The Lease Pumper's Handbook

Chapter 4
Understanding the Oil Well

Section C

COMPLETING THE WELL

As noted in the previous section, once the well has been drilled and the casing cemented in, tubing is installed to bring oil and gas up from the reservoir. The tubing connects to the wellhead where a control valve system such as a Christmas tree is installed to permit control over the rate and direction of flow of the products raised from the reservoir. The valve assembly is often referred to as the wellhead. This section provides more details about tubing and wellheads.

C-1. The Final String of Casing.

Some oil wells only have two strings of casing—that is, the surface pipe and the final string that reaches from the surface all the way through the reservoir to the bottom of the hole. This final string is also referred to as the *oil string* or *long string*.

If the well is deep, the upper joints of the final string may be designed to have more tensile strength and the lower joints may be designed for collapse strength. If the lower joints are heavier than any other joint in the long string, a similar joint is placed at the top so that any tool that will go through the first joint will go through them all. This top joint is sometimes referred to as a *gauge joint*.

Cased-hole completion. As the bit drills through the reservoir that contains hydrocarbons, an analysis of the cuttings assists in determining what type of completion will be done. Most oil wells are completed by running the casing all of the way through the reservoir. Enough cement is then pumped down through the inside of the casing and up between the casing and the open rock formation to cement the string in place all the way through the producing zone and to a selected distance above the impervious cap.

Open-hole completion. In some wells, casing is not run through the reservoir. Instead, the well is drilled to immediately above the oil producing reservoir. Casing is then run and cemented into place. After the cement has set, the well is *drilled in.* The drilling in procedure involves drilling through the reservoir and leaving the reservoir open, creating what is referred to as an *open-hole completion.*

C-2. Perforating and Completion.

After the cement has set in the final string of a cased hole completion, the next step is to perforate the casing. In the early days of drilling, a charge of nitroglycerin was set off in the well bottom to create fractures in the reservoir formation.

Later, the bullet perforating gun was used. It fired .50-caliber shells through the walls of the casing, but proved dangerous because accidental discharges before the gun was placed into the well occasionally killed

people. Also, flow paths created by the bullet tended to fill in with crushed rock.

The jet gun now in use can penetrate much deeper as it is required to perforate the wall of the casing, the cement, and many inches into the rock of the formation.

When preparing to perforate, the crew needs to know the bottomhole pressure inside the pipe and the anticipated pressure inside the formation. If the pressure is much greater in the formation than inside the casing, the instant that the perforations are established through the pipe, fluids driven by the bottomhole pressure will rush into the casing and blow the perforating gun up the hole at a tremendous speed, wadding up the electric line ahead of it and creating numerous problems.

C-3. Tubing.

True tubing is seamless, not welded, pipe. This construction increases its strength and reduces the possibility of production loss due to split tubing. Tubing pipe was once produced with 10-pitch V-threads, but most of this has been replaced by improved tubing with 8-pitch round threads, generally referred to as *8 round*. The round threads are rolled into the pipe, not cut by a threading machine. The 8 round tubing is much stronger and easier to make up with less danger of cross threading.

Tubing is classified according to its wall thickness and the quality of the metal used to make it. The tubing must be matched to the installation, including the depth of the well and factors such as high gas pressures. Typically, tubing is designated with a letter and a number. For example, H-40 is an economical tubing used for shallow wells, J-55 may be used for wells to about 7,000 feet, and P-105 is a heavy-duty pipe often used for deep wells. Exotic metallurgies are used in problem wells

Because tubing must reach an exact depth in the well and be installed without being cut and threaded, tubing is available in random lengths from 28-32 feet and in shorter lengths called *pup joints*. Pup joints (Figure 1) are available in even two-foot lengths of 2, 4, 6, 8, 10, or 12 feet and are added at the top of the tubing string for final spacing.

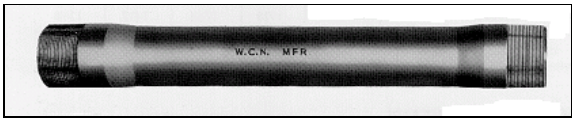

Figure 1. A tubing pup joint.
(courtesy Dover Corporation, Norris Division)

Additional information about tubing is provided in Chapter 17C and included in Appendix D, Pipe, Tubing, and Casing.

C-4. The Tubing String.

The tubing string is run in the well after the casing has been cemented into place and the reservoir has been opened to the well bore. A typical tubing string consists of the following items from the bottom up:

- Mud anchor.
- Perforated subs.
- Seating nipple.
- Pup joint (optional).
- Packer or holddown (optional).
- Safety joint (optional).
- Tubing.
- Pup joints (as needed).
- Tubing hanger or slips and seal.
- Spacer pup joints.

The mud anchor. The mud anchor is basically a joint of tubing at the bottom of the string that is used to:

- Collect fine silt or mud that is removed each time that the tubing string is pulled.
- Provide a protected place to contain the pump gas anchor while the pump is in the hole.
- Allow the tubing string to be set on the well bottom without damaging the string or plugging the intake of the rod pump.

A mud anchor is a full joint of tubing but may be cut off to be no more than 16-24 feet long. Some companies use a tubing cap plug or a collar and bull plug to close off the bottom end. Others cut off the bottom upset section and weld the opening closed with any acceptable method so that it has no external protrusions that may get stuck or collect scale. Still others will slice the bottom four ways then heat and close the bottom by folding the four flaps over with a large steel hammer.

Perforations. A portion of the tubing string in the reservoir must be perforated so that oil and water may enter. The perforations in a string of tubing may be arranged in any of several ways. Some of these options are to:

- Install a perforated pup joint (Figure 2) above the mud anchor by using a collar in between. Perforated pup joints may be as short as 2 feet or up to about 12 feet long. The typical length selected is 3 or 4 feet. The holes are ½ inch in diameter and spaced a few inches apart on all four sides. These small holes prevent large objects from entering the tubing.

Figure 2. A perforated pup joint.
(courtesy Dover Corporation, Norris Division)

- Leave the bottom of the pipe open below the seating nipple or use a short joint. Very few operators use this approach because large objects may enter and cause the pump to stop functioning.
- Perforate the mud anchor with an electric drill or by cutting holes with an oxyacetylene torch. These holes begin no farther than 6 inches below the upset on all four sides and extend 2-4 feet. The holes are 3-6 inches apart.

Seating nipples. The seating nipple provides a connection for the pump while sealing the pump to the tubing. This seal permits fluid to be produced up through the seating nipple and pumped to the surface. Cup- and mechanical-type seats are used. The cup-type requires a seating distance of about 6 inches. Either three or four cups will be placed on the pump. A larger no-go ring of metal above the cups prevents the pump from sliding through the seating nipple.

Cup-type seating nipples are reversible. A reversible seating nipple is 12-16 inches long. When scoring or other damage that may cause the seat to leak occurs, the nipple can be reversed to provide a new seating surface.

The mechanical-type seating nipple is about 8-10 inches long and is not reversible. The seat is usually tapered at the top to accept a metal-to-metal seat. The seat on the pump is made of a metal that gives slightly to ensure that the seating nipple seals.

The packer. Flowing wells may be completed with or without a packer. A packer provides a seal downhole that can block the flow of fluids between the tubing and the wellbore wall or casing. The packer is installed in a tubing string near the bottom and is set just above the casing perforations.

The packer can help the well flow reducing the cross-sectional area of the opening, increasing the flow velocity. If a well does not have high bottom hole pressure, the gas pressure in the *annular space* or *annulus*—that is, the space between the tubing and the casing—will bleed into the tubing perforations as the casing empties of liquid. This casing pressure acts as a flow cushion while liquid accumulates once more in the well. A packer can reduce this erratic change in pressure.

The holddown. A holddown is similar to a packer in that it latches the tubing to the casing near the bottom of the well just above the casing perforations. However, the holddown does not form a seal between the casing and the tubing in the annular space; therefore, fluids may pass by it freely in either direction without restriction.

If the well is deep and is to be completed as a pumping well, the holddown will be installed to prevent *breathing*—that is, the up and down movement of the bottom of the tubing with each stroke of the rods. Breathing is reviewed in detail in Chapter 6.

C-5. Correlating Perforations.

When running the tubing in the hole, one of the most important tasks is setting the perforations in the casing at the most desirable depth from the surface. This will affect the performance of the well, the number of barrels of fluid produced, the amount of gas produced, as well as how much gas is retained in the formation.

There are several options for correlating perforations, and operators must reach their own conclusions as to which is best for a particular well and for reaching their production goals.

C-6. A Typical Wellhead.

As each string of casing is run into the well, an appropriate wellhead section must be installed. Figure 3 shows a wellhead with a Christmas tree mounted on top. This configuration would be satisfactory for a flowing well. Below the Christmas tree, the wellhead consists of two sections: the casing head (labeled A in the drawing) and the intermediate head (labeled B).

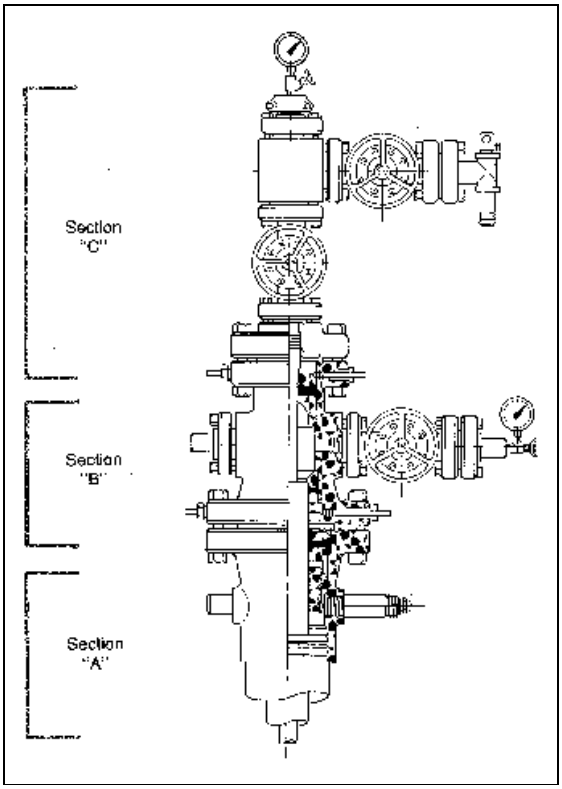

Figure 3. A typical wellhead and Christmas tree.

The casing head (A). The unit illustrated may have external threads, internal threads, or a slip-on collar for welding directly to the casing. The welded installation allows the tubing string to be positioned at a precise level. This is especially important for a pumping unit installation. A plug, a ball valve, or gate valve may be installed on one

side, and a 2-inch bleeder valve is installed on the other side. The valve that is installed on the surface pipe is left open to prevent pressure from developing that might threaten the fresh water zone. Typically, the wellhead will use a gate valve, which is one of the three multiple round opening styles of valves: the gate, needle, and globe. Such a valve is often referred to merely as a *gate*.

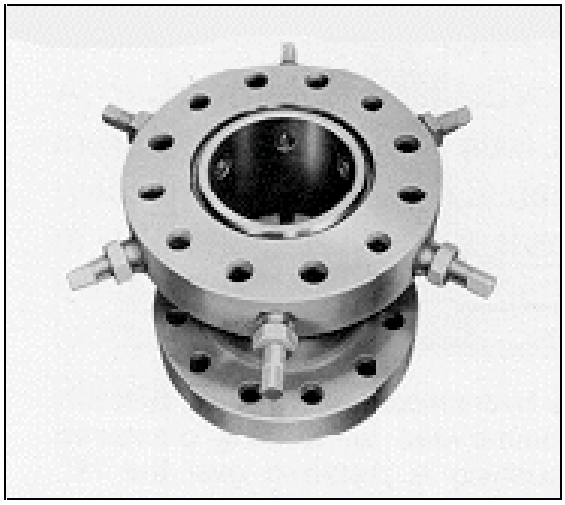

Figure 4. A casing hanger with hanger locking devices shown.

The intermediate head with casing hanger. The final string of casing will usually be suspended from the intermediate head. The casing hanger bolts on top of the casing head generally have a metal seal ring and 12 or more studs with nuts. Some casing hangers, such as the one shown in Figure 4, provide a means of attaching the tubing string to the casing hanger. If the final string is attached to the casing hanger, there will be two openings on the sides with valves screwed into the sides. One will usually be available and the second side will be connected to the flow line going to the tank battery.

The tubing hanger. The final step in running tubing is to install the tubing hanger, popularly called the *donut*. The tubing hanger should be cleaned and covered with a lubricant or thread compound before being lowered into the hole. The *dogs* or locking devices should be run in snugly to hold the top tapered edge firmly down. This allows the safe removal of the Christmas tree with pressure still on the casing.

Figure 5. A tubing hanger.

Additional information about wellheads and their use is presented in later chapters.