

TILOS-PNOC-EDC (TIPED) WELL PLUGGING TOOL

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ABSTRACT

The master and wing valves of a geothermal well normally encounter mechanical defects due to corrosion, deposition and wear. It is necessary to replace these valves to fully control the production and reinjection wells and to sustain operation of the power plant. Prior to master and wing valves replacement, the wellhead is depressurized to zero. It has been a practice to engage a foreign contractor to handle the plugging of the production casing prior to valve replacement. Recently, PNOC-EDC, Southern Negros Geothermal Production Field (SNGPF) introduced a TIPED Well Plugging Tool as an alternative to the plugging equipment used by the foreign contractor. TIPED mechanically plugs the 9-5/8" production casing, henceforth, depressurizes the geothermal wellhead. The set-up is composed of a collapsible structure, mechanical hoist and dynamometer. The push rod with a plugging tool head is lowered by a mechanical hoist while maintaining a differential force against the uplifting pressure of the well. The dynamometer installed at the end of the wire rope cable indicates the applied pull requirement. A conical rubber at the head assembly sets and seals the top of the 9 5/8-inch production casing. The structural assembly is supported with a main anchor clamped at the 20-inch surface casing of the wellhead. The TIPED Plugging Tool has been successfully used in SNGPF in depressurizing geothermal wells and eventually in replacing the defective master and wing valves.

1.0 INTRODUCTION

In a geothermal production field, it is but imperative that geothermal wells are drilled. These wells could be for exploration, production or re-injection purposes. But for an efficient geothermal power production, the master valves

and other parts of these wells are to be consistently and regularly monitored and maintained.

As the well continues to discharge geothermal fluids, its well parts are exposed to severe conditions such as high temperature and pressure. Thus, special maintenance is required or these will wear out and get damaged. When the damages are on or upstream of the master valve, the situation typically requires plugging the well so that defective wellhead or master valves are removed for servicing or replacement.

Plugging the well is not only for implementing maintenance activities upstream of the master valve, it also allows Fluid Collection and Disposal System (FCDS) personnel to isolate the wells when necessary. Moreover, plugging makes implementation of scheduled downhole surveys possible and prevents damages to the master valve brought about by leakage.

Replacement of these master valves can be done in two ways. First is through quenching the well. Plugging the well does the second one. (see 2.2 Significance of the Well Plugging Tool)

Plugging the well is the preferable method of replacing defective master valves. So far, the use of Geopack (a geothermal valve changer) is the convenient and effective way of correcting valve defects. However, there is no such unit available at PNOC and can only be acquired through lease from foreign services.

It is for these reasons that TIPED or Tilos-PNOC-EDC Plugging Tool, which is economical and at par with other commercially accepted geothermal valve changer, is designed. This tool is intended for a safer and reliable operation. With this especially designed plugging tool, maintenance as well as other

activities or procedures can be done on the well economically and without much difficulty.

The cost of its fabrication and operation is one of the major aspects of consideration in the design of this tool. It is a cost-saving alternative for the existing geothermal packer method.

2.0 TIPED WELL PLUGGING TOOL

2.1 Tool Description and Distinction

The tool is made of carbon steel with rubber seal. It has four components, the ball guide, head hanger, head with rubber, and rubber holder. The rubber provides the sealing from high-pressure geothermal fluid coming from beneath the surface. The rubber is replaceable. The tool is designed to plug a 9 5/8" production casing of a geothermal well. The tool is attached in a push rod with 5" diameter and 20 ft in length.

The tool is designed to plug a high-pressure geothermal well, in effect, master and wing valves replacement could be done. The main sealing component is made of a high pressure and temperature rubber seal up to 8.0 MPa and 280°C respectively. The tool head with the rubber contacts with the 9 5/8" production casing using a mast component, pulleys, wire rope cables, and chain block. The main procedure is to run-in the push rod with the tool at the bottom to the pressurized 9 5/8" casing using the chain block.

Downward force exerted by the chain block should be greater than the pressure of the well. The mast provides the structural component for anchorage between the upward pressure of the geothermal well and the downward pull of the chain block. The main anchoring against the pressure of the well is on the CHF while the downward force of the chain block is mainly at the legs of the structure.

2.2 Significance of the Well Plugging Tool

All components of the wellhead assembly such as the expansion spool, master valve, tee joint and wing valves need to be in its best working condition in order to have control over the activities on geothermal wells. By reason of normal wear and tear these components, especially the master valves, develop leaks that necessitates servicing or replacement.

Replacement of these master valves can be done in the following schemes - quenching and plugging of the well. Quenching the well is done by pumping water, with the aid of a high-pressure pump, inside the well to lower the wellhead pressure to zero. However, this operation may result to thermal shock and eventually lead to casing failure or cause other damage. Thermal shock is a consequence of introducing cold water into a high temperature well environment.

On the other hand, plugging the well with the use of Geopack in changing the master valves has the shortest downtime, and has the least possibility of casing failure. The probability of casing failure is minimized in this process because defective valves are changed without altering well temperature. However, its operation is costly especially that no unit is available at PNOC. Operating with Geopack can cost the company about US\$ 10-20,000.00 per well.

Meanwhile, TIPED Plugging Tool operates in the same way with the existing commercial geothermal valve changer. The tool is portable and has a retrievable plugging seal that is run-in to the well through the push rod. It will temporarily plug the well allowing valve replacement, after which the tool is recovered. With this TIPED Plugging Tool, the well is made readily available for use after valves are finally changed. The operation is also done without altering well temperature, thus, eliminating the likelihood of casing failure and production downtime. Furthermore, with the plugging tool at hand, financial expenditures can be reduced.

With the effectiveness, practicality, and economical cost of its operation, TIPED Plugging Tool definitely is an asset to PNOC.

2.3 Design Considerations

From the inception of TIPED Plugging Tool, important factors were especially considered. Although developing a plugging tool that is economical is one of the main aims in pursuing this innovation. Safety and simplicity of operating the designed tool were never ignored. So in the course of shaping the design, the following conditions were given special attention:

- a. Wellhead valves can be replaced without quenching the well.

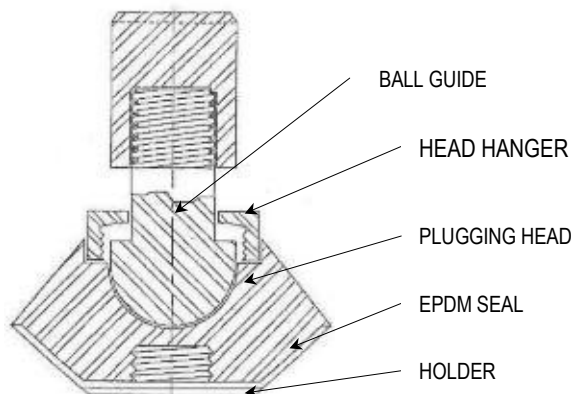


Figure 1. Plugging head assembly

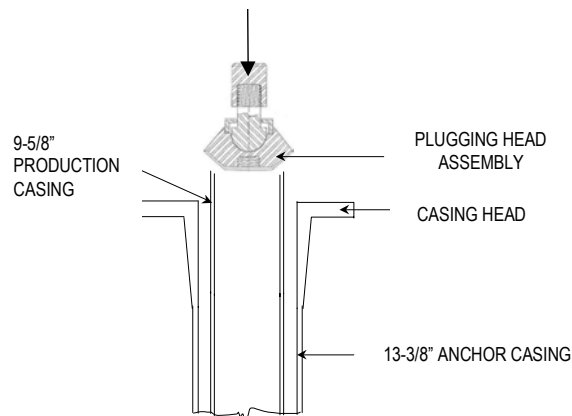


Figure 2. Typical plugging of 9-5/8" casing.

- b. Well plugging equipment is uncomplicated to use and portable.
- c. Mechanical devices are able to withstand wellhead pressure of 8.0 MPag.
- d. Plugging head is set on top of the existing 9 5/8" production casing.
- e. Rubber seal can withstand wellhead pressure of greater than 10.0 (MPag) and temperature of 250°C.
- f. The cost of fabrication and operation is inexpensive.

2.4 Components of the Plugging Tool Assembly

2.4.1 Mast

The portable mast is a structure suitable for wellhead valve replacements. The mast is erected to its working position by sectional components. It is also dismantled per section for ease in moving from one well area to another. The essential load-carrying members are provided with pins. The mast has a maximum load capacity of 20 metric tons. The structural materials conform to the applicable ASTM specification covering steel shapes, plates and figures.

2.4.2 Plugging Head and Seal

The plugging head assembly (Figure 1) is made from solid steel AISI 4140 material. It is designed with a bevel-edge so that it can seat

on top of the 9-5/8" production casing. The ball allows the plugging head to pivot directionally so that it can still seat on top of an off-centered 9-5/8" production casing. The offset should not be greater than 3/4" so that the complete sealing can be done. Figure 2 shows how the plugging head plugs the 9-5/8" production casing during the operation.

Seals are most commonly made from elastomers because they are the most practical seal materials (Harisuna, et. al., 1978). Elastomers are rubber materials that can expand with little force applied to it. They are chemically vulcanized rubber materials formed by cross-linking the macromolecules with various vulcanization additives. Because of their structure, elastomers have a high retractility, which means that the remaining deformation is very small.

The rubber seal is preformed so that it fits into the plugging head. The seal is known as Ecorubber III black, made from peroxide-cured ethylene-propylene-diene (EPDM) rubber. The seal was tested at well PN28 with wellhead pressure of 2.42 MPag and temperature of 210°C and at well NJ6D with wellhead pressure of 4.52 MPag and temperature of 80°C.

3.0 WELL PLUGGING ACTIVITY DONE WITH TIPPED PLUGGING TOOL

3.1 Plugging of PN2RD Well

Plugging of PN2RD was the first actual plugging operation using the TIPPED Well Plugging Tool

which was fabricated at SNGP. The well with wellhead pressure of 0.5 MPag was fully depressurized and became zero after the production casing was plugged using the tool. Thereafter the leak of the 13 3/8" was repaired.

3.2 Plugging of SG2

This is the second plugging activity using the TIPED Well Plugging Tool. It has successfully plugged the production casing and replaced 2 units of wing valves of SG2 at 1801 hrs Friday October 11, 2002. The maximum wellhead pressure prior to plugging was 4.09 MPag.

3.3 Plugging of SG3D

The third plugging activity using TIPED Plugging Tool has successfully plugged the production casing and replaced two defective wing valves of SG3D on October 24, 2002. The shut-in pressure was 4.24 MPag.

4.0 LIMITATIONS OF THE TIPED PLUGGING TOOL

Operation with the use of TIPED Plugging Tool is applicable on two conditions. First condition is when the gate of the master valve can be operated at full bore. Misalignment of the gate will obstruct the outer diameter of the tool and thus, impedes total plugging. Second, the well should have a production liner casing.

5.0 STRUCTURAL DESIGN

5.1 Design Data

Casing:

Nominal Diameter: 9-5/8"

Thickness:

(43.5 lb/ft) = 0.435" = 11 mm

(47.0 lb/ft) = 0.475" = 12 mm

Inside Diameter :

(43.5 lb/ft) = 8.755" = 222 mm

(47.0 lb/ft) = 8.681" = 220 mm

Wellhead Pressure: 5.0 Mpa

Wellhead Temperature : 160°C

Calculation Results:

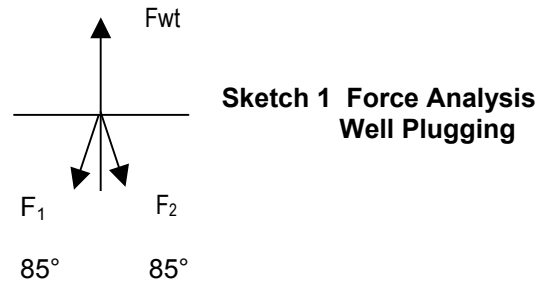
Upward Force (Fw)

$$F_w = p \times A = (5 \text{ Mpa}) \frac{145 \text{ psi}}{1 \text{ Mpa}} (\pi/4) (8.755")^2$$

$$F_w = 43,646 \text{ lb}$$

$$F_w = 19,797 \text{ kg}$$

Determining the load at wire rope:



Let additional force due to rope load bending and frictional force equal to 50% of Fw :

$$F_{wt} = 19,797 \text{ kg} \times 1.50$$

$$F_{wt} = 29,696 \text{ kg}$$

(Note: This force corresponds to 7.5 Mpa WHP)

$$\Sigma F_v = 0 :$$

$$F_{wt} = F_1 \sin 85^\circ + F_2 \sin 85^\circ + W$$

$$\text{Let : } F_1 = F_2$$

$$W = \text{regular weight of push rod}$$

$$F_{wt} = 2 F \sin 85^\circ = 1.9924 F$$

$$F = \frac{29,696 \text{ kg}}{1.9924}$$

$$F = 14,905 \text{ kg}$$

Using : 3/4" wire rope, Class 6 x 37 IPS, steel core(IWRC)

S = 23,500 kg nominal breaking load and double sheave groove pulley

$$\text{Factor of Safety} = \frac{23,500 \text{ kg} \times 2(\text{double sheave})}{14,905 \text{ kg}}$$

$$FS = 3.15 \text{ for (WHP = 5.0 MPa)}$$

Chain Block:

Using a chain block of 10 ton capacity

$$\text{Factor of Safety} = \frac{10,000 \text{ kg}}{6,191 \text{ kg}}$$

$$\text{FS} = 1.62$$

Using 5/8" diameter wire rope,
Class 6 x 37 IPS (IWRC)
S = 16,400 kg nominal breaking strength

$$\text{Factor of Safety} = \frac{16,400 \text{ kg}}{6,191 \text{ kg}}$$

$$\text{FS} = 2.65$$

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