Cased-Hole Logging Environment

2

Planning a Production Logging Job

Planning is an important part of a production logging job. Frequently these jobs can only be done in safety during daylight. Thus, the correct type of equipment must be available for the expected well conditions. Before attempting any production logging job the following checklist should be consulted:

1. Full well-completion details
2. Full production history
3. All open-hole logs
4. PVT data

Lack of any part of this data will result in delays that may jeopardize the entire job.

Pressure-Control Equipment

Practical details should not be forgotten. In particular, considerable care and attention should be given to the matter of working on a well that has pressure at the wellhead. It is a good idea to plan well in advance with the logging-service company using the following checklist:

1. Wellhead connection
2. Riser requirements
3. Tubing restrictions (minimum ID)

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4. Tubing-head pressure
5. Safety (H_2S/pressure/temperature ratings)

In general, when working against wellhead pressure the logging cable will be a single-conductor armored cable about 1/4 in. in diameter. To seal the wellhead assembly against well fluids, a stuffing box or hydraulic packing gland will be used. For high pressures, a "grease-seal" assembly will be used. In order to get logging tools into and out of the well in a safe and efficient manner, a section of riser will be needed. A typical setup is illustrated in Fig. 2.1. Note that, above the wireline blowout preventer, this pressure-control assembly has (l) a tool trap, (2) multiple sections of riser, and (3) the pressure sealing equipment. When retrieving a tool from the well, it is sometimes difficult to gauge exactly where the cable head is in the riser. If it is pulled up against the pressure sealing assembly too briskly, the tool may shear off the end of the cable and drop back into the well. To prevent this undesirable event, the tool trap catches the tool at the base of the riser.

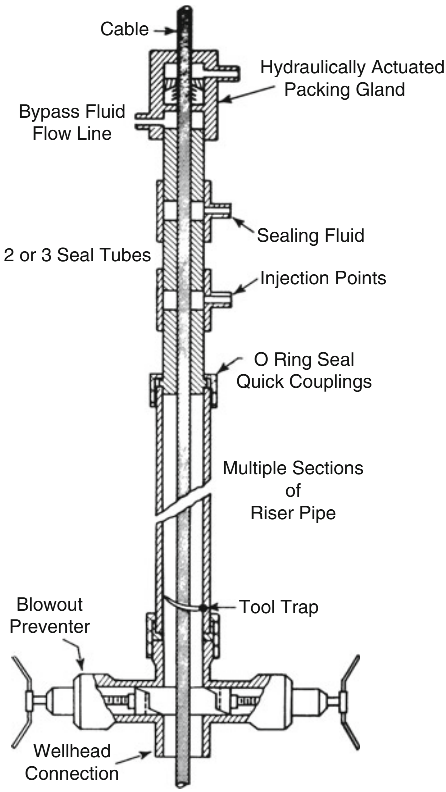

Fig. 2.1 Production logging wellhead pressure-control assembly. Courtesy Schlumberger

The cable itself is at all times subject to an extrusion force, since the portion inside the riser experiences wellhead pressure, while the portion outside the riser experiences atmospheric pressure. The upward force is thus the difference in pressure multiplied by the cross-sectional area of the cable itself. Sometimes this upward force can be surprisingly large and tools will not go down the well unless "ballasted" with additional weights.

Question #2.1
Tubing head pressure is 4,986 psi. The logging cable OD is 7/32 in. The tool weighs 20 lb and is 16 ft long.

(a) Calculate the upward force on the cable.
(b) If weights are available, each 4 ft long and weighing 26 lb, how many are needed to make the tool go down the well?
(c) In that case, how long a riser is required?
(d) If the top of the BOP is 10 ft above ground level, the grease-seal equipment measures 10 ft, and the sheave assembly requires 6 ft of clearance, how tall must the workover rig be in order to log this well?

It is also important to plan the arrangement of the Christmas tree—the objective being to be able to log the well without disturbing the dynamic behavior of the production or injection process. Sometimes this consideration is forgotten in the planning with the result that the only way to get production logging tools into and out of the well is by shutting in the well. This is undesirable, since a well may take hours or days to reach equilibrium again after being shut in. Figure 2.2 illustrates an ideal Christmas-tree setup. Note the numbered items in the figure:

#1 Valve on the riser side of the production line
#2 Valve on the production line
#3 Valve on the well side of the production line
#4 Pressure gauge on the riser
#5 Bleed-off valve on the riser

Question #2.2
(a) What happens if item # 1 is missing?
(b) What happens if item #3 is missing?
(c) Why are items #4 and #5 needed?

The Borehole Environment

In many of the problems that arise in completed wells, quantitative analysis will require detailed knowledge of flow rates, casing and tubing sizes and weights, as well as the types of flow that are occurring. For example, in the analysis of flowmeter data, fluid speed needs to be related to volumetric flow rate. Conversion from one set of units to another can be facilitated by using:

Appendix A: Conversion factors between metric, API, and customary (US) measures
Appendix B: Average fluid velocity vs. tubing size
Appendix C: Average fluid velocity vs. casing size

Question #2.3
Use Appendix C to find the flow rate in 7-in., 26-lb casing if the fluid speed is 9.1 ft/min.

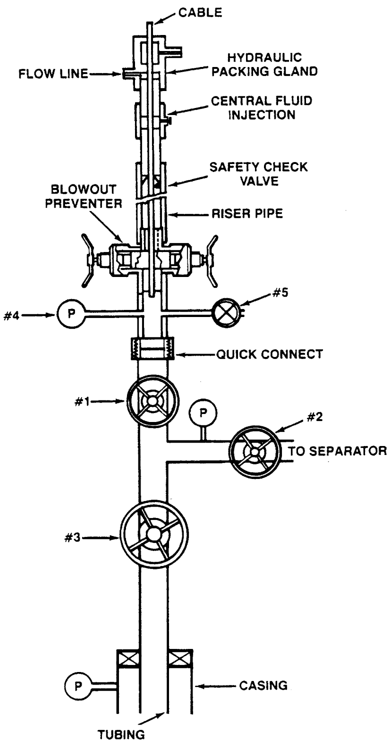

Fig. 2.2 Correct Christmas-tree arrangement for production logging

Choosing Production Logs

Depending on the type of problem encountered, a choice will exist regarding the correct tool or logging technique to be used. The following suggestions are offered as a quick guide. A more informed choice can be made after studying the individual tools in the chapters that follow.

Flow rates	
Low (0 and up)	Radioactive tracer log
Low to medium (10–1,900 B/D)	Packer or diverter flowmeter
Medium to high (50–5,000 B/D)	Full-bore flowmeter
High (3,000 B/D and up)	Continuous flowmeter
Fluid type	
Oil/water	Gradiomanometer
Oil/gas	Gradiomanometer or densimeter/vibrator
Gas/water	Densimeter/vibrator or gamma–gamma log
Formation content	
High-salinity water	Pulsed neutron log
Low-salinity water	Carbon/oxygen log
General	Elemental concentration log
	Spectral gamma ray
	Resistivity through casing
Casing/tubing inspection	Electromagnetic thickness tool
	Flux-leakage-type tool
	Multi-fingered caliper
	Ultrasonic imaging
	Optical imaging
Cement/channeling	Cement bond log
	Radial differential thermometer
	Temperature log
	Noise log
	Radioactive tracer log

Conveyance Methods

The conveyance of a production logging tool string to the required depth in a well can present challenges when the well is not vertical. Where the well is deviated from the vertical problems can arise since the tool string (lowered on a conductive wireline) may not slide down the well path past a certain angle of deviation. More challenging yet is the task of conveying the production logging tools to the end of a horizontal well. To overcome these difficulties the logging industry has evolved a number of conveyance mechanisms that strive to overcome such mechanical difficulties.

Combinations of techniques can be used to ensure that the tools get to where they need to be and the data is recorded. These can be classified as:

- *Conventional wireline*: Tool string is gravity fed to TD and data is recorded in real time as the wireline conductor cable is reeled up.
- *Wired coiled tubing*: Tool is “pushed” down-hole with coiled tubing and data is recorded in real time as the coiled tubing is retrieved.
- *Assisted wireline*: Tool string is equipped with a motorized “tractor” that pulls the tool string to the end of the well. Data is recorded as the tool is extracted from the well in a conventional manner.
- *Wireless conveyance*: Tools are “pushed” via plain coiled tubing or heavy “slick line” and data is recorded in a digital memory format for downloading later when the tool is retrieved back at surface. In this case depth control is managed by recoding the logging signals as a function of time which can then be keyed to a known depth vs. time recording made at surface as the coiled tubing or nonconducting line is recovered.

Figure 2.3 illustrates a motorized tractor that can be added to the lowered production logging string and activated to mechanical crawl along the low side of the casing to pull the tool string to the required depth even in horizontal holes. The spring loaded drive wheels can be activated from surface to open up and engage the pipe walls and then can be turned as drive wheels to propel the logging tool string along the well path.

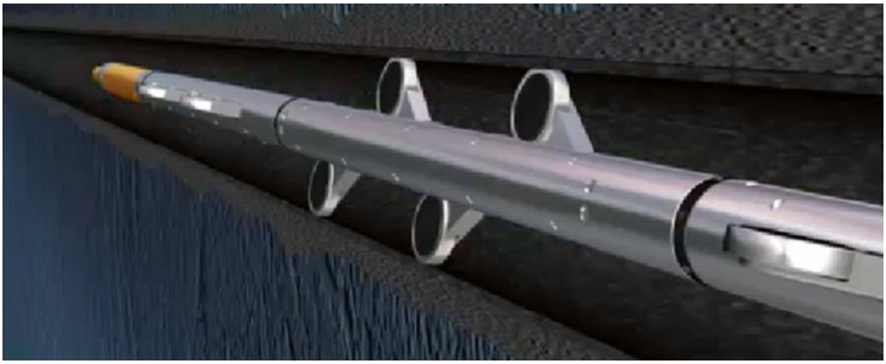

Fig. 2.3 Wireline tractor for production logging in highly deviated pipe. Courtesy Welltec®

Answers to Text Questions

Question #2.1
Cable area = $\pi/4 \times (7/32)^2 = 0.03758$ sq in.
Differential pressure = 4,986 psi.

(a) Upward force = $4{,}986 \times 0.03758 = 187.4$ lb.
(b) Weights required = $(187.4 - 20)/26 = 6.44$.
(c) So use seven weights.
(d) Riser requirements = 16-ft tool + (7×4 ft) = 44 ft.
(e) Rig height = $10 + 44 + 10 + 6 = 70$ ft.

Question #2.2
(a) The well must be shut in before tools can be run in or out of the well.
(b) No effect on ability to log well.
(c) To bleed off pressure in the riser before undoing the quick-connect riser connection.

Question #2.3
500 B/D

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