Installation & Operation of Free Type Tandem Dual Zone Hydraulic Pumps

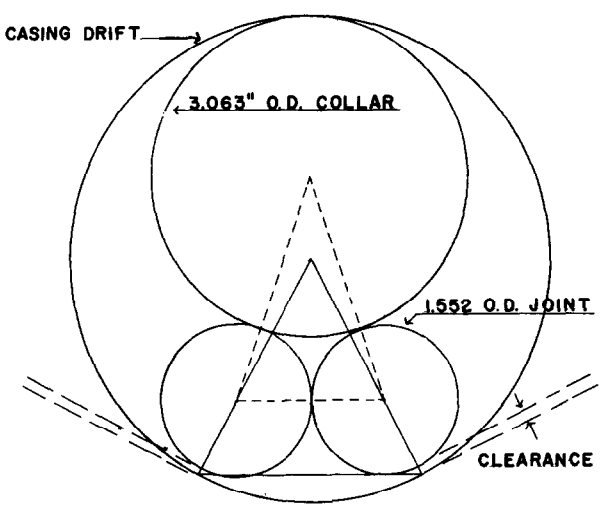
By BOB G. MURPHY
Cities Service Petroleum Company

The production problem of simultaneously depleting dually completed oil wells, which are producing by water drive or strong water influx, creates a need for artificial lift equipment that will produce ever-increasing water volumes to obtain optimum production from both zones. The solution to this problem is a function of well depths, fluid withdrawal rates, application of surface and subsurface equipment, future downhole equipment maintenance, casing sizes, and clearance in the instance of dual or triple tubing strings.

This paper will deal with the problem from a standpoint of free type tandem dual zone hydraulic pumps set at a depth of 8000 ft in 5 1/2 in. casing, using one string of 2 3/8 in. OD EUE tubing and two parallel strings of 1.315 in. OD integral joint tubing with a joint OD of 1.552 in.

By March 1, 1961, Cities Service Petroleum Co. has installed and is operating three dual tandem hydraulic pumping installations in West Texas. This equipment was installed in wells which were produced by natural flow until increased water production forced installation of artificial lift equipment. Experience gained in these installations is being offered as one method of dual hydraulic artificial lift.

FIG. 1



CASING O.D.	WEIGHT-LB./FT.	DRIFT-I.D.	CLEARANCE-INCHES
6-1/2	15.50	4.825	0.104
5-1/2	15.50[a]	4.653	0.018
5-1/2	17.00	4.767	0.075
5-1/2	20.00	4.653	0.018

[a] EXTREME LINE

MURPHY

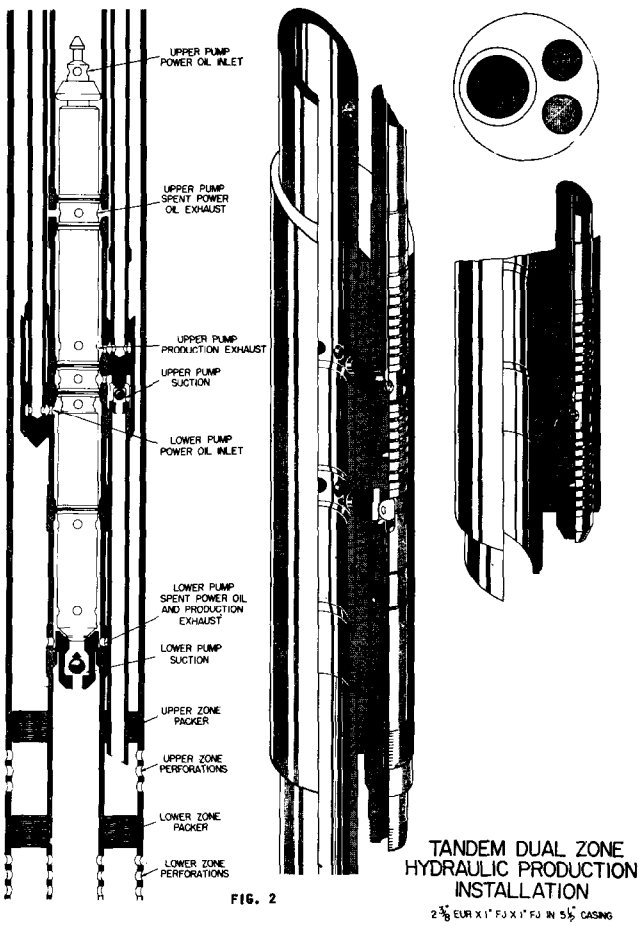


FIG. 2

TANDEM DUAL ZONE HYDRAULIC PRODUCTION INSTALLATION

2⅜ EUR X 1" FJ X 1" FJ IN 5½ CASING

INSTALLING DOWN-HOLE EQUIPMENT

In a three string tubing installation, clearances are of primary consideration, especially in 5 1/2 in. casing. Fig. 1 illustrates these clearances in different weight pipe. However, should some joint other than the integral or flush joint type 1 in. tubing be used, it is suggested the 2 3/8 in. EUE collars be beveled to permit pulling the 1 in. strings.

Well control is assured by the use of a blowout preventer that will contain 2 in. regular and offset rams as well as 1 in. offset and blind rams.

The 2 3/8 in. EUE main tubing string is landed with a locator sub and seal assembly in a permanent type production packer which is set just above the lower zone. A side door type choke is placed in the main tubing string opposite the upper zone perforations for future production stimulation treatments. Also, a full opening snap set packer is placed in the main string and set above the top zone perforations. Coupled above the snap set packer

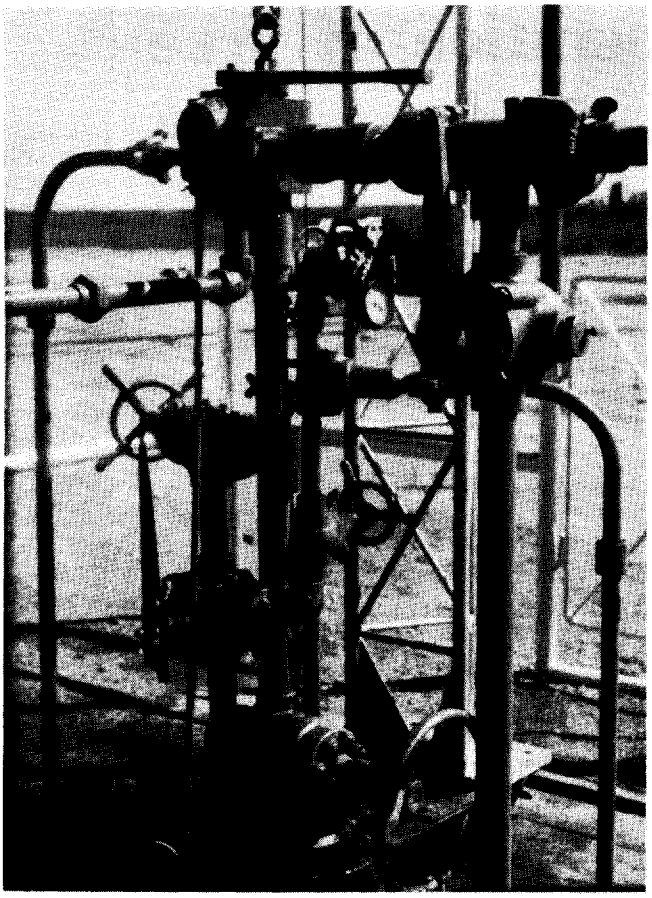


Fig. 3

is the bottom hole pump cavity and shoe as illustrated in Fig. 2. A special made offset triple "donut" type hanger is used to land the 2 3/8 in. main string in the tubing head, while the first parallel string landing spear is made up on the 1.315 in. OD tubing, and the tubing is run through the special offset triple donut and into the well. Then, with a small amount (1500 to 2000 lb) of tubing weight applied, the spear is landed in the pump cavity shoe. The landing spear is furnished with a friction ring which will insure the operator that the spear has been seated in the shoe.

Unseating of the spear requires an upward pull of 1500 to 2000 lb above the tubing weight to release the friction ring. It is to be noted that all weight above the tubing weight used in seating the spear will be required to unseat the spear. Construction of the spear insures positive pressure balance between the seals, and thus eliminates unseating forces on the parallel strings. After the spear is seated, the 1 in. tubing string is landed with a small mandrel in the special triple donut at the wellhead. Then, the second 1 in. parallel tubing string and spear is run and landed in the same manner as was the first 1 in. string; and a special made triple string tree is nippled to the wellhead to complete the well installation (Fig. 3).

OPERATING PRINCIPLE

Fig. 2 illustrates the bottom hole pump cavity and landing shoe with the dual tandem pumps and the 1 in. landing spears in place. It can be seen from the figure that the pump cavity and landing shoe are run on the main 2 3/8 in. tubing string above the snap-set packer and connected, by a short piece of 1 in. tubing, to the parallel side of the packer.

The pumps shown are simply two "free type" hydraulic production units joined together and run "piggy back". Rubber o-rings with teflon back up rings are used as seals throughout the cavity. The pump assembly is equipped with cups to permit the "piggy back" unit to be pumped into and out of the 2 3/8 in. tubing string. Further, to retain the pumps when they are pumped out of the well, a catcher is located in the four way valve at the surface.

When the tandem pumps are seated in the cavity, the top pump is stroked by power oil down the 2 3/8 in. tubing string. This power oil is exhausted to the casing. The production end of the top pump takes suction from the upper zone through the upper packer and the 1 in. tubing between the upper packer and crossover. In the 1 in. tubing a standing valve prevents flooding of the top zone while the pumps are being pumped out of the cavity. The upper zone production is then exhausted from the pump to a 1 in. tubing string and pumped to the surface.

The lower pump is stroked by power oil which is pumped down the other 1 in. tubing string and exhausted to the casing. The lower pump end takes suction through a wireline retrievable standing valve in the 2 3/8 in. tubing string from the bottom zone and exhausts this production to the casing. Thus, it can be seen that the lower zone is the source of the common power oil while the upper zone production remains isolated. It is also obvious that this system provides a need for only one surface power oil system to operate both zones. The lower zone was chosen for the power oil because it is cleaner and relatively free of paraffin. The top 2500 ft of the 1 in. upper zone production tubing was plastic coated to combat paraffin from that zone.

FREE TYPE PUMP

The fluid level and the withdrawal rate determined the pump design, and the tandem pumps were of the "free type" and of the proper size to run in 2 3/8 in. OD API EUE tubing. Pumps chosen for these installations were balanced design, with one to one ratio and were capable of producing 268 BPD at 100 per cent efficiency.

It is pointed out again that these installations are in 5 1/2 in. casing with a permanent type production packer set above the lower zone.

The pump cavities are set about 8000 ft below the surface, and both zones originally flowed in these wells, but now must be lifted because of produced water. Although the tandem pumps are secured together, each pump is operated independently; thus, one zone may be shut in while the other is produced. Should one zone be capable of flowing while it is necessary to pump the other, a dummy pump may be run respective to the flowing zone and may allow that zone to flow. As an example, should the lower zone have the necessary bottom hole pressure to flow, a dummy pump could be run on bottom and with communication between the engine and pump end. This arrangement would convert the former 1 in. zone power oil string to a 1 in. lower zone production string. And this 1 in. tubing string could be circulated with clean power oil and swabbed in if it were necessary to kick off the lower zone.

SPECIAL EQUIPMENT

The downhole pump cavity and shoe which is the first of this exact design to be installed in 5 1/2 in. casing required a triple tree that would house one string of 2 3/8 in. OD EUE API tubing and two strings of 1 in. integral joint tubing. The first problem was to design a

donut that would fit a 6 in. tubing hanger housing and hold all three strings. This problem was solved by building a donut with a threaded 2 3/8 in. EUE offset opening top and bottom and two 1 in. recessed offset openings. The offset donut is made up on the 2 3/8 in. string and landed. The 1 in. strings are run through the 1 in. recessed offset openings and landed with small mandrels in the large "donut" and sealed with o-rings. A triple 6 in. flange with one 2 in. seal sub and two 1 in. seal subs was bolted to the hanger flange. On top of this flange a 2 3/8 in. threaded EUE double recessed body valve was used to control the main string and two 1 in. EUE recessed body valves were used to control the 1 in. strings. (Fig. 3).

SURFACE EQUIPMENT

The surface equipment employed is similar to that of most hydraulic installations and is composed of a power oil tank, a triplex pump, a prime mover, and the necessary header parts and valves to make the system complete and effective. Since two pumps are being operated at different pressures from a single header, pressure compensated valves or constant flow controllers were used to prevent the pump which operated at the lower pressure from taking more power oil than it needed to operate at the desired speed.

It is found as with most hydraulic pumps the higher the water percentage of total fluid pumped the higher the pump efficiency when pumping from under a packer. On the other hand, the more gas in solution the lower the pump efficiency. Thus, since both pumps can be pumped into and out of the hole with the equipment at hand provides a definite monetary saving in maintenance work. An additional advantage is that both pumps operate independently on a common power oil system; that is, overproduction of one zone will not force an underproduced zone to be shut down prematurely. The flexibility of this equipment will permit a dual well to be simultaneously produced by natural flow and artificial lift and without a major equipment change. The surface equipment was so designed to facilitate larger volume casing type single hydraulic pumps when the produced water volumes reach proportions that exceed the present tandem pump design.

Table 1 is a summary of the type of pumps, setting depths, and production tests on these installations.

CONCLUSION

Dually completed oil wells producing from water drive reservoirs require large volumes of produced water to be lifted to deplete the reservoirs. The production problem of simultaneously depleting both zones is further complicated.

This paper has dealt with one method of artificially lifting dually completed wells. That two zones can be depleted or partially depleted simultaneously is an economic advantage compared to the system in which one zone is abandoned and the other zone depleted and vice versa; and again is proved the old adage, "that the present worth of a barrel of oil in the stock tank is worth two in the reservoir."

TABLE I

	Lower Zone Pump 1-7/8"x1.3x1.3 Free Type				Upper Zone Pump 1-7/8"x1.3x1.3 Free Type			
Well	Depth	Oil	Water	Efficiency	Depth	Oil	Water	Efficiency
A	8290	123	0	57%	8275	91	151	86%
A	8290	83	19	51%	8275	58	204	98%
A	8290	70	4	42%*	8275	46	75	69%
B	-	-	-	- **	-	-	-	-
C	-	-	-	-	-	-	-	-

*Pumps operating at 60% of rated speed.
**Installations to new for tests.