

5 DRILLING AND WELL TESTING PRACTICES

5.1 In this section

Section 5 covers the various activities involved in rotary drilling, completing, testing, and maintaining a well. Health and safety requirements during drilling operations shall be covered by the well owner's or construction contractor's safety management system, or both in compliance with occupational health and safety statutes of the country where the drilling activity takes place.

NOTE
(1) Geothermal drilling differs from conventional oil, gas, and water well drilling in the following principal areas:

- (a) Temperature. Elevated reservoir temperatures reduce drilling bit performance, adversely affect drilling fluid and cementing slurry properties, reduce the performance of BOP components, increase corrosion rates and, in some reservoirs, provide a condition where loss of downhole pressure can result in reservoir liquid flashing to steam, resulting in a flowback or blowout from shallow depths;
 - (b) Geology. Many reservoirs are hosted in interlayered volcanic or sedimentary rocks, or both, and are commonly associated with local and regional faulting. As a consequence, highly permeable features are common and these can be implicated in depth intervals coincident with major losses of circulation. Shallow volcanics generally have low bulk densities and offer low resistance to blowdowns and concentrations
 - (c) Geochemistry. Geothermal fluids contain varying concentrations of dissolved solids and gases. These dissolved components provide scale or other corrosive fluids, and may reduce scaling during well operations. Dissolved gases are normally dominated by CO₂ but also contain significant quantities of H₂S, both of which can provide a high risk to personnel and reduce lifespan of drilling tools and permanent well materials;
- (2) This code covers rotary drilling. Other drilling techniques include cable tool drilling, percussion drilling (utilising a downhole hammer) and pegging. Normally, they would be used only for relatively shallow and drilling of hard rock or unconsolidated, unconsolidated formations, and consequently are not covered in detail in this code. But drilling practices described for conventional rotary drilling have general application to wireless casing operations. A conventional wireless casing operation adapted for geothermal drilling requires provision for the safe recovery of the lower barrel, and the use of a drill string without a non-return valve.

Chapter 5

Drilling and Well Testing Practices

Drilling and Well Testing Practices

- Activities in rotary drilling, completing, testing and maintaining a well.
- Health and safety requirements shall be covered by well owners or contractors safety management systems and in compliance OHS&A statutes of the country.



Drilling and Well Testing Practices

- Differences in Geothermal drilling
 - Elevated reservoir temperatures – bit, cement, BOP, corrosion, liquid flashing to steam, blowouts.
 - Interlayered volcanic or sedimentary rocks –highly permeable, low bulk densities.
 - Geothermal fluids with dissolved solids and gases – acidic or corrosive fluids, H_2S and CO_2 , high risk to personnel and equipment materials.

Pre Spud Checklist

Occupational Safety & Health Administration OIL & GAS RIG INSPECTION CHECKLIST FOR DRILLING & WELL SERVICING OPERATIONS

| | | |
|---|--|--|
| Operating Company: <hr/> Company Man: | Rig #: <hr/> | OSHA Inspection #: <hr/> Date/Time of Inspection: |
| Drilling/Servicing Company Name & Address: <hr/> <hr/> <hr/> <hr/> Phone #: _____ Fax #: _____ Safety Manager: | Location: Field: _____ Well #: _____ Well Name: _____ Section: _____ Coordinates: _____ Serial #: _____ Town: _____ County: _____ Zip Code: _____ | Closing Conference Date/Time: _____ Inspected By: _____ Type of inspection: LEP: <input type="checkbox"/> Fatality: <input type="checkbox"/> Complaint: <input type="checkbox"/> No Inspection <input type="checkbox"/> |
| Toolpusher: | Driller: | Number of employees: Site: Total: |
| Ton Miles Logged: | BOP Test: | Operations: DRILLING: <input type="checkbox"/> SERVICING: <input type="checkbox"/> |
| Depth of Well: | Days on Location: | Type of servicing operation conducted: |
| Start Date: | Other employers on site: | CHECKLIST REVISION & ISSUE DATE: |

Drilling Fluids

- At least one person directly in control of the operational rig shall have a valid well control certificate (2 years).
- Drilling fluid properties to be measured and controlled are:
 - density
 - viscosity
 - gel strength
 - water loss, and
 - solids content.
- Monitoring of drilling fluids volumes, flow rate, temperatures and contents of returns – early Well Kick warnings and losses.
- Drilling fluids circulated to lift cuttings, hole cleaning and cooling.

Drilling Fluids

(Continued)

- Drilling fluids circulated to lift cuttings, hole cleaning and cooling.
- Return fluids shall be cooled before pumping back to maintain fluid properties, avoid boiling and avoid equipment damage.
- When using water for drilling, consideration should be given to pumping high viscosities sweeps to help in hole cleaning.
- Ensure adequate supply of water when drilling **blind**, or stop drilling until water storage is built up.



Drilling String Practice

- Design, selection and use of drill string components as per API RP 7G.
- New drill string connections should be broken in Thread lubricants for high temperature should be used for rotary shouldered connections, **casing threads X** – API RP 5 A3.
- Calibrated torque gauge to be used to ensure that correct make-up torque is applied to drill string connections.

Drilling String Practice

(Continued)

- Drill string component inspections at regular intervals for wear, corrosion, cracking, pitting based on previous drilling and storage.
- Tripping speeds to be restricted to avoid surge and swab pressures. Should have non return valve at lower end of drill string.
- Cooling downhole tools while tripping in by circulating through the drill string to avoid damage and formation damage.



Well Control

- A drilling well head with BOPs shall be installed for all phases of drilling after **first** casing string is cemented.
- Drilling wellhead attached to deepest cemented casing that extends back to surface except when shallower casing satisfies design requirements for predicted service conditions.
- BOP shall have provision to completely **SHUT OFF** the well with or without drilling tubulars in the hole, together with kill and choke line below shut off point.



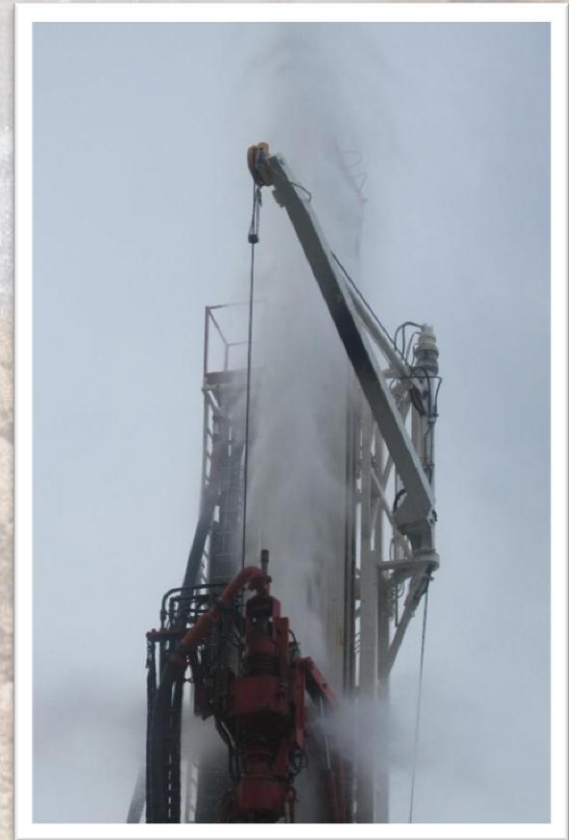
Well Control

(Continued)

- Minimum Drilling well head requirements:
 - Valve or Ram type BOP with shut off rams.
 - Annular type BOP with kill and choke lines lower part of lower.
 - BOP or drilling spool between BOP and casing head.
- Master valves installation – avoid damage by tools, have primary isolation of well bore, using a sleeve or flange with smaller ID.

Testing and Inspection of BOPs

- When drilling underbalanced with positive annulus pressure a rotating BOP and diverter shall be included in the well head.
- Drilling well heads shall be pressure tested assembly and prior to drilling out cement from casing.
- BOPs shall be regularly inspected, function tested and maintained in accordance with API STD 53.
- **BOP drills – regularly to familiarize the crew with well control.**



Drill Practices to Avoid Well Influx

Avoid flow back or well discharge by these practices:

- Filling the drilling before re-establishing circulation.
- Maintaining trip speeds to avoid surge and swab.
- Filling hole with fluid when pulling out drilling string.
- Cooling drilling fluids on surface.
- Pumping at adequate rate to cool the well.
- Avoid pumping fluid with foam down the well.
- Adequate fluid density maintained over reservoir pressures.
- Hole filled with fluid with sufficient density.
- Controlled rate of penetration to allow hole cleaning.
- **Pumping water down the annulus when drilling blind and monitoring the pump on the annulus.**
- Breaking circulation in stages while tripping in the hole.

Well Control by Monitoring

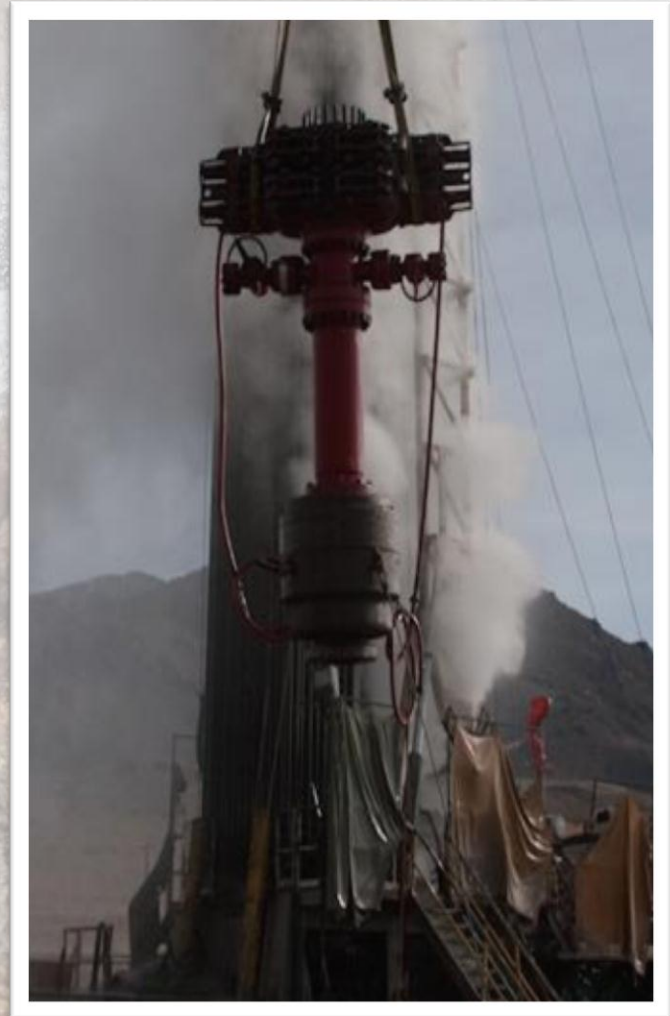
Drilling parameters to be monitored to maintain well control:

- Changes in the total volume of drilling fluids.
- Signs of formation gas in the drilling fluid returns.
- Increase in temperature and flow rate of returns.
- Drilling break or increase in rate of penetration (ROP)
- Loss of circulation.
- Pumping at adequate rate to cool the well.
- Loss of drill string weight while drilling.
- Contamination of drilling fluids by reduction in density or chemical properties.
- Change in stand pipe pressure due to deeper loss of returns.

Well Control by Monitoring

(Continued)

Well control procedures shall be implemented at the first sign of a flowback or possible flowback – ready to pump cold water down the well.



Managing Hazardous Gases

When hazardous gases are detected in the fluid returns:

- Take all safety actions are taken to ensure that personnel are not a risk.
- Pick up off bottom, continue rotation, increase pump rate.
- If needed close the BOP and well circulated back to the pits through the choke lines.



Managing Hazardous Gases

(Continued)

- The sensors recording the gas parameters should be working and working properly with **alarms** set for gas levels.
- The working breathing apparatus and escape pack breathing apparatus to be available in working and fully charged condition.
- List of personnel on location to assist in accounting for crew when assembling at muster point.



Running Casing

- Casing shall be handled and stored as per API RP 5C1.
- Avoid physical or welding damage to casing and connections.
- Lower thread protectors (pin end) should not be removed until in the mast, except when cleaning and inspecting threads.



Running Casing

(Continued)

- Prior to running threaded casing thread protectors should be removed, threads cleaned and visually lubricated.
- Casing to be drifted on the racks as per API Spec 5CT.
- Damaged casing to be rejected, marked and replaced.
- Casing joints to be measured, recorded and reconciled in the final casing tally.
- Different casing grades, weights or connections shall be positively identified.
- Centralisers with stop rings and not placed over couplings.

Running Casing

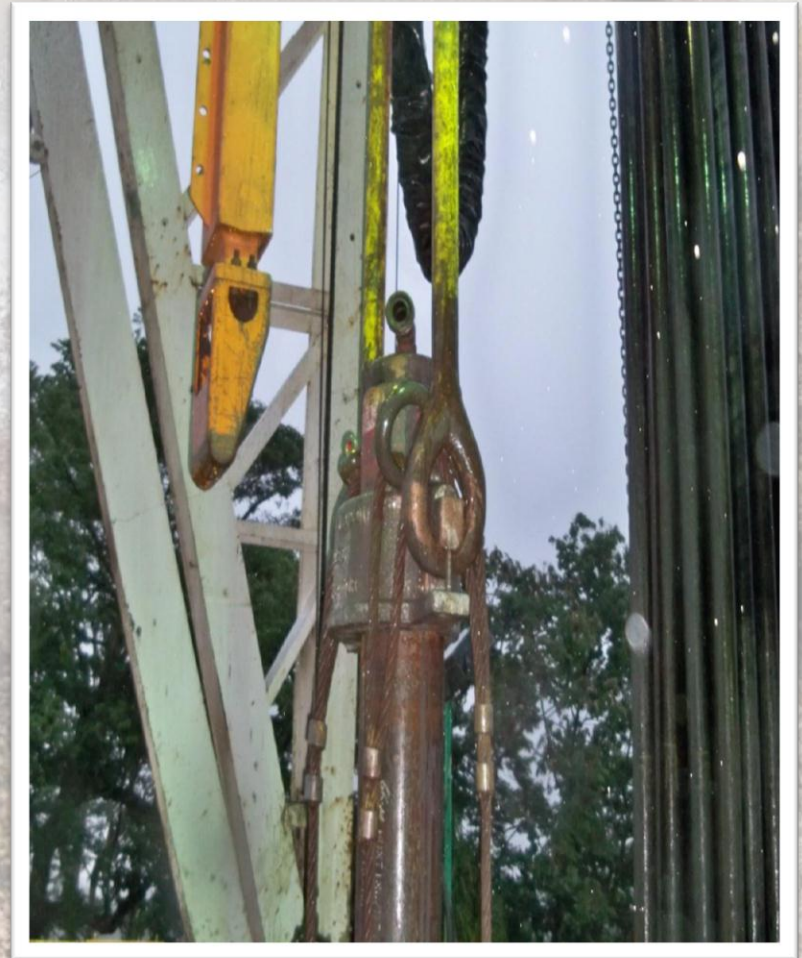
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- Casing preparations prior to starting running casing include:
 - All casing handling equipment and accessories
 - All cementing materials
 - All cementing accessories
 - Measuring devices
- Shall be on the ground and fully operational.
- Thread locking lubricants shall be formulated to perform well at the anticipated elevated temperatures.
- If welding is unavoidable, qualified welders to be used.

Running Casing

(Continued)

- Prior to running casing hole should be free of ledges, dog legs and thick wall mud cakes, have additional rat hole.
- Circulate the hole prior to running casing to remove any cuttings and reduce gel strength and fluid loss (wiper trip?).



Running Casing

(Continued)

- Proprietary connections shall be torqued as per manufacturer's recommended procedure and type of thread lubricant used.
- Thread dope for casing shall be as per API RP 5A3.
- A backup tong and make up tong to be used to make up casing connections, do not use locked rotary table.
- Casing running speeds controlled to avoid excessive surge.



Running Casing

(Continued)

- Casing running speed to be reduced before inserting slips to prevent shock loading.
- While running casing, circulate the hole using circulating head to cool the well while reciprocating the casing to avoid differential sticking.
- Prior to cementing after running casing circulate the hole to cool the well.

Cementing Casing

- Cementing program
 - Designed to ensure entire length of annulus is filled with a good quality cement, no water entrapped in the casing to casing annulus.
- Slurry volume allowance for:
 - Displacement of contaminated slurries.
 - Overgauge hole.
 - Losses to the formation.

Cementing Casing

(Continued)

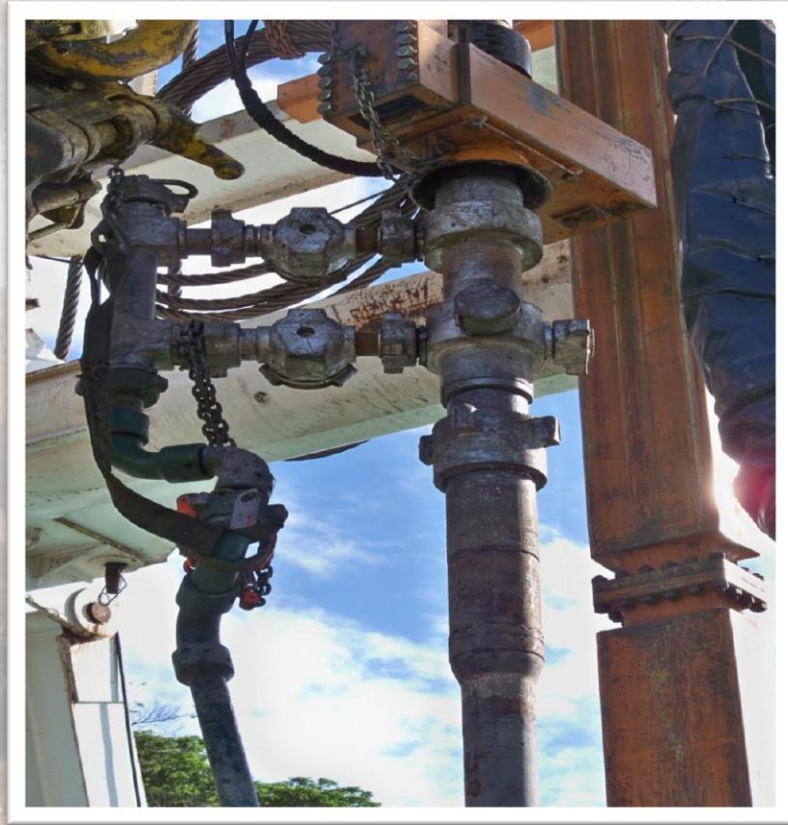
- Cement spacers prior to pumping cement for removal of mud and mud cake and reduce contamination of cement.
- Water or dense mud spacers, chemical flushes to seal loss zones and mud removal and scavenging cement slurry.



Cementing Casing

(Continued)

- Cement delivery pipework shall be installed so that pumping of cement can commence immediately after cement is displaced from inside casing (top plug), to avoid periods when cement slurry not in motion.



Cementing Casing

(Continued)

- Mixtures used for cementing shall be monitored and measured throughout the job to ensure the actual concentrations are maintained as close to design values.
- The cement returns to be monitored continually to check if the sub standard cement is in the casing to casing annulus, then flush the annulus to the shoe with water and may even break down the formation (watch collapse pressure and internal yield of casings and delivery lines).
- Back fill the casing to casing annulus if primary cement does not reach the surface, avoid trapping water.

Cementing Casing

(Continued)

- While pumping cement pressure applied to be limited to prevent casing damage over entire casing length.
- Pressure test drilling wellhead and casing prior to drilling out cement based on max anticipated service conditions and be held for five minutes and any leaks to be fixed.
- Squeezed (shutter) the casing shoe with cement if needed.
- The cellar shall be cleared of cement slurry before the cement sets, use sugar as a retarder.

Lost Circulation

In order to reduce likelihood of inducing circulation losses:

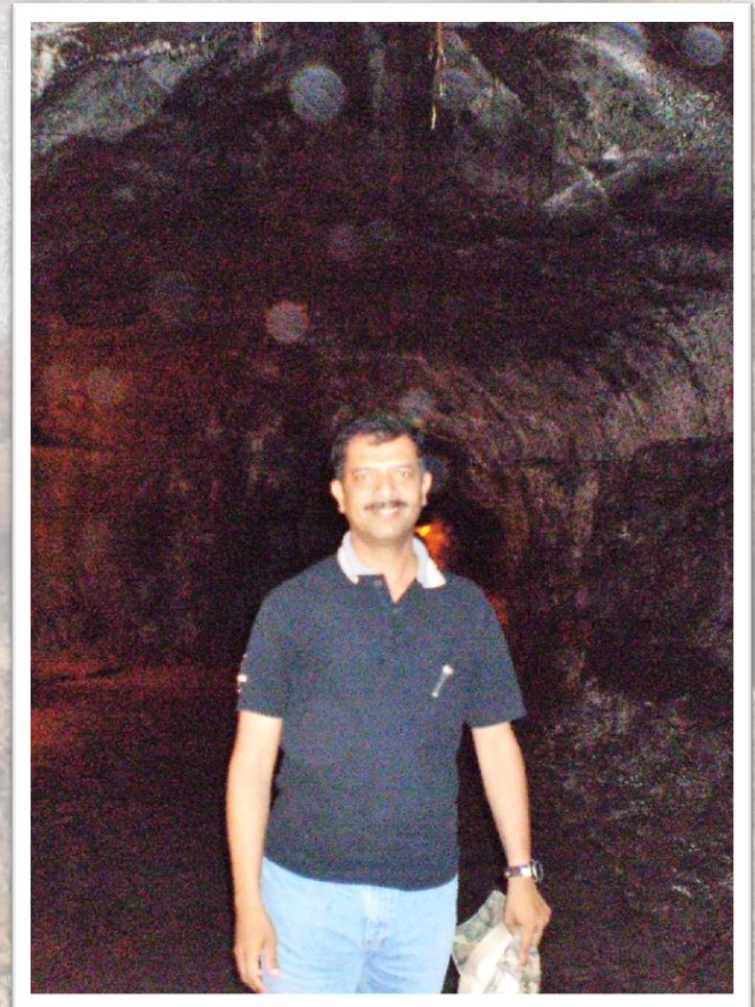
- Use drilling fluids with density causing pressure marginally over the reservoir fluid pressures.
- Controlled tripping speed to avoid surge and surge pressures.
- Avoid excessive wall cake build up.

Lost Circulation

(Continued)

When drilling the deepest cement casing, try to seal all the loss zones.

- Partial losses sealed with mud or LCM.
- Drill to the bottom of loss zone prior to treatment.
- Chemical sealing additives.



Lost Circulation

(Continued)

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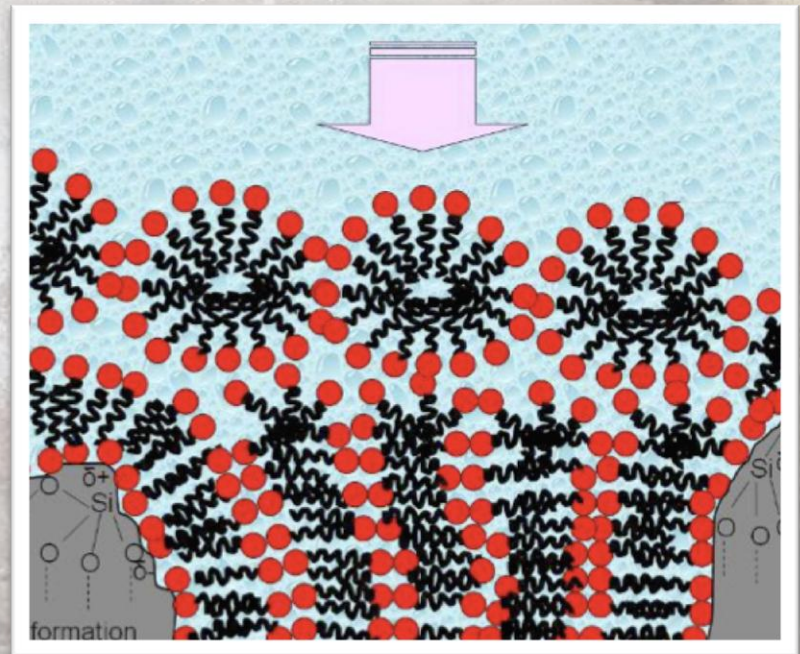
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Lost Circulation

(Continued)

When drilling the deepest cement casing, try to seal all the loss zones.

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- Chemical sealing additives.



Directional Drilling

- Selection of directional drilling equipment shall have consideration for additional capacity to overcome drag in the inclined hole.
- Kickoff point at least 50 meters below previous casing shoe.
- Drill string design should consider limitations of API RP 7G, not to be exceeded for hole geometry and drilling.
- Avoiding the rotation of hard banded tool joints when inside the casing where there is a change in hole angle.

Directional Drilling

(Continued)

- Pump liquid down annulus when total loss circulation (TLC) or use high temperature rubber protectors.
- When well is completed run a casing caliper to access the casing for any damage.
- Surveys across the complete wellbore to determine well track which will help in anti collision on multi well site.

Fishing

- All tubulars and tools run in the well bore shall be measured: Lengths, OD, ID, Fish necks and serial numbers.
- Fishing tools shall have a max OD not larger than the min drift diameter of the smallest casing in the well.
- No tools with large OD or fish neck to be run in hole which will make fishing them difficult.



Fishing

(Continued)

- Allowance in depth calculations for thermal expansion and contraction of the fish and the fishing string.
- The operating limits of the drill-stem as per API RP 7G.
- Explosives for fishing – consideration of operational temperature limitations.



Well Completions

- Inner cemented casing shall be logged to provide baseline record for casing condition and monitoring.
- Prior to running perforated liner ream the hole.
- Clean the well bore after reached **TD**, and strap out of the hole.
- Assess the well condition prior to running in the perforated liner, and make provision for well control as needed.
- Have adequate water supply for well quenching.

Well Completions

(Continued)

- Check for how long the well will stay quenched.
- Blank ends at the top of casing joint for well control.
- Blank liner on rig floor (end seal) for rapid installation If the time is not adequate, drop liner in the well.
- Internal tapered guide on top of slotted liner for easy entry of wireline and drilling tools
- The ID of the slotted liner to be clean of debris if manually slotted.

Installation of Permanent Wellhead

- Removal and installation of permanent well head shall be undertaken with the well in a fully controlled condition.
- Either keep the well dead by pumping water into the well, or setting a retrievable packer or drillable bridge plug inside the inner cemented casing.
- All permanent well head components shall be pressure tested prior to installation on the well.
- A protection system be installed if possible to prevent surface water entering the casing annuli and allows any gas migrating up to be vented away.
- Cellar cleaned and drains cleaned to prevent water accumulation in the cellar.

Installation of Permanent Wellhead

(Continued)

- After completing the well and prior to allowing the well to heat, a fixed point on the well head shall be measured and recorded with reference to a datum point on the cellar.



Installation of Permanent Wellhead

(Continued)

- Rig shall be released after the well has been completed in a safe condition and well head equipment shall be secured against operation by unauthorized personnel.
- The range of conditions under which a well can be safely operated shall be specified and documented, and later reviewed to reflect any changes in reservoir conditions.

Well Logging and Testing

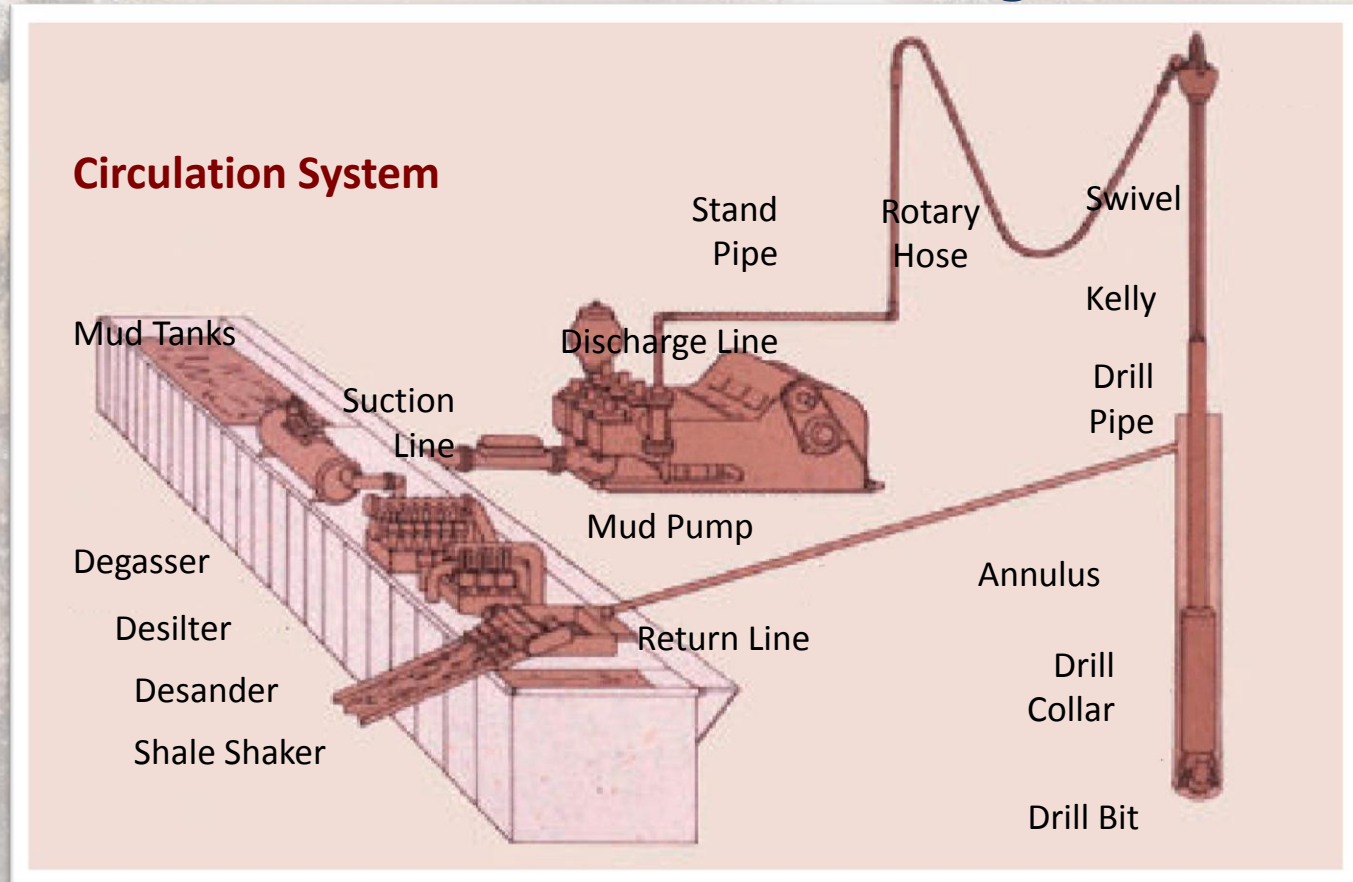
- Downhole conditions shall be assessed by running downhole logs and tests, while drilling, on well completion and periodically during the life of the well.
- Allowing or inducing the well to flow.
- Downhole pressure – temperature – spinner surveys.
- Pressure measurements at depth of primary permeability for well injectivity and reservoir permeability, skin effect.
- Formation integrity of leak off tests.

Well Logging and Testing

(Continued)

- Geophysical logs to map hydrothermal alteration and fracture encountered in the well bore.
- Fluid sampling at surface or downhole.
- Sampling of drilling cuttings – lag time calculations for correct sampling and correction factors when using aerated fluids.
- Cutting cores while drilling.

How to Calculate Theoretical Lag Time



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The are 3 steps:

1. Calculate annular volume at certain depth of hole
2. Calculate pump output
3. Calculate the theoretical lag time

1. Annular volume (AV) in barrels per foot = $ID^2 - OD^2 / 1029.4$

where ID is inner diameter of casing or open hole in inches

and OD is the outer diameter of drill pipe or drill collar

Barrels per foot x 391.208 = Liters / meter

Liters / meter x number of metres = Volume of casing or volume of open hole

Example: $12.25^2 - 5^2 / 1029.4 = 125.06/1029.4 = 0.1215$ barrels / foot

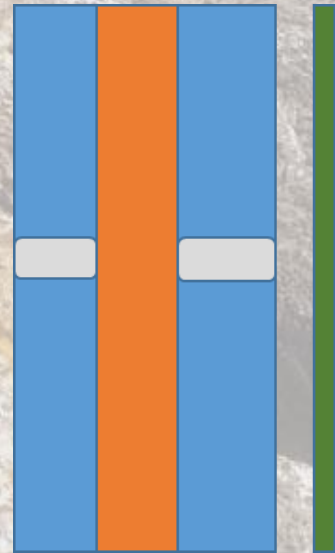
$0.1215 \times 391.208 = 47.528$ litres/meter x 100 metres = 4752.8 liters

2. Inside Drill string (IDS) volume in barrels per foot = $ID^2 / 1029.4$

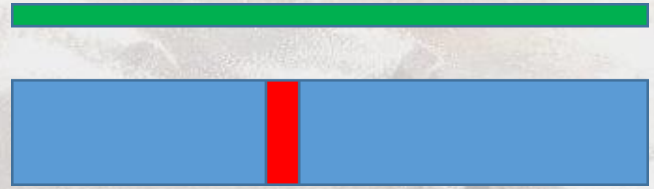
Where ID is the inner diameter of the drill pipe

Example: $4.276^2 / 1029.4 = 18.18/1029.4 = 0.01776$ barrels / foot

$0.01776 \times 391.208 = 6.948$ litres/meter x 100 metres = 694.86 liters



3. Total Volume = AV of hole + IDS volume for 100 metres = 4752.8 + 694.86 = 5447.66 litres



Pump Output from Triplex Pump:

Stroke Length in inches = 12 inches

Diameter of the liner in inches = 6.5 inches

Triplex Pump Output in bbl/stk = $0.000243 * (\text{liner diameter in})^2 * (\text{stroke length in})$
 $= 0.000243 * 6.5^2 * 12 = .1232 \text{ bbl/stk}$

Number of strokes per minute = spm = 100

Total pump Output per minute = bbl/stk x spm
 $= 0.1232 * 100 = 12.32 \text{ bbl/min}$

$\text{Bbl/min} * 119.24 = \text{Liters/min} = 12.32 * 119.24 = 1469 \text{ liters per min}$

$\text{Lag time} = \text{Annular Volume of Hole} / \text{Pump out per minute} = \text{Time taken}$

$4752.8 \text{ litres} / 1469 \text{ litres per minute} = 3.23 \text{ min}$

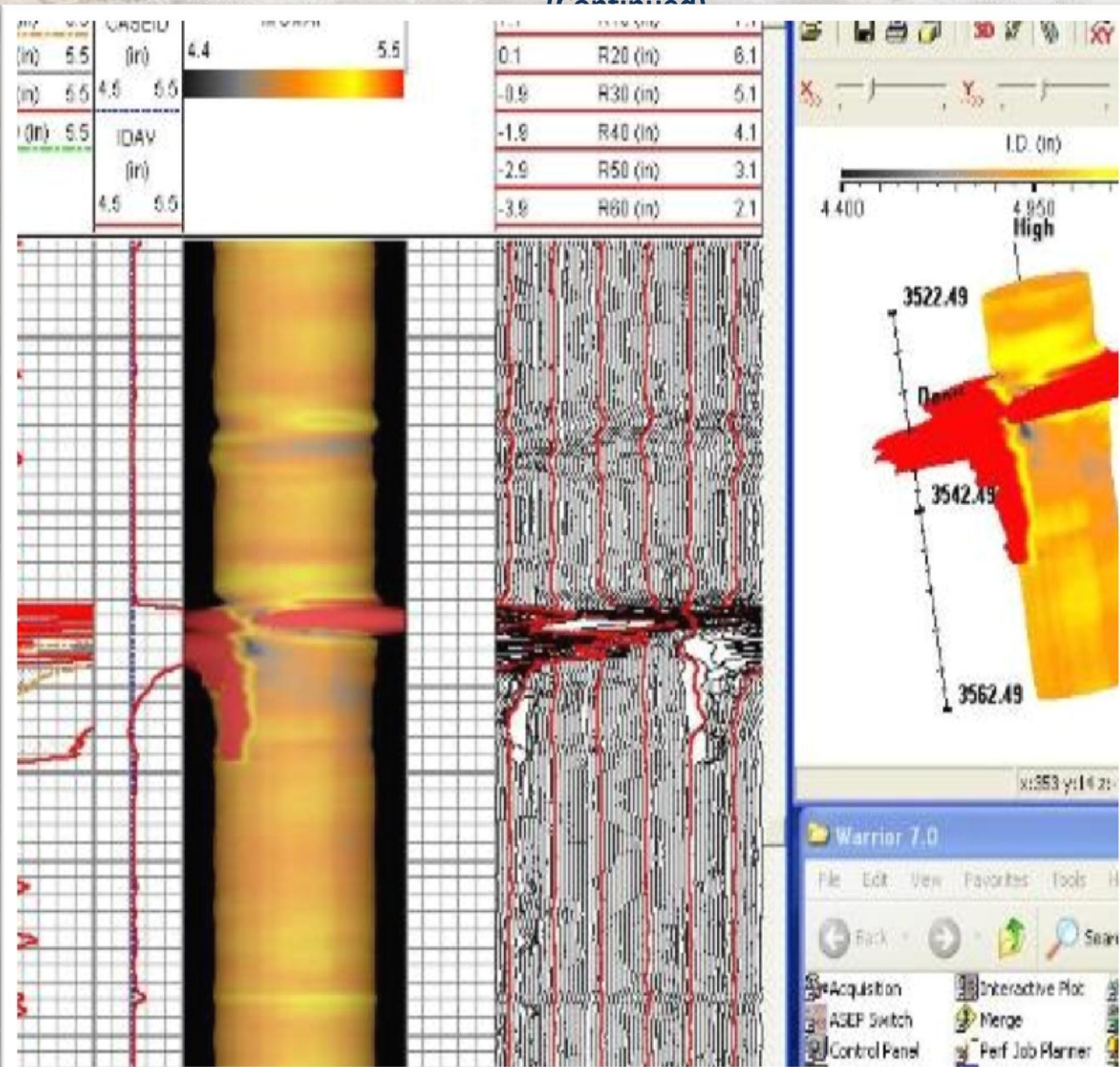
Well Logging and Testing

(Continued)

- Running downhole logs to assess cement placement.
- Down hole cameras.
- Dummy wireline runs.
- Mechanical calipers.
- Downhole retrieval of casing scale.
- Downhole videos or lead impression blockage.
- Downhole and well head conditions anticipated during logging and testing activities.
- Planned duration of the activities.
- Any changes that could happen downhole.

Well Logging and Testing

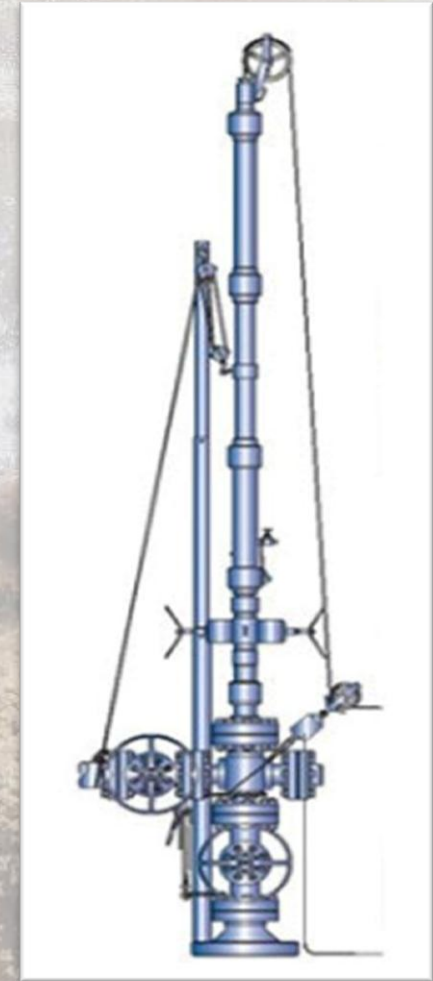
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Well Logging and Testing

(Continued)

- Wireline BOP or lubricator.
- Discharging of an uncased hole can cause hole collapse due to reduction in downhole pressures.
- Pressure measurements taken with drilling mud in the well may not give true formation fluid pressures.



Well Logging and Testing

(Continued)

- Cooling of the hole from the drilling process could affect the temperature measurements.
- Fluid samples taken from a well during drilling may be contaminated with drilling fluids.
- All tools should be fishable.

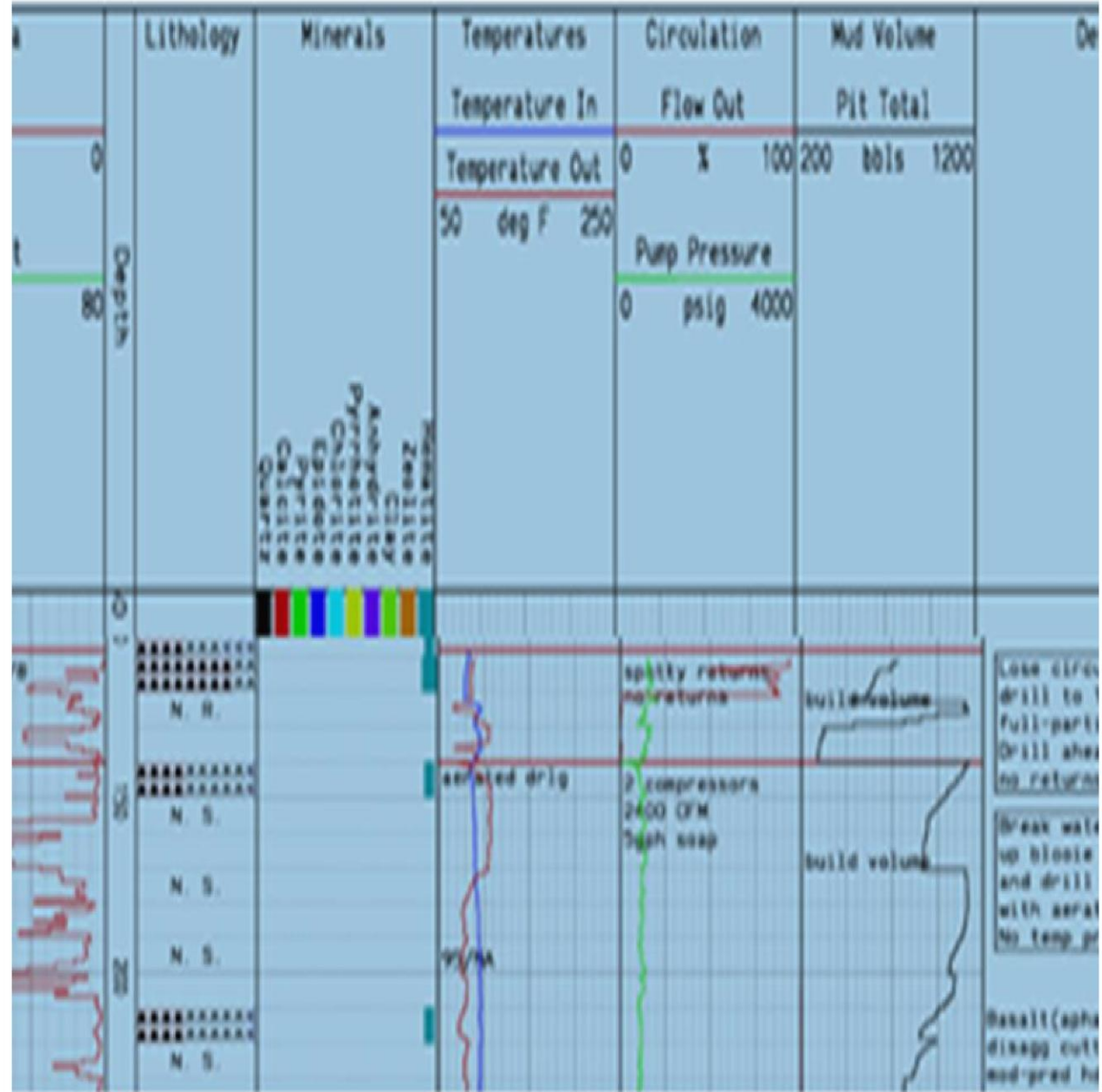
Well Logging and Testing

(Continued)

- Thermal effects should be considered while selecting and running equipment.
- Wireline log data should be validated through comparable down and up logs across the same interval.
- Depth calibration against well construction records with provision for wireline stretch and expansion.

Drilling Records

- **Quality data acquisition** and retention of data and other information gathered during drilling including drilling parameters, cuttings logs and well logs.



Drilling Records

(Continued)

- Shall be permanently maintained and stored by well owner, and appropriate Government ministry or agency responsible for granting drilling licenses and maintaining geological data.

Drilling Records

(Continued)

Purpose of drilling records:

- Subsequent monitoring of well condition.
- For any well workover, intervention or abandonment.
- As offset data for planning of subsequent wells.
- Assist directional drillers to avoid collision by later wells and ensure well tracks within legal boundaries.
- Reservoir engineering and understand the geology.

Drilling Records: Wells

(Continued)

- Well design and Drilling Program.
- Design modifications.
- Daily drilling activity records (detailed).
- Hole measurements and casing string depths.
- Casing specifications.
- Cementing reports.

Contents

- I. Well History Report
- II. Bit Record & BHA Report
- III. Operations Analysis & Summary
- IV. Well Information Summary
- V. Cost Summary
- VI. Directional Information
- VII. Geological Data
- VIII. Cement and Casing
- IX. Attachments
 - a. Baker Hughes Inteq Directional Reports
 - b. Halliburton Cement Reports
 - c. Hughes Christensen Bit Report
 - d. Baker Hughes Drilling Fluids Recap
 - e. Daily Drilling Reports
 - f. Drilling Program

Drilling Records: Wells

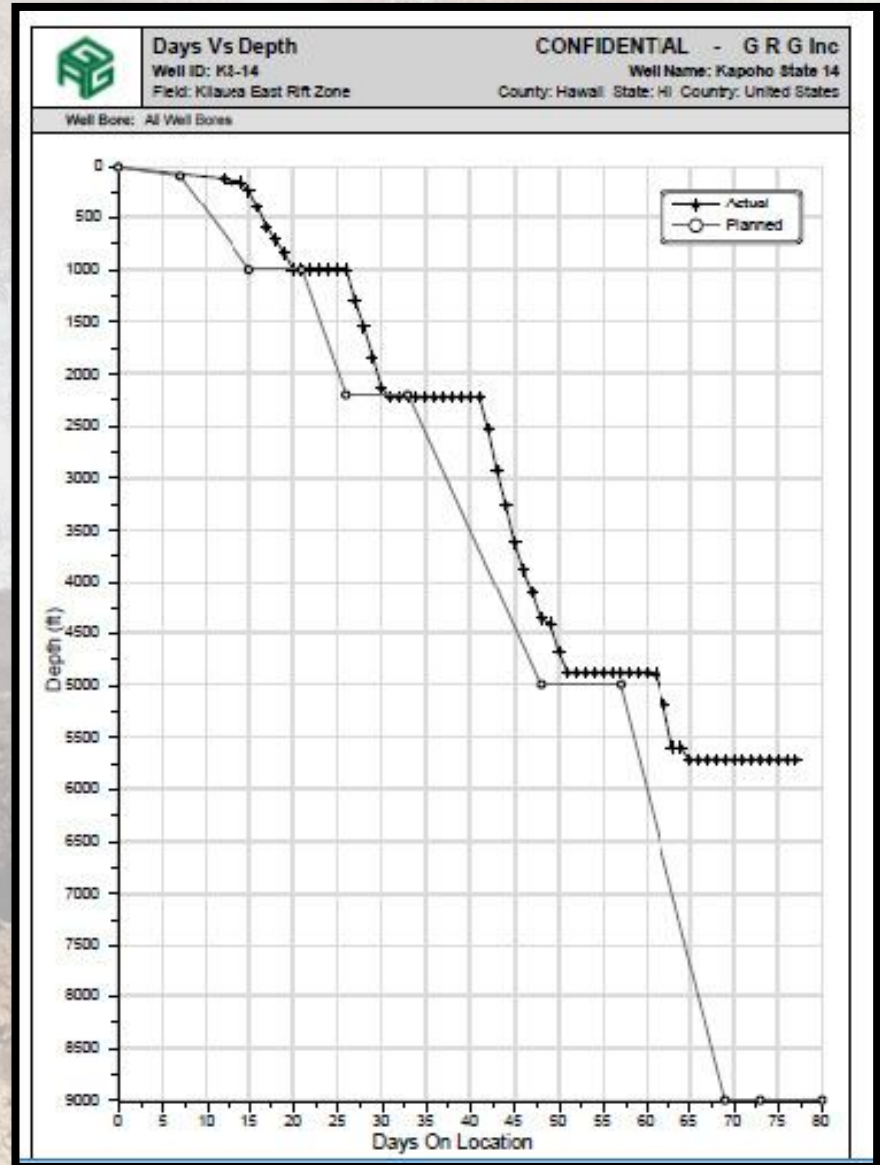
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- Wellhead assembly (as built pictures).
- Downhole directional survey and pressure temperature surveys.
- Time Analysis and Cost Details.
- Unrecovered fish details.
- Wellhead location coordinates and datum level.
- Loss Circulation zones.
- Drilling Bits records.
- Detailed Master Log – Cores and cuttings.

Drilling Records: Daily

(Continued)

- Daily drilling activity records
(*INFOSTAT Rimbase – IADC Drilling Report*)



Drilling Records: Daily

(Continued)

- Tool and drill string diameters.
- Drilling bit details.
- Drilling depth consumables – drilling fluids.
- Casing and cementing reports (if applicable).
- Detailed daily activity report.
- Changes in drilling conditions.
- Pressures.
- Drilling parameters.
- Daily cost and time breakdown.
- Safety tracker and personnel on board (POB) numbers.



Daily Drilling Report

Well ID: 14-14

Field: Blue Mountain

Geothermal Resource Group

Well Name: Blue Mountain 14-14

Sect: 14 Town: 36N Rng: 34E County: Humboldt State: NV

Report No: 22

Report For 16-Jan-09

| | | | | | | | | |
|-----------------------|--|-----------------------|-----------------|---------------------|--------------------|------------------------|-----------------------|-------------|
| Operator: | NGP BM 14-14 | Rig: | Thermasource | Spud Date: | 31-Dec-08 | Daily Cost / Mud (\$): | 44,366 / 6,626 | |
| Measured Depth (ft): | 3075 | Drilling Days (act.): | 17 | Well Bore: | Original Well Bore | AFE No. | AFE (\$) | Actual (\$) |
| Vertical Depth (ft): | 3071 | Drilling Days (plan): | 41 | RKB Elevation (ft): | 30.00 | 136.01 | 3,815,750 | 1,749,610 |
| Proposed TD (ft): | 3500 | Days On Location: | 22 | Last BOP Test: | 13-Jan-09 | | | |
| Hole Made (ft) / Hrs: | 275 / 21.5 | Last Casing: | 13.375 at 1,995 | | | Totals | 3,815,750 | 1,749,610 |
| Average ROP (ft/hr): | 12.79 | Next Casing: | 9.625 at 3,500 | Working Interest: | 100% | Well Cost (\$): | 1,749,610 | |
| Personnel: | Operator: 2 | Contractor: | 13 | Service: | 5 | Other: | Total: 20 | |
| Current Operations: | Drill 12 1/4" hole with 8" mud motor f3075' to 3144' @ 06:00 hrs | | | | | | | |
| Planned Operations: | Drill to 3300', Pull out of hole, MIU MWD and tools, RIH and Dir work f3300' | | | | | | | |
| Toolpusher: | Chad Patton | | | | | | | |
| Wellsite Supervisors: | Jack Auten, Dan Darnell | | | | | | Tel No.: 866-719-9614 | |

Operations Summary

| From | To | Elapsed | End MD(ft) | Code | Operations Description | Non-Prod |
|-------|-------|---------|------------|------|--|----------|
| 0:00 | 0:30 | 0:50 | 2,800 | SURV | Survey @ 2754', MRT 176 deg F | |
| 0:30 | 6:30 | 6:00 | 2,893 | DRIL | Drill 12 1/4" hole with 8" mud motor f2800' to 2893' | |
| 6:30 | 7:00 | 0:50 | 2,893 | CIRC | Circ f survey @ 2893' | |
| 7:00 | 7:30 | 0:50 | 2,893 | SURV | Survey @ 2847', MRT 185 deg F | |
| 7:30 | 15:00 | 7:50 | 2,967 | DRIL | Drill 12 1/4" hole with 8" mud motor f2893' to 2967' | |
| 15:00 | 15:30 | 0:50 | 2,967 | CIRC | Circ f survey @ 2967' | |
| 15:30 | 16:00 | 0:50 | 2,967 | SURV | Survey @ 2941', MRT 188 deg F | |
| 16:00 | 0:00 | 8:00 | 2,967 | DRIL | Drill 12 1/4" hole with 8" mud motor f2967' to 3075' | |

Comments

Drill 12 1/4" hole with 8" mud motor f2800' to 3075'

Casing/Tubular Information

| Type | Size | Top MD | Top TVD | Bottom MD | Bottom TVD | Hole Section | Avg OH Diam | LOT |
|------|--------|--------|---------|-----------|------------|--------------|-------------|-----|
| FULL | 30.000 | 30 | | 75 | | | 36.000 | |
| FULL | 20.000 | 30 | 30 | 331 | 331 | | 26.000 | |
| FULL | 13.375 | 30 | 30 | 1996 | 1996 | INT1 | 17.500 | |

Cost/AFE Information

| AFE No | AFE Description | AFE Amount | Daily Mud | Well Mud | Daily Total | Well Total | % Spent |
|------------|-----------------|------------|-----------|----------|-------------|------------|---------|
| 136.01 | | 3,815,750 | 6,626 | 68,342 | 44,366 | 1,749,610 | 45.85% |
| Totals \$: | | 3,815,750 | 6,626 | 68,342 | 44,366 | 1,749,610 | 45.85% |

Mud Information

| Density | Vis | PV | YP | Filt. | Cake | pH/ES | Solids | Oil | Water | Sand | LGS | Chlor. | Cal. | % Gels | | | Temp | | Mud Loss |
|---|-----|----|----|-------|------|-------|--------|-----|-------|------|-----|--------|------|--------|-----|-----|------|-----|----------|
| | | | | | | | | | | | | | | 10s | 10m | 30m | In | Out | |
| 16-Jan-09 11:00 Sample from Mud Pits, Type: Fresh Water Based | | | | | | | | | | | | | | | | | | | |
| 8.70 | 45 | 11 | 19 | 8.2 | 2 | 9.4 | 3 | 0 | 97 | 0.24 | 4 | 1900 | 120 | 7 | 15 | 164 | 174 | | |

Mud Consumables

| Item Description | Qty. | Cost | Item Description | Qty. | Cost |
|-------------------|------|------|------------------|------|------|
| Lime - SACKS | 5 | 0 | Mix II - SACKS | 30 | 0 |
| PolyPac R - SACKS | 6 | 0 | SP-101 - sacks | 7 | 0 |

Bit/BHA/Workstring Information

| No | Run | Make | Model | Diam | Depth | This Run | | | R.O.P. | | | | Mud Pump | | | | | | | |
|---|-----|--------|---------|--------|-------|----------|------|--------|---------|-----|-------|---------|----------|-----|-------|-------|-------|-------|-------|-----|
| | | | | | | In | Dist | Hrs | Avg | Max | WOB | RPM | Torque | Wt | Flow | Press | J.Val | P.Drp | HHP | JIF |
| 3 | 1 | HCBITS | MXL-C28 | 12.250 | 2003 | 1,072 | 69 | 12.8 | 20.0 | 14 | 195 | 164 | 9 | 614 | 1352 | 109 | 98 | 33 | 302 | |
| Jets: 28 28 28 | | | | | | Out | 3242 | Grade: | Cutter: | 3/3 | Dull: | WT / NO | Wear: | A | Brgs: | E | Ggs: | 2 | Pull: | HP |
| BHA - No. 4 - BIT, MMTR, STAB, 2 XO, DCM, STAB, DC, STAB, SSUB, 2 DC, STAB, 2 DC, XO, JAR, 11 HWDP = 611.45 | | | | | | | | | | | | | | | | | | | | |

Drilling
Records:
Daily
(Continued)



Daily Drilling Report

Well ID: 14-14
Field: Blue Mountain

Geothermal Resource Group

Well Name: Blue Mountain 14-14
Sect: 14 Town: 36N Rng: 34E County: Humboldt State: NV

Report No: 22

Report For 16-Jan-09

Drilling Parameters

| From | | To | | ROP | | WOB (lbs) | | RPM | | Torque (ft lbs) | | Flow (gals/min) | | PSI |
|----------------------------------|-------|------|------|-------|-----|-------------|-----|-----|-----|-----------------|-----|-----------------|-----|-----|
| From | To | Avg | Max | Avg | Max | Avg | Max | Avg | Max | Avg | Max | Avg | Max | PSI |
| 2,800 | 3,075 | 15.0 | 20.0 | 5 | 20 | 195 | 202 | 130 | 160 | 614 | 626 | 1,352 | | |
| Annular Velocity: Drill Collars: | | | | 175.0 | | Drill Pipe: | | | | 116.0 | | | | |

Comments: Drill 12 1/4" hole with 8" mud motor 12800' to 3075'

Miscellaneous Drilling Parameters

| | | | | | | | | |
|------------------------|--------------------|---------|----------|---------|------------|--------|---------------|-------------|
| Hook Loads (lbs): | Off Bottom Rotate: | 101,000 | Pick Up: | 105,000 | Slack Off: | 97,000 | Drag Avg/Max: | 2000 / 5000 |
| Slow Circulation Data: | | | | | | | | |
| Pump 1: | 54 spm | 160 psi | | | | | | |
| Pump 2: | 58 spm | 184 psi | | | | | | |
| Hours on BHA: | Since Inspection: | 201 | Total: | 201 | Jars: | 201 | | |

Survey Information

| Survey Type | Meas. Depth | Inc. | Azimuth | TVD | Closure | Vertical Section | Coordinates | | |
|-------------|-------------|------|---------|---------|---------|------------------|-------------|--------|--------|
| | | | | | | | N-S | E-W | D.L.S. |
| MSS | 2,941.0 | 8.00 | 151.0 | 2,938.5 | 54.7 | -42.6 | S 42.6 | E 34.0 | 1.099 |

Mud Log Information

| Depth (ft) | | TVD (ft) | | Gas (Units) | | Gas | Drilling | Pore | Mud | Shale | ROP | |
|------------|-------|----------|----|-------------|-----|----------|---------------|-------|-------|-------|-------|------|
| From | To | From | To | Avg | Max | at Depth | Connect. Trip | Press | Dens. | Dens. | Shale | Sand |
| 2,810 | 2,980 | | | | | | | | | | | |

Formation Name:

Lithology: 90-100% Phyllite, 0-10% Clay, 0-10% Quartz Veining

Rig Information

Equipment Problems: None
Location Condition: Good
Transport:

Solids Control Information

| | | | | | | | |
|---------------|-----|--------|--------|-----------------------------------|--|--|--|
| Screen Sizes: | Top | Middle | Bottom | Equipment Usage (Hrs): | | | |
| Shaker No 1: | 165 | 165 | 230 | Deeliter: 12 | | | |
| Shaker No 2: | 165 | 165 | 230 | Centrifuge 1: 24 (Solids Removal) | | | |

Inventory

| Bulk Material | Used This Report Period | Received This Report Period | Inventory | Bulk Material | Used This Report Period | Received This Report Period | Inventory |
|---------------|-------------------------|-----------------------------|-----------|---------------|-------------------------|-----------------------------|-----------|
| DIESEL | 1506 | | 11,529 | | | | |

Drill Pipe Inventory

| DP Size | Joints | Weight | Grade | Thread | DP Size | Joints | Weight | Grade | Thread |
|---------|--------|--------|-------|--------|---------|--------|--------|-------|--------|
| 4.5 | 15 | 42.0 | G | 4.5XH | 4.5 | 207 | 16.6 | G | 4.5XH |

Safety Information

| | | | | |
|-----------------------------------|--|------------------------|--------------------|--|
| Meetings/Drills | Time | Description | | |
| Safety | 30 | Rig service and Brakes | | |
| First Aid: | Medical: | Lost Time Accidents: | Days Since LTA: 17 | |
| <input type="checkbox"/> BOP Test | <input checked="" type="checkbox"/> Crownmatic Check | | | |

Weather Information

| | | | |
|------------------|------------|----------------|--|
| Sky Condition: | Clear | Visibility: | |
| Air Temperature: | 18.0 deg F | Bar. Pressure: | |
| Wind Speed/Dir: | / | Wind Gusts: | |

Drilling
Records:
Daily
(Continued)





6 WELL OPERATION AND MAINTENANCE

6.1 In this section

Section 6 covers the techniques and procedures to be adopted throughout the life of a well, following well completion. This includes operations pertaining to monitoring, inspecting, and repairing the well and wellhead components, and the discharging of the well. It does not include abandonment (see Section 7 starting on page 123).

6.2 Maintaining well integrity

Each well that has not been abandoned shall be operated and maintained to meet the objectives of this code, and be in general accordance with Section 2.

Any known deviation from the requirements of Section 2 (starting on page 11) shall require specific engineering assessment and an appropriate ongoing management plan.

When a potential defect is identified, additional monitoring or remedial work required to maintain the well condition shall be planned and carried out as soon as practicable, depending on the nature and the assessed risk resulting from that defect. Monitoring shall continue, at an appropriate frequency to allow for timely identification of any change in well conditions, until the defect is remedied.

6.3 Well monitoring

6.3.1 – Well Monitoring Plan

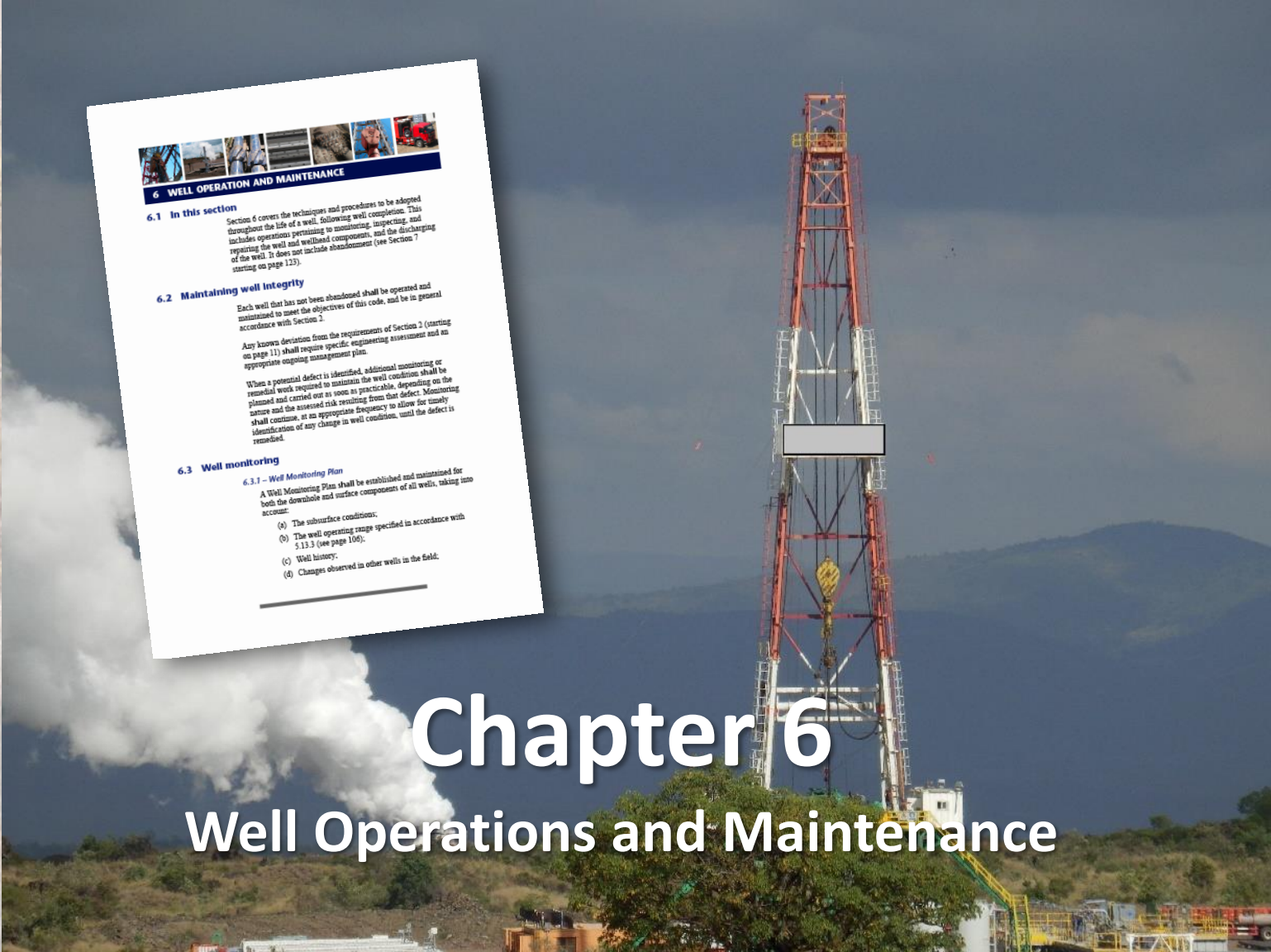
A Well Monitoring Plan shall be established and maintained for both the downhole and surface components of all wells, taking into account:

- (a) The subsurface conditions;
- (b) The well operating range specified in accordance with 5.13.3 (see page 106);
- (c) Well history;
- (d) Changes observed in other wells in the field.



Chapter 6

Well Operations and Maintenance



Well Operation and Maintenance

- Procedure to be adopted during the life of a well.
- Maintaining well integrity
 - Operated and maintained as per the code and any changes need engineering assessment.
 - When a potential defect is identified, additional monitoring and remedial work shall be undertaken ASAP (as soon as possible) depending on the nature and assessed risk.

Well Operation and Maintenance

(Continued)

- Well Monitoring – specify monitoring frequency.
 - Plan shall be established for both the downhole and surface components of all wells based on:
 - Subsurface conditions
 - Well history
 - Operating range
 - Changes in nearby wells
 - Ground subsidence
 - Well configuration
 - Equipment availability

Well Operation and Maintenance

(Continued)

Multiple Well Monitoring cover multiple wells or reservoir:

- Scope of work shall included any well or wells excluded.
- Copies of plan to appropriate agencies.
- Processes to be put in place to record any variations and take necessary action.

Well Operation and Maintenance

(Continued)

Identification of defects and Impairments:

- External or near surface leakages or corrosion of casing.
- Corrosion leakage of wellhead equipment.
- Broken or perforated casing and failed casing connections.
- Leaks in casing and buckled casing.
- Collapsed or corroded casing.
- Annular flow outside the casing.
- Chemical deposition or scale.

Observation of Change

Plan shall observe the following type of changes:

- Changes in discharged fluid chemistry, enthalpy, pressures or flow rates of production wells.
- Changes in surface manifestations of geothermal flow, new hot areas on or near the well site.
- Any indications of fluid entering into a cemented casing annulus at surface or deterioration of cement.
- Any changes in flow from the casing annuli.
- Loss of pressure measured at a side valve when the well otherwise known to be under pressure.

Wellhead Inspection Record

Documented Annual Inspection

- Wellhead pressure.
- Well Status (shut in, bleed, production, injection).
- Operating condition of well head valves.
- Leakage from valve gate or stem seals.
- Condition of protective paint coatings.
- Condition of anchor casing.
- Condition of the site and cellar drainage.
- Changes in vertical position of wellhead and position of CHF measured relative to the cellar datum.



Wellhead Maintenance

- Wellhead free of corrosion.
- Protective painted cleaned before fresh coat.
- Severe external corrosion of anchor casing is seen, casings outside shall removed to check casing and replaced after the remedial work is done.
- Anchor casing shall be replaced if pressure rating is compromised for the particular well.
- Or corrosion removed and casing painted.
- Casing annulus protection system should be maintained.
- No leakages across flanges, tappings, fittings, glands, valves and similar equipment and in sound operating conditions.

Risk Assessment

- Risk assessment for each well based on well monitoring and inspections, which should be documented.
- Any remedial works identified by the inspection program shall be completed as soon as practical.
- Especially when the potential deterioration could cause a risk to personnel safety and environmental damage.



Wells in Operation

- Master valve shall remain operational and capable of being closed at all times.
- Master valve nor side valves not to be used as flow control valves except in emergency situation.
- Master valve not to closed on a flowing well.
- Minimize the rapid change of temperature of well casings, cement sheath and wellhead. Controlled heating and cooling to mitigate this risk. Put the production well on bleed, increasing bleed rate or injecting hot fluid in the well are some measures.

Wells in Operation

(Continued)

- Bleeding of well should be done upstream of master valve through side valve, pipework should be anchored.
- Bleeding lines terminated at some distance away from the wellhead to avoid corrosion and accumulation of hazardous gases within low lying areas like the cellar.
- Designed in a way to avoid health or environmental hazard or noise nuisance.
- Any flow from the well shall be controlled by a valve, orifice plate, applies to low flow rates or high discharge rates.

Workovers

Operations conducted on completed well using drilling rig or similar equipment to achieve:

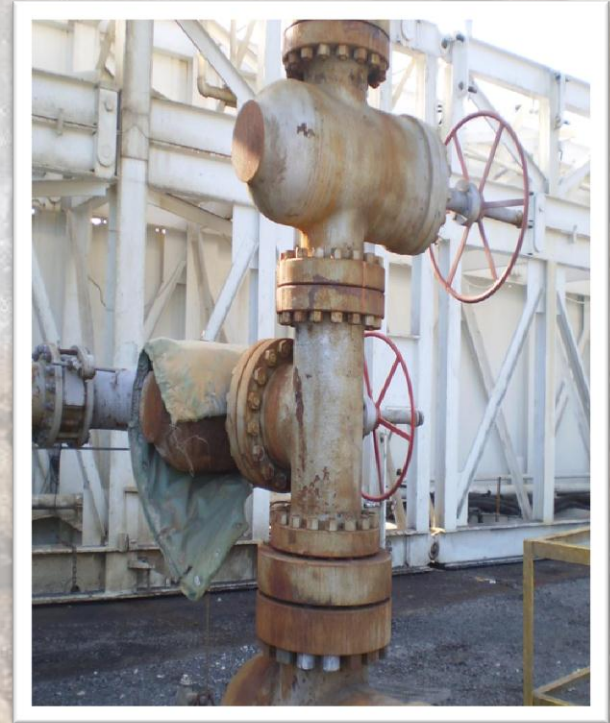
- Repair or replacement of a wellhead component.
- Repair or replacement of damaged casing.
- Removal of scale deposits from the well.
- Installation or removal of non cemented liner from the well.
- Any other work inside the well needed to modify the existing conditions in the well.

Workovers

(Continued)

More operations conducted:

- Workover operations shall comply with Section 5 needs and hazardous gases monitoring and managing.
- Prepare a well workover program including well control methods.
- Preferable to set a retrievable packer in the well than quenching the well, ***End of Well Workover report.***



Quenching

- When quenching the well with cold water gradually cool the well in a controlled manner.
- Initial flow rates to be controlled at low level at first and then gradually increased until well is off pressure.
- Sequence of 25 liters/minute for the first hour increase in 25 liters/minute increments every 30 minutes.
- During quenching control the non condensable gases by venting in order to control wellhead pressure.
- Any gas pressure that builds up in the well should be reduced slowly by bleeding prior to well quenching.

Wellhead Removal and Replacement

- Replacement of wellhead components may be undertaken using a retrievable packer set inside sound casing.
- Snub the packer, set it and take an upward pull to ensure packer is set.
- Otherwise, well is quenched and kept in the quenched condition for **twice** the estimated maintenance time required.



Wellhead Removal and Replacement

(Continued)

- Ensure adequate and secure water supply to keep well in the quenched condition.
- Any welding that is performed shall be in accordance with the welding procedures (pre- and post-heat).
- Cutting and removal of parts to avoid damage to other casing sections, if the wellhead height is changed – new height.



Downhole Works

- A drilling wellhead including BOPs shall be installed in any well that has potential to discharge during the downhole works.



Downhole Works

(Continued)

- A new casing or scab liner across damaged or failed casing, shall be cemented over its full length. The well bore below scab liner should be isolated from any other operations using a drillable plug or packer set in the casing.
- When drilling scale in a permeable well, fluid returns and pump pressures should be continually monitored as bit can be plugged or drill string can get stuck.

Suspended Wells

- Cement plugs shall be placed (not less than 100 meters) of continuous cement inside production casing.
- Cement plug placed on bridge plug near production casing shoe above 10 meters of the liner.
- Minimize dilution of cement slurries by well fluids
- Cement should withstand ambient fluids and temperatures.

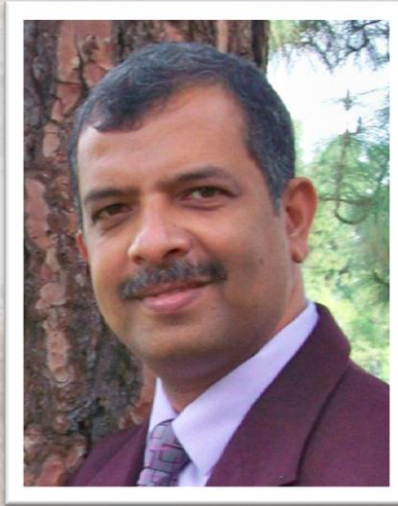
Suspended Wells

(Continued)

- Casing above the sound cement should be filled to surface with drilling fluid (bentonite).
- Pressure test cement plug to a sufficient test pressure to provide sufficient integrity for duration of well suspension.
- Wellhead can be removed except the CHF.
- End of Well Workover report shall be prepared.



Questions



Thank You!

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