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Application of Modified Inflatable Packer to Repair Production Casing Leak in Big Hole Geothermal Well

Ali Mundakir, Agus A. Zuhro, Budi Setiawan

PT. Pertamina Geothermal Energy, Jakarta 10340, Indonesia

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ABSTRACT

Continuity of steam which produced from the geothermal well is the most important thing in geothermal operation. There are several issues that can decrease the steam supply or even deplete it. Leaking of production casing is a common problem in geothermal operation, which usually caused by aquifer flow that enter the production casing. It can cause the cooling of reservoir temperature which lowering the steam flow, and in the end lowering the capacity of electrical energy generated.

PT. Pertamina Geothermal Energy (PGE) as the leading geothermal company in Indonesia operates 5 fields with a total installed capacity of 617 MW. To meet the production capacity, a total of 166 production and injection have been drilled. Some of them are "Big Holes" that utilize 13.3/8" as the production casing. Until recently, a total of 22 big hole wells (about 13% of the wells) has been undergone well repairation due to leakage in production casing. The root cause of the leakage is mostly the casing configuration which used "tie-back" system. The system is basically divided cementing process of production casing into two steps to reduce hydrostatic pressure for each step. *A receptacle* is then used to connect between the first stage and the second stage of the production casing. After several years in operation this tie-back type of connection was found as the cause of the leakage in production casing.

Workover and well repair operation were then done to solve the leakage. The work was done by first applying bridge/wooden plug on the top of production perforated liner 10.3/4" to isolate its reservoir zone. The operation then continued by cementing plug and/or squeeze job to fill the leakage in the receptacle of production casing. After that, bridge plug and wooded plug will be drilled or pushed until the bottom of the well. These Conventional Workover and Well Repair operation normally takes around 25 days and costs about USD 2 Million due to long working day of the operation. There is also a big risk in which its reservoir zone is getting plugged by cement used during the squeeze job. In this case, it will decrease or even deplete the well production capacity.

To avoid the risk, PGE has initiated to use a "Modified Inflatable Packer" to repair the production casing leakage in well HLS-C1 of Hululais Geothermal Field of Indonesia in 2018. The Modified Inflatable Packer was installed just below the casing leak point, then that packer is released and pulled out to surface after the leaking has been shut. This method removes the use of bridge plug or wooden plug including the operation to drill and push that plug. This operation also eliminates the risk of plugging reservoir zone that cause decreasing well production capacity. It also reduced the cost by shortening the operation time. The workover on well HLS-C1 was completed in 10 days with the cost of USD 770K. Moreover, its production capacity remains the same based on the well testing that done afterward.

INTRODUCTION

PT. Pertamina Geothermal Energy (PGE) as the leading company in using Geothermal Energy to generate electricity in Indonesia, has 14 (fourteen) geothermal fields which is managed independentlyin 5 (five) operational areas that have already produced, with totsl indtslled cspscity on December 2017 of 617 MW was increased 85 MW from 2016. Beside area which is independently operated, PGE also manages geothermal fields with joint operation contract scheme that is oparated by work partners Star Energy Geothermal Salak (SEGS), Star Energy Geothermal Darajat (SEGD), Star Energy Geothermal (Wayang Windu), Ltd. (SEGWWL), Sarulla Operations, Ltd. (SOL), and Bali Energy, Ltd. (BEL) with total installed capacity 1.095 MW.

Figure 1. PGE Geothermal Fields

166 wells had drilled since PGE was built as subsidiary of PT. Pertamina (Persero), even it is developed well or exploration well, which are spread in 9 areas or PGE Geothermal Project such as Bukit Daun, Sungai Penuh, Karaha Bodas, Hululais, Kotamobagu, Lumut Balai, Lahendong, Kamojang and Ulubelu.

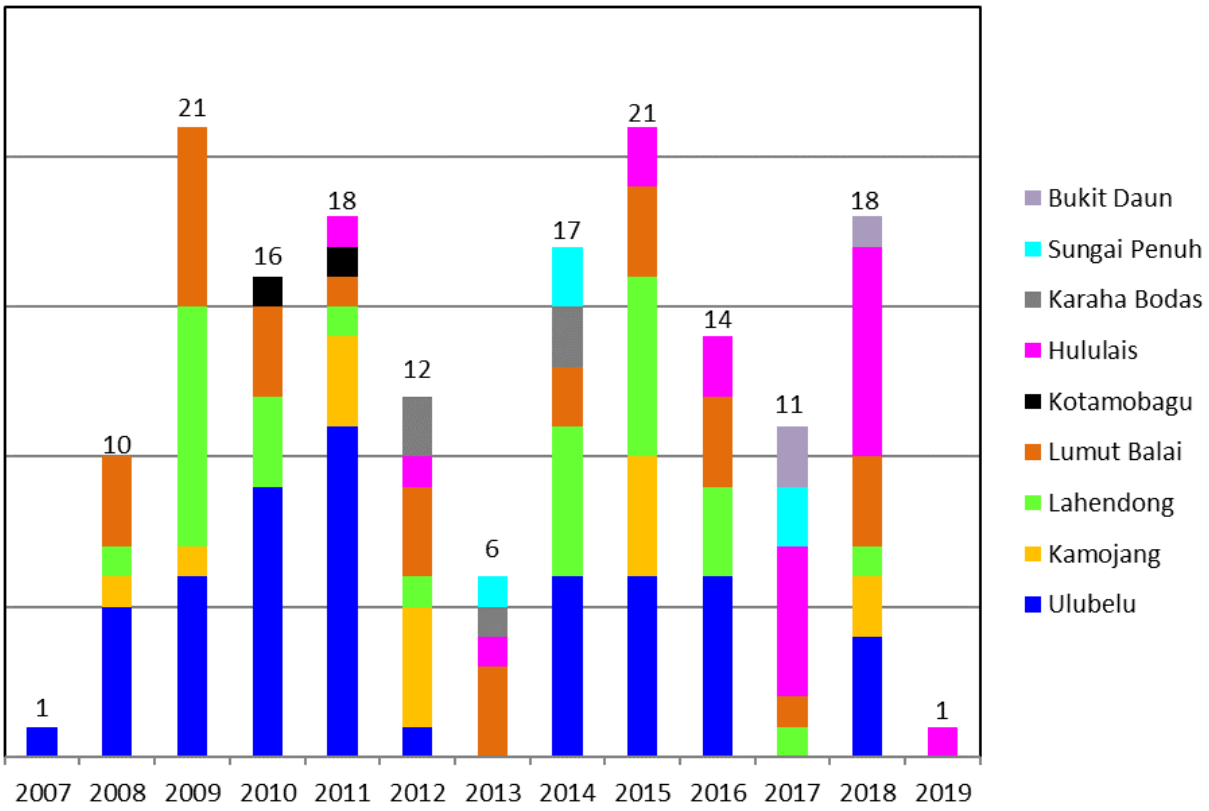


Figure 2. PGE Drilling Recapitulation in 2007-2019

From those 166 wells, 30 wells has already executed "well's workover", where the 16 wells are aimed to handle the proble of leakage in production casing. From the statistic data, it can be stated that around 10% from total amount of PGE drilling wells which have leaage in production casing or in other words, 1 from 10 PGE wells are having leakage in production casing.

For the needs of this paper, production casing can be defined as the last casing which is cemented in drilling operation. Outside Diameter (OD) of production casing which is generally used is 13-3/8", 10-3/4", or 9-5/8". The first two are generally considered as "big hole" and the last one is called as "standard hole". Production casing can be installed and cemented as single string from production shoe to the surface or can be installed and cemented as two segments which are called as liner-tieback system.

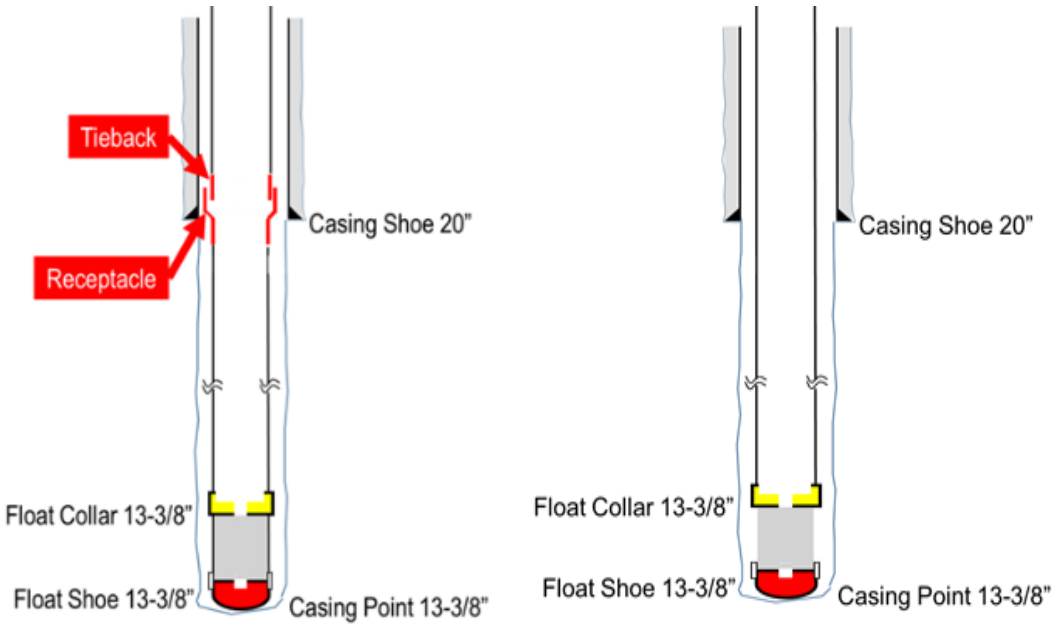
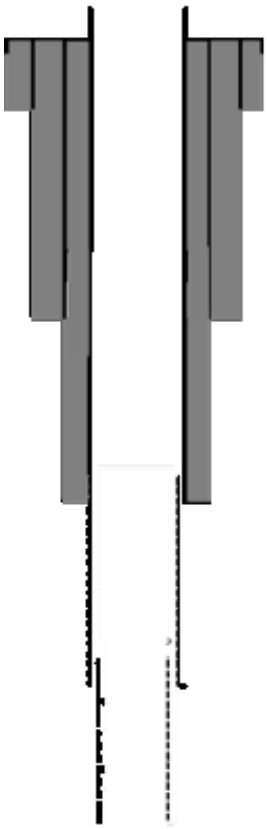


Figure 3. Single String and Liner-Tieback System

Since 2007, PGE is uding OD production casing 13-3/8" (big hole) with L-80 grade specification, weight 68 lb/ft and BTC connection type. Here is the casing configuration which is generally used in PGE.



Casing	Size	Conn	Grade	Berat (ppf)
Conductor	30"	-	X-56	310
Surface	20"	BTC	K-55	133
Production	13-3/8"	BTC	L-80	68
Perforated Liner	10-3/4"	BTC	K-55	40.5
Perforated Liner	8-5/8"	BTC	K-55	24

Figure 4. PGE Casing Configuration (Big Hole)

THE PROBLEM OF LEAKAGE IN PRODUCTION CASING

Since 2010, PGE has been conducting well's workover in many working areas, especially in wells which have been producted. Here is the workover recapitulation in every working area.

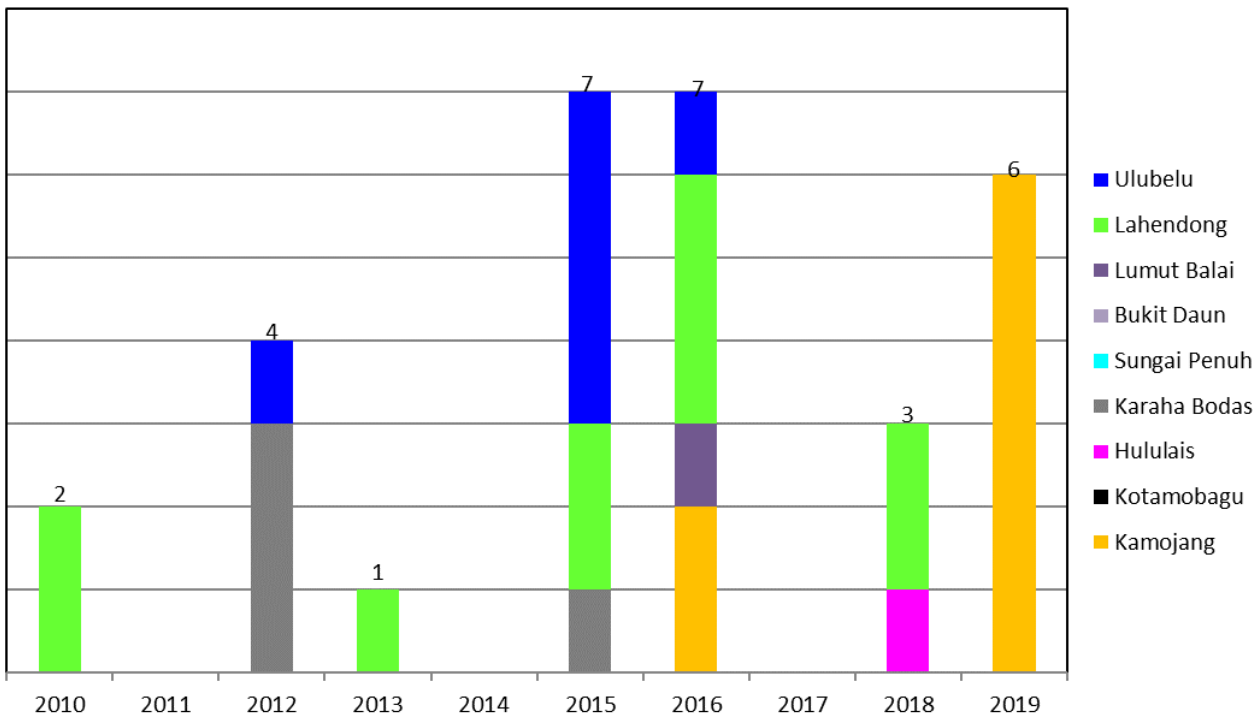


Figure 5. PGE Workover Recapitulation

From 166 wells which are drilled, 30 wells have already conducted workover. The reason why workover should be conducted are :

1. Total sidetrack/multilateral work are 2 wells.
2. Total handling of leakage in production casing are 16 wells.
3. Total hole cleaning are 8 wells.
4. Total completing job are 4 wells

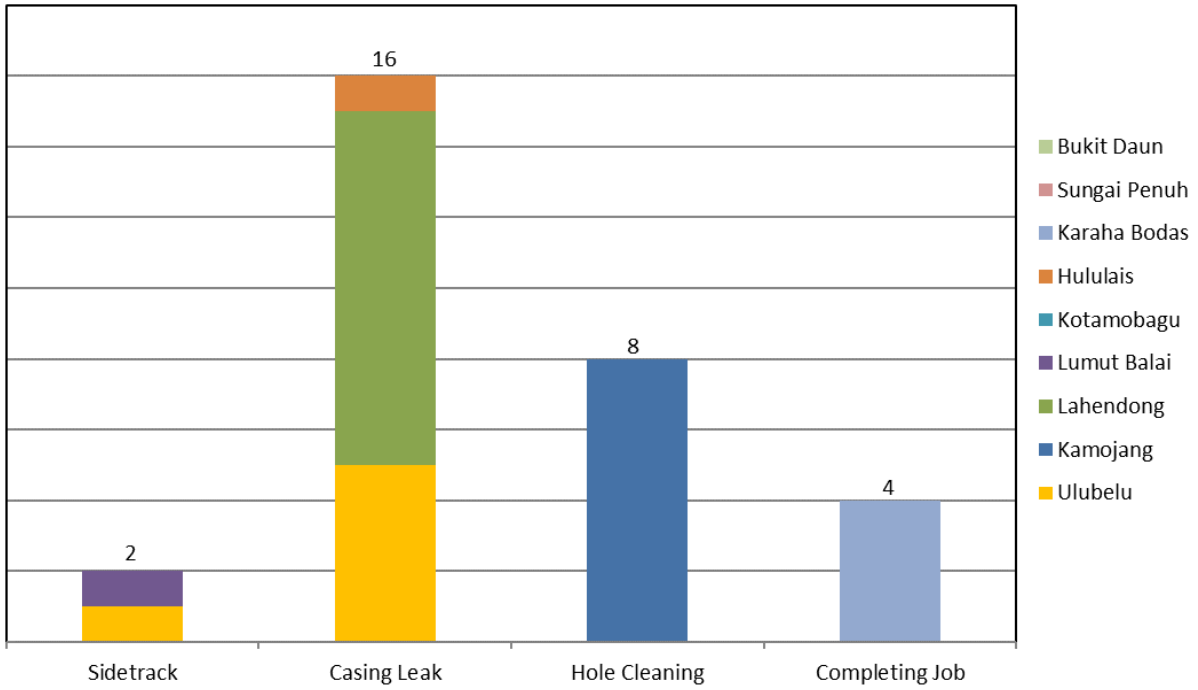


Figure 6. Workover Type in PGE

From the statistic data, it can be stated that around 10% from the total amount of wells, which are drilled by PGE, are having leakage in production casing or in other words, 1 from 10 PGE wells are having leakage in production casing.

The leakage in production casing can be caused by:

1. Leaking on liner lap

2. Damaged by production fluid

3. Casing collapse

4. Poor cement bond.

Table 1. Recapitulation of Leakage in Production Casing

Root Cause	Ulubelu	Lahendong	Hululais	Total	Percentage
Leaking on Liner Lap	5	0	1	6	37.50%
Damaged by Production Fluid	0	5	0	5	31.25%
Casing Collapse	0	4	0	4	25.00%
Poor Cement Bond	0	1	0	1	6.25%

Improvement from design side has conducted by PGE to maximize production casing integrity. This paper is specifically discussing how to handle leakage in production casing which is caused by leaking on liner lap (problem number 1).

CONVENTIONAL METHOD

In installing and cementing production casing 13-3/8" by tieback method, probably formed a gap between level 1 and level 2 casing series. This gap may make groundwater comes into production casing and lower the well's temperature.

Generally, the core of handling the leaking on liner lap is when conducting squeeze cementing job to patch leakage on that point.

Procedures which have to be done are as follow:

1. Well Quenching

2. Exploration of Inside Liner Production

3. Wooden Plug/Bridge Plug Setting

4. Plugging Material & Cement Plug Drop

5. Squeeze Cementing Job

6. Cement & Plugging Material Drilling

7. Wooden/Bridge Plug Drilling & Pushing to the bottom of the well

8. Completion Test

The leakage handling by this method have to be done by bigger rig capacity, example rig of 1500 HP. It is because when drilling and pushing wooden/bridge plug, it needs bigger WOB value and flow rate, besides that, it needs bigger hookload to activate jar if there is stuckpipe on the attempt to push.

Wooden plug and bridge plug working concept is different, where the wooden plug does not need higher pressure to set. For incoming process from wooden plug into well is by putting into the well. To know whether the wooden plug position is suitable to the plan, which is exploring the position by using chisel 12-1/4". If the position is not suitable, then push the wooden plug by using chisel 12-1/4" without rotating. So, the wooden plug concept is safer and easier than bridge plug.

Although bridge plug has drillable type, but in fact, it will be difficult to conduct bridge plug drilling because there is no bearings that hold the bridge plug, so we have to push the rest of bridge plug until it reaches the hole bottom.

However, for the use of wooden plug, there is a bigger risk when making sure that the reservoir zone has clogged by cement. Usually, after the wooden plug is set, then plugging material such as gravel and fine sand are dropped. Sometimes, those plugging materials are dropped between the gap of wooden plug and top of liner adapter 10-3/4". So, it causes the blockage of reservoir zone by plugging materials. The dropping of plugging materials can spend longer time until ideal condition is temporarily closed, and production liner is proved by the fluid level stabilization in production casing. If plugging materials are successfully set on the wooden plug and able to temporarily clog production liner, then another risk which can be raised is the possibility that cement will damage plugging material condition and drop into reservoir zone when cement plug is conducted, so it causes the deceasing or losing of well production capacity.

Besides that, wooden plug is set on Top of Liner 10-3/4" because the upper dimension has OD 10.4" (bigger than ID Liner)

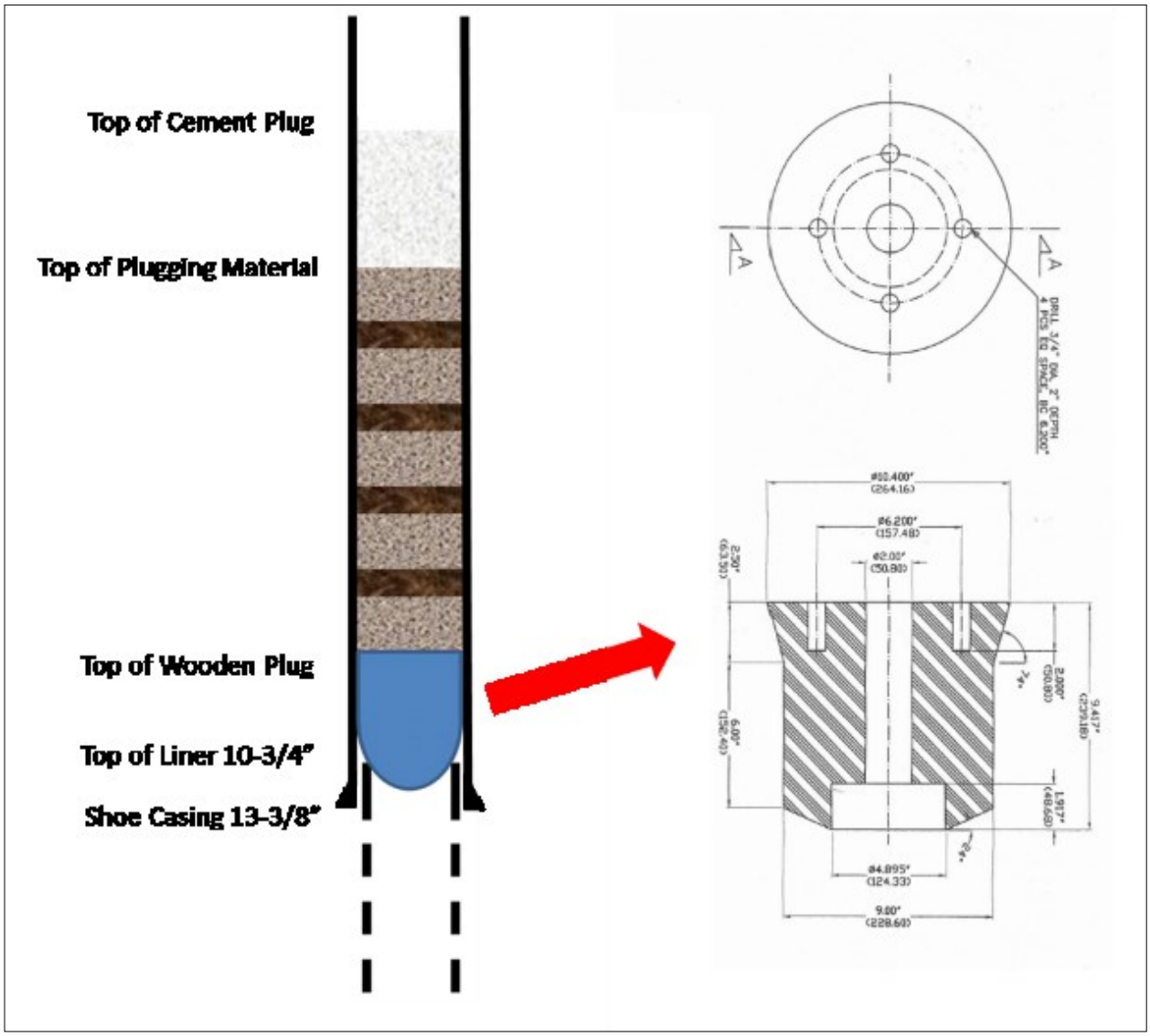


Figure 7. Setting Wooden Plug

Generally, the prevention timeline of leakage in casing is by using conventional method which needs 18 days, with bigger time portion when drilling and pushing bridge/wooden plug, the detail as follows:

Table 2. Conventional Method Timeline

Activity	Day	Cumm Day
Well Quenching	0.58	0.58
Tag Top of Liner 10-3/4"	0.76	1.35
Tag Top of Liner 8-5/8"	0.65	2
Tag liner shoe 8-5/8" (Bottom Hole)	0.67	2.67
Drop Wooden Plug, Material Plugging, Cement & Squeeze	3.09	5.76
Drill Cement & Push Wooden Plug	8.59	14.35
Jets Wash, Completion Test, L/D String & N/D BOP 13-5/8"	3.57	17.93

Total cost estimation which is needed to the prevention of leakage in casing is by using conventional method is around US$ 950K (exclude mobilization and demobilization).

MODIFIED INFLATABLE PACKER METHOD

The length of working time and higher prevention cost of leaking in production casing by conventional method become challenge in PGE innovation. In 2018, PGE conducted innovation in preventing leakage in production casing in one of the wells in Hululais Project by applying modified inflatable packer.

In the procedure, the differences between conventional method and this method is, there is no drilling and pushing wooden/bridge plug, but it replaces to retrieving modified inflatable packer. The procedure as follows:

1. Well Quenching

2. Inside Liner Production Exploration

3. Modified Inflatable Packer Setting

4. Plugging Materials & Cement Drop

5. Squeeze Cementing Job

6. Cement & Plugging Materials Drilling

7. Modified Inflatable Packer Retrieving

8. Completion Test

The way inflatable packer works is similar to bridge plug, which needs higher pressure on setting, the difference is the bridge plug cannot be retrieved, but inflatable packer can be retrieved by deflating the packer.

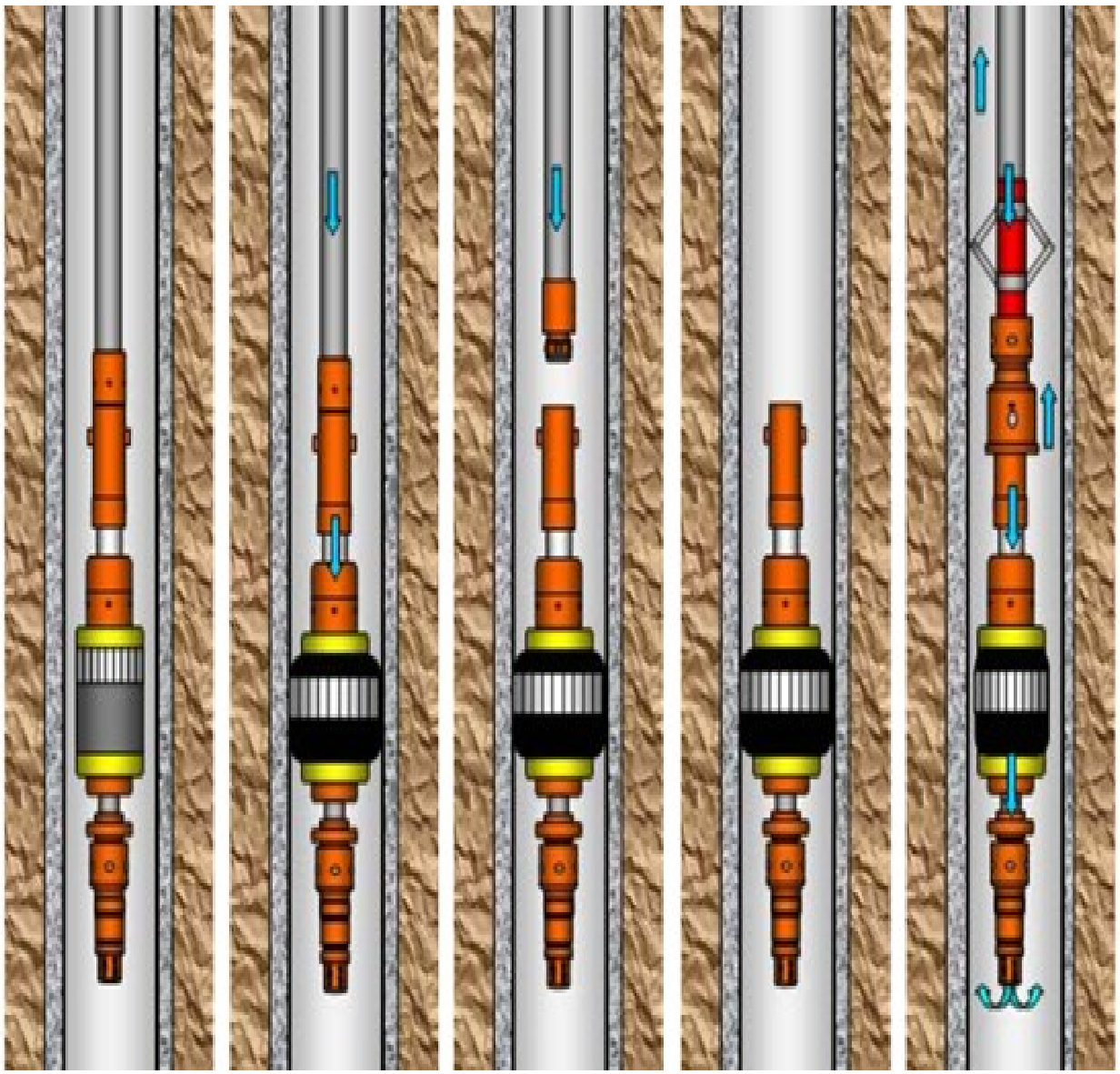
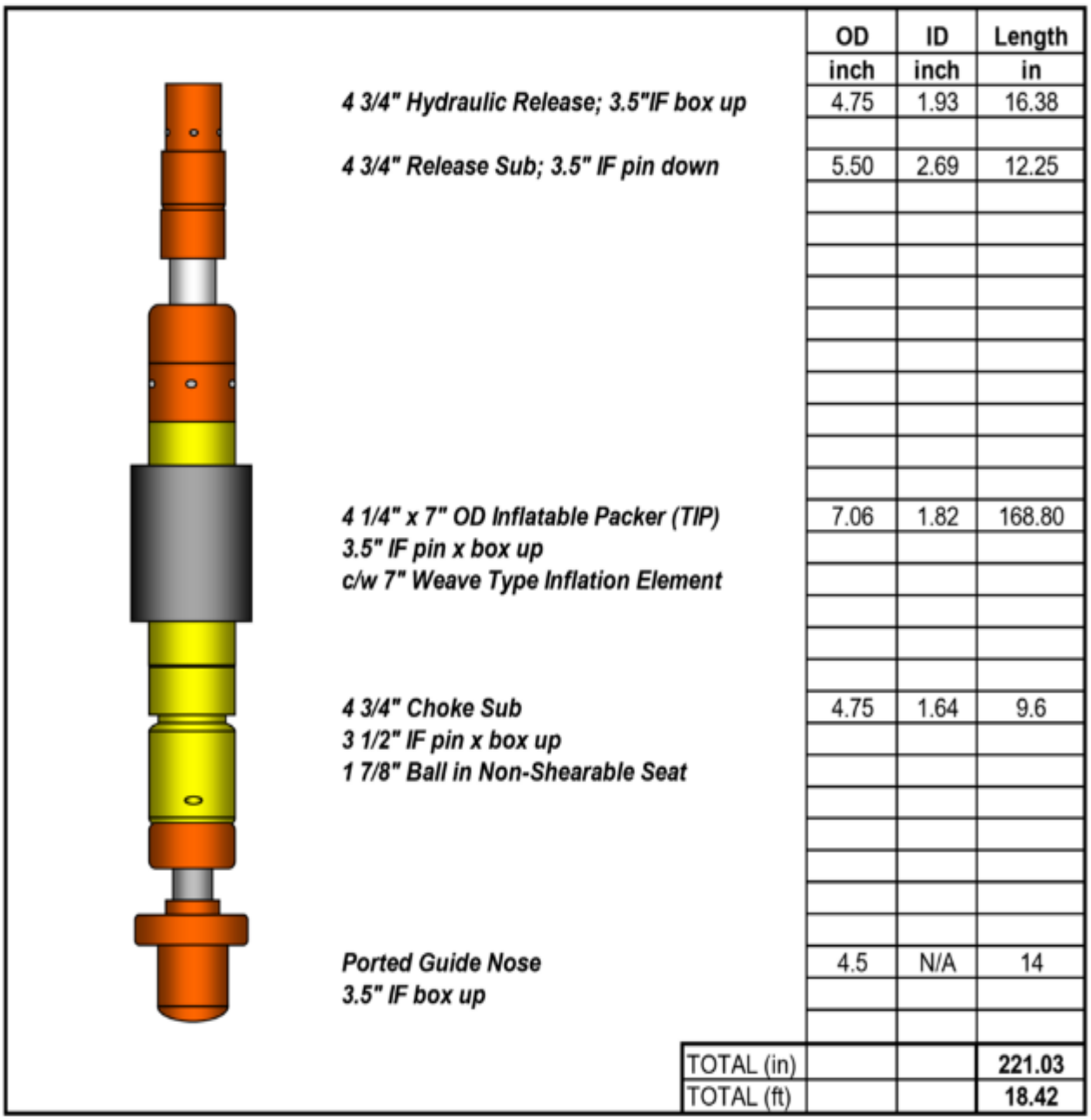


Figure 8. Running & Retrieving Inflatable Packer

Problem identification which is aided is nowadays inflatable packer in market has OD 7-3/8”, so the packer deflation mechanism can be executed, then packer may drop to the bottom of the well or other position.



	OD inch	ID inch	Length in
4 3/4" Hydraulic Release; 3.5"IF box up	4.75	1.93	16.38
4 3/4" Release Sub; 3.5" IF pin down	5.50	2.69	12.25
4 1/4" x 7" OD Inflatable Packer (TIP) 3.5" IF pin x box up c/w 7" Weave Type Inflation Element	7.06	1.82	168.80
4 3/4" Choke Sub 3 1/2" IF pin x box up 1 7/8" Ball in Non-Shearable Seat	4.75	1.64	9.6
Ported Guide Nose 3.5" IF box up	4.5	N/A	14
TOTAL (in)			**221.03**
TOTAL (ft)			**18.42**

Figure 9. Inflatable Packer Original

Because of shoe modification from packer, it has OD 11-1/2” by hoping that the packer will drop and detain on Top of Liner 10-3/4” (ID 10.05”) so it will be easier to be caught by retrieving tool.

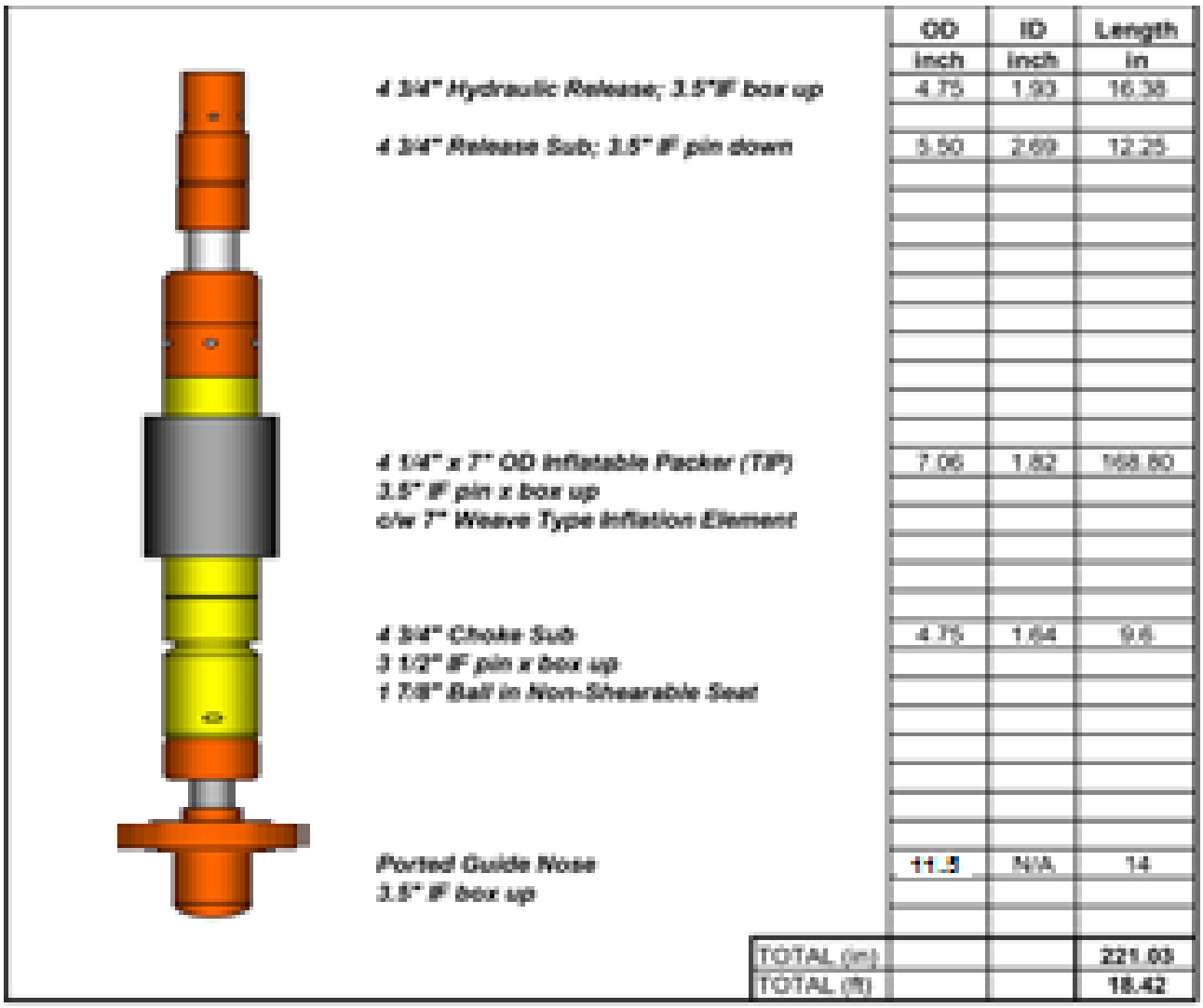


Figure 10. Modified Inflatable Packer

Besides that, the advantage of inflatable packer is similar to bridge plug, which is set in any depth position, in the case of handling leakage in casing, it will be set under casing position which is leaking so it will fastened time to tripping and squeeze cementing job.

By using modified inflatable packer, the needed time is only 10 days, the detail as follows:

Table 3. Inflatable Packer Method Timeline

Activity	Day	Cumm Day
Well Quenching	0.58	0.58
Tag Top Of Liner 10-3/4"	0.76	1.35
Set Modified Inflateble Packer	0.26	1.61
Drop Pluggig Material, cement and Squeeze Job	2.69	4.3
Drill Cement & Pretrieve Packer	2.25	6.55
Jets Wash, Completion Test, L/D String & N/D BOP 13-5/8"	3.57	10.12

The estimation of total cost which is needed to prevent casing leakage is by using modified inflatable packer method is around US$ 770K (exclude mobilization and demobilization).

CONCLUSION

In operation timeline & cost, modified inflatable packer method is to prevent leakage in production casing of big hole type in PGE is better than conventional method, which decreases the timeline from 18 days to 10 days and it implicates in decreasing cost around US$ 950K to US$ 770K.

Table 4. The Result of Method Comparison

Method	Time (Day)	Cost (US$ x 1000)
Conventional	17.93	950
Modified Inflateble Packer	10.12	770
Saving	7.81	180
% Saving	44%	19%

REFERENCE

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