirts.

Kommentiert [SNKH1]: Á þetta ekki að vera WC6 ?

Damaged parts:

Both valve stems were broken as described above. A failure analysis study of the fracture was made by S.N. Karlsdóttir (Karlsdottir, 2013). The results from the failure analysis showed that the fracture is a brittle failure with a possible contribution from hydrogen embrittlement and Sulpide Stress Corrosion Cracking (SSC).

The gate and gate segments in both valves were also distorted (fig. 3), and when the valve was operated, that is, opened or closed, the mechanism (levers) for directing the gate and gate segments to a proper position was stuck. The seat skirts were also distorted, probably because the mechanism for directing the gate and gate segments to a proper position had gotten stuck.

Possible damage mechanisms

The material of the broken stems is 17 – 4PH (UNS S17400). According to the NACE MR0175/ISO 15156-1 standard 17 – 4PH stainless steel (NACE MR0175/ISO 15156-1: 2001(E), 2001) is not recommended above 316°C (600°F). A possible cause of the valves getting stuck is thermal expansion mismatch effects. The valve body material WC6 has a lover thermal expansion coefficient than the ss 410. Thus, during heating in open position with the expansion gate wedged open, the temperature of the fluid heats up from around 200 to 450°C, the difference in the expansion of the stainless-steel gate and segments and the valve body is approximately 1,0 mm creating immense forces and jamming the gate and segment. Combining a stuck gate and a damaged or a brittle stem material is a likely way to a disaster.

Galling on the contact faces on the back sides of the gate and segment may also have contributed to the stuck gate. Experience from high temperature steam power plants indicates contact surfaces in steam valves are prone to galling. The 410 stainless steel has been reported to have a very low galling resistance (Review of Wear and Galling Resistance of Stainless Steels, 1978). Furthermore, the lubricity of steam and brine at high temperatures is very poor. Besides, most lubricants are washed out by superheated steam.

New parts

New gate segments and gate seat skirts were ordered from TIX, the valve manufacturer. These parts are again made from type SUS 410 stainless steel as no other option was possible from the manufacturer. The seat and gate faces are Stellite 6 clad as standard, but additional requirements were made, that is, having the contact faces on the back side of the gate and segment Stellite 6 clad as well. New seat skirts of the same SUS 410 material were used as before. For the broken valve stems the 17 – 4PH could not be used based on the failure analysis and previous analysis. Some materials of similar strength as 17 – 4PH were considered. Also, corrosion resistance is also very important, and only materials conforming to NACE MR0175 – ISO 15156-3 were considered. The main materials considered were highly alloyed nickel alloys and cobalt alloys. A decision was made to obtain stems made from Inconel 725. When asked for alternative stem materials, TIX could not deliver. The new stems of Inconel 725 were fabricated by Texas Honing inc. in Houston, a PCC company. The hydraulic cylinder valve actuators were made by a local workshop in Iceland. A stem packing rings of graphite and carbon fiber were used in the stuffing box and high temperature grease (SL -HT 1000) injected into the stuffing-box lantern ring. Figures 5 and 6 show the refurbished wellhead master valve from IDDP 1 for the IDDP 2 well at Reykjanes, Iceland, and a drawing of the valve stem machined for the IDDP 2 wellhead valve.

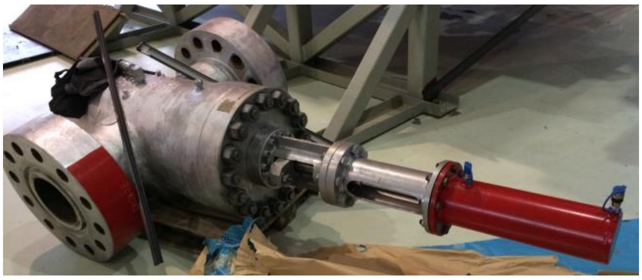

Figure 4: Refurbished valve prior to installation on the IDDP 2 wellhead.

Figure 5: IDDP 2 arrangement of IDDP 2 wellhead

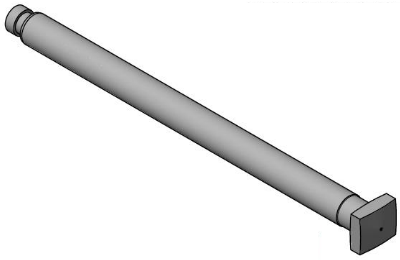

Figure 6: Valve stem

Conclusion

One valve was installed on the IDDP 2 well in January 2017 after cementing a 7" sacrificial casing and installing an expansion spool. The valve had a temporary valve stem made from SAF 2507 duplex made by a local workshop. After installing the Inconel 725 valve stems, both valves were installed on the wellhead in September 2019, prior to flow testing the well. The valves performed flawlessly during the flow test in 2020.

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