COMPARISON OF WELLHEAD COMPLETION DESIGNS FOR GEOTHERMAL OPERATIONS IN INDONESIA: EXPANSION SPOOL AND CASING HEAD COMPLETIONS

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ABSTRACT

Geothermal wellheads shall be designed to operate during the life of the well. In a hot, acidic, and corrosive geothermal operating conditions, the selection of wellhead completion is critical. The purpose of this study is to compare the conformity of two wellhead completion designs for application in Indonesia: expansion spool completion and casing head completion. Using cross-sectional analysis, this study assessed wellhead designs currently available in the market and comparing the results against technical judgements. This study also discusses the advantages and disadvantages of both designs, and the rationale behind the current design preferences in the geothermal industry in Indonesia.

1. INTRODUCTION

The wellhead is important to geothermal wells. Depending on the chosen configuration, the wellhead is installed on the top joint of either the Anchor casing or the production casing at the surface.. The two main functions are namely as a buffer of casing and as a place to install flow control devices. Although wellhead should never be exposed to tensile or compressive load, it would get exposed such load due to thermal expansion on the production casing. Pressure sealing or isolation function at the given pressure and temperature in corrosive conditions shall be considered

1.1 Wellhead Construction

Casing head completion and expansion spool completion are the two types of wellhead completions that are commonly used for geothermal service. In many geothermal fields In Indonesia, expansion spool completion is recently not popular for the current typical wellhead completion. The spool provides a room that allows for axial elongation of the production casings. Figure 1 (a) shows how an expansion spool completion wellhead configuration differs to casing head completion wellhead in Figure 1 (b).

The main components of a wellhead are depicted in Figure 1, include:

- Casing Head Flange (CHF) usually, and preferably, attached to the top of 20" anchor casing – or in some instances is attached to the top of 13-3/8" production casing. The casing head flange may incorporate side outlets to which side valve are attached.(Optional) expansion or adaptor spool. Side outlets may be incorporated in the expansion spool (as an alternative to those on the CHF).

- Master valve. An API 6D (or ANSI) full bore conduit gate valve. It is the main valve that controls wellbore steam stream.

- Side valve. Installed at the sides of wellhead. It is an ANSI valve with main function to allow quenching during drilling and production.

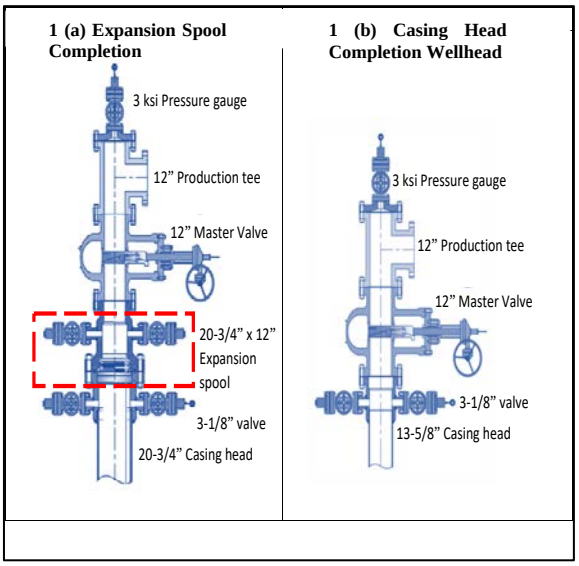

Figure 1 (a) Expansion Spool Completion and (b) Casing Head Completion Wellhead.

In expansion spool completion, the 20-3/4" casing head sits on the 20" surface casing. This type of wellhead completion is also known as double-skin completion, with the production casing is put into words as the inner skin, and the surface casing-casing head-expansion spool assembly as the outer skin. The spool also functions as an adapter to the 12" master

valve. On the other hand, in the casing head completion, the 13-5/8" casing head sits on the 13-3/8" production casing. This completion is renown as single-skin completion. As the production casing expands due to thermal exposure, the wellhead draws upward along with the expansion.

2.2. Pressure Rating

The wellhead should be designed to comply with codes of practice for pressure vessels or boilers, and in accordance with API Spec. 6A–and most importantly, rated for the maximum pressure/temperature exposure possible at the surface under static or flowing conditions. The pressure ratings are derated as temperature increases in accordance with ANSI B16.5 and API 6A. The derated pressures are plotted against temperature in Figure 2.

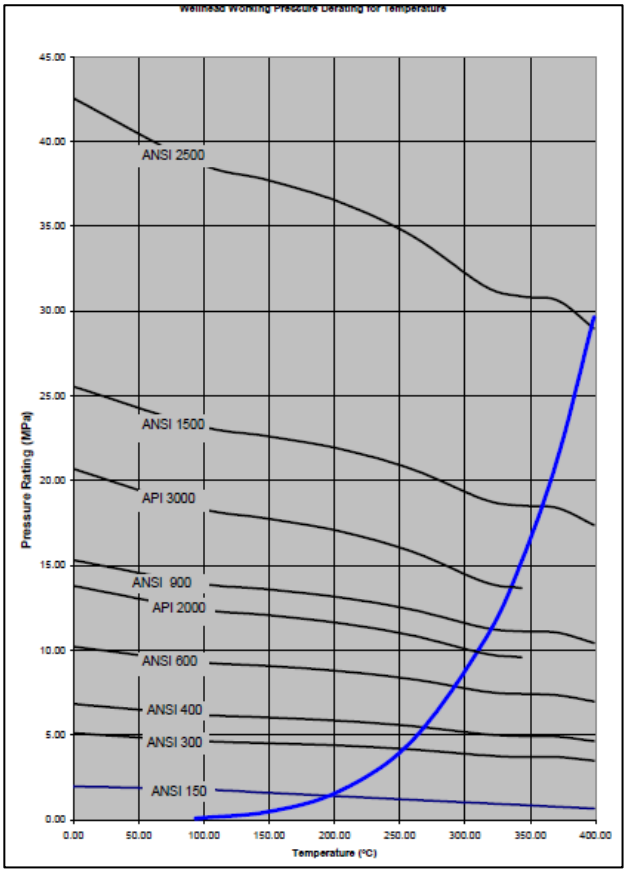

Figure 2. Wellhead Working Pressure Derated for Temperature (Hole, 2008)

The fluid at the wellhead may be water, saturated steam, superheated steam, cold gas, or mixtures of some of these fluids. Due to the column of fluid in the well, surface conditions cannot equate to downhole values, but in some circumstances can approach downhole conditions closely.

3. DISCUSSION

3.1. Thermal Considerations

The expansion spool allows the production casing to expand freely without the wellhead moving. Wellhead expansion is, however, not a major problem as a properly cemented casing only expands by a couple of centimeters.

The expansion spool is sometimes fabricated locally and is then without the pressure seal. Manufactured expansion spools have a pressure seal between the production casing and anchor casing. This seal has to be carefully installed and the seal maintains pressure tight by periodic injection of a special sealing compound (polytetrafluoroethylene).

There are several side outlet valves attached to the casing head and expansion spool to allow pressure testing of the annulus, and for killing of wells. These outlets often cause leaks that can be difficult to seal. But if the side valve are specified correctly and are of the expanding gate type – this problem of leaking valve is avoided.

There were findings at geothermal fields in Indonesia, due to elevated temperature, the production casing of 13-3/8" hit the top of the expansion spool and blocked up the wing valves. The pack off seals (which is made of polytetrafluoroethylene) in the expansion spool experienced embrittlement and lost its sealing ability. It resulted in the leakage of steam into the surface casing and broke the cement bond between the production and surface casing. The experience in the industry says that pack off seals did not last longer than 2 years. Liquid seal polymer is injected to extend the lifetime of the seals for a while, repeatedly, until there is no more space in the spool for polymer to inject. However, the seal continues to embrittle and finally losing its sealing ability completely.

In spite of the best efforts made in cementing the casing strings, there is usually some residual relative axial thermal expansion between casings at the surface. If the wellhead is mounted on the anchor casing (which is typical), the production casing movements relative to the anchor casing is accommodated below the master valve, within a double flanged spool such that interference with the base of the master valve is prevented.

3.2. Deposition Factor

The operation valve for the master valve sits either directly above it or on the horizontal leg downstream of the wellhead Tee. The wellhead tee has a flange on top with a 3-1/8" valve for logging. A guiding tube is attached to the flange to keep the logging wire from going with the flow, through the side port of the tee. The well flow is usually throttled at the wellhead by a fixed orifice or a control valve. The preferred method now is to use a control valve in order to match the flow requirements of the plant. Usually there is a small by-pass around these valves to allow the well to flow when shut. For the same purpose there is a pipe from the well to a small separator or rock muffler to keep the wellhead hot, when not in use. The wellhead also has a small valve for fluid sampling and for pressure gauges etc.

3.3. Dimension Factor

During the lifetime of the wells, well workover is anticipated for reasons like hole cleaning. 500-750 HP rigs with 25 ft ground to rotary beam clearance are commonly used. The height of the 20" expansion spools themselves is 3 ft. Based on the experience, this additional height will require rig providers to attach pony sub structure to the rig's legs. Such modification affects rig strength, delivery time and cost. It also compromises with flowline installation difficulties. It is also considered, in the future well workover, the 9-5/8" production casing may be relined. Without the use of

expansion spool, cutting and relining the string can be done using landing joint assembly or with the use of running tool lowering the liner adapter at 3 or 5 metres beneath the casing head. This type of thread is a high strength thread, well suited to accommodate casing axial load. The 9-5/8" production casings sit at a level lower than the casing head to accommodate casing growth.

Recent wells of geothermal operators in Indonesia are no longer adopting expansion spool completions (e.g. Company A since the 2000s, Company B since the 1990s). They introduce a casing tie-back assembly to compromise with wellhead movement issue. A casing tie-back assembly separates long-string casings into two parts: upper; and lower. It is introduced to compromise with wellhead movement issue. These two strings are attached by means of receptacle assembly completion. The axial expansion of these strings is distributed to upward and downward instead of upward only as of which in the case of single-stage cementing. Hence, reducing the elongation and axial force up to the wellhead.

3.4 Cementation Considerations

Expansion spool makes the wellhead sits on the 20" casing head attached to surface casing. The cement bond to this surface casing is formation-to-casing bonding. This bond is not proper to hold such load due to poor bonding to the formation.

Geothermal drilling practitioners have long learnt that the cement in this section has never highly satisfying and considered this as a weak point. The cement at this section is considered to fail earlier than the other, thus, it is not proper to withstand such load from the wellhead. A better bond occurred at 13-3/8" to 20" casing cement section (casing-to-casing bond). If a single skin wellhead configuration (the one with no use of an expansion spool) is stacked on the 13-3/8" casing, this would have less cement integrity and casing load issues.

The 20" annulus to 30" hole is frequently leaking due to cement shrinkage while cementing job. Thus, top job has to be done. Water intruding into the section in between these cement space. When steam is produced, this water heats up and expands. The entrapped water might migrate to the surface out of the exposed cement face in between the 13-3/8" production casing and 20" surface casing. These risks the expansion spool seats if deployed. Any exposure of cement face in between the production and surface casing can be covered by casing clamp, later on after such a time the well producing steam.

The 30" section is drilled with auger. That means no gravity driving the direction of the drilling. Whereas at the next section (20" section), it is drilled with rig and string. It does have gravity driving the direction of the bit to the centre of the earth. With this idea, the 30" and 20" hole might not be centralised. It is, again, an issue for cement bond. There is less cement in thickness at one side of the hole, making it weaker and has less integrity.

One has to deal with difficulties when installing the expansion spool, due to production and surface casing centralising issue. The off-centre production casing must be run through the bit guide and bolted on the flanges. Improper flange alignment causes uneven bolt stress, gasket misalignment, and leads to joint leakage.

Based on the industry experience, measured casing draw-up varied from 15 cm to 30 cm using tie back system. These numbers of draw up are accommodated by the pipeline support dampener. It is confirmed that these numbers are able to be accommodated by the SAGS team's pipeline design.

3.5 Wellhead Weldment

A different casing head weldment operation comes up between expansion spool and casing head completion. Expansion spool completion does not allow casing to casing-head weld work done at well site workshop (pre-welded), whereas single casing head completion does. Furthermore, casing head completion allows wellhead to casing connection job while waiting on cement (WOC). This presumes that you must weld the CHF to the Anchor or the Production casings – threated connections are also acceptable.

On the other hand, with double skin completion system, as soon as the cement of 20" surface casing is firm, the casing head is welded to the surface casing. This welding job, including hours of preheating, welding, and Post-Weld Heat Treatment (PWHT), is considered as wasted rig time of approximately 8~12 hours.

4. CONCLUSION

Use of an expansion spool arrangement may reduce wellhead expansion & contraction movement, but rarely totally eliminates it. The results from the above discussion is summarised in Table 1 below.

Table 1. Comparison table between two completion systems

Item	Casing head completion (single skin)	Expansion spool completion (double skin)
Pack off seals	No regular maintenance on sealing mechanism	Embrittlement and losing sealing ability issues
Spool height	No additional MV stack height (subject to cellar design).	Additional MV stack height, might require pony sub for WO rig
Casing head	Smaller size, pre-weld	Upsized, weld at cellar (subject to RT opening)
Wellhead rise	Visible WH rise	Sets visual ease, even though does not completely eliminate WH rise
Double skin protection	Single skin	When the pack off seal does not isolate the pressure properly, or even the seal is not in use, there will be no double protection

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Note: As indicated above an expansion spool completion does not necessarily require use of a pack-off.

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