Producing Dually Completed Wells With Sucker Rods

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Progress has been made in the field of sucker-rod pumping of dual-completed wells. The evolution, resulting from field problems, in equipment and methods to pump dual wells with sucker rods will be the scope of this paper.

The desirability of one oil well's producing oil out of two separate horizons which cannot be commingled is obvious. An abundance of publications have enumerated the rather spectacular savings achieved by the relatively small expenditure of buying and installing dual-zone production equipment as opposed to drilling a separate well. However, once a producer has made the decision to sucker-rod-pump a dual well, he must then select the method that will be the most economical and that will best serve his operating needs. We shall describe the application, advantages, and limitations of the various methods that are considered standard installations, that he has to choose from as well as some of the possible variations in the standard hook-ups.

The first, and probably the simplest method to understand, is the method of setting two pumping units and of running two strings of tubing and sucker rods and two down-well pumps. In this installation, the long string produces the lower zone from beneath a packer, while the short string produces the upper zone from above the packer.

The prime advantage of this system is the complete control of the production rate from each zone, since either unit may be speeded up, slowed down, or shut down at will. A second advantage is that gas may be separated from the upper zone and removed at the casing head. A third advantage is that the upper zone may be treated down the casing.

The disadvantage of the two-pumping-unit method is high initial installation cost. There are well service problems associated with pulling or running either string, because of the proximity of the two stuffing boxes at the well head. The lower zone gas must be produced through the pump, unless a third vent string of tubing is installed or hollow sucker rods are used in the long string.

The danger of the two pumping units' entangling, if either pump should sand up or pound fluid throwing slack in the bridle, is reduced by different field practices. Some producers, who have favored this method of sucker-rod-pumping dual wells, install a piece of steel plate between the carrier bars of the horseheads as a shield between the two polished rods. Other producers mount one of the units on a substructure, so that at the bottom of the stroke on the high unit and at the top of the stroke of the low unit the carrier bars, supporting the polished rods, do not pass. One pumping unit manufacturer has designed a stabilizer for the carrier bar which prevents the bridle from twisting should there be any slack.

If two strings of 2 3/8-in. OD API tubing are used, at least 7-in. OD casing is required, and the tubing couplings on one string must be turned down and beveled liberally at the ends to facilitate running the strings one at a time.

Two strings of 1 1/2-in. ID tubing may be run in 5 1/2-in. OD casing for the two-pumping-unit method of dual pumping. The sucker rod strings are limited to 5/8-in. rods with the rod boxes turned down to 1 3/8-in. OD. Insert pumps are available for this small tubing up to and including 1 1/4-in. bore. A 1 1/2-in. bore-tubing pump may be used at moderate depths, but it will necessitate pulling both strings of rods and tubing to check the lower pump.

Also some 2 1/16-in. OD tubing with flush joints has been used in 5 1/2-in. OD casing for the two-pumping-unit method.

The second method, and in most cases the most economical of all methods from the standpoint of original equipment cost, is the two-packer method. In a two-packer installation, the lower packer separates the perforated intervals of the lower and the upper zones. The upper packer is set above the upper-zone perforations, permitting the annulus between the tubing and the casing to be used to conduct the fluid pumped from the lower zone to the surface.

As illustrated schematically in Fig. 1, the upper zone fluid is taken into the pump suction at the crossover shoe and is discharged up the tubing string. A packoff and seal below the upper pump separates the fluids of the two zones, while the polished rod stroking through the packoff actuates the lower rod string and the lower pump.

The upper and the lower pumps may be located any distance from a few feet apart (in some installations the polished rod of the upper pump serves as the pull rod of the lower pump) to several thousands feet apart. Initially, the spacing between the pumps must be accurately established so that both pumps may be seated. With competent supervision, this problem is relatively simple. But an indispensable requirement is a variety of pony rods and box and pin subs to provide the exact spacing required within a relatively few inches.

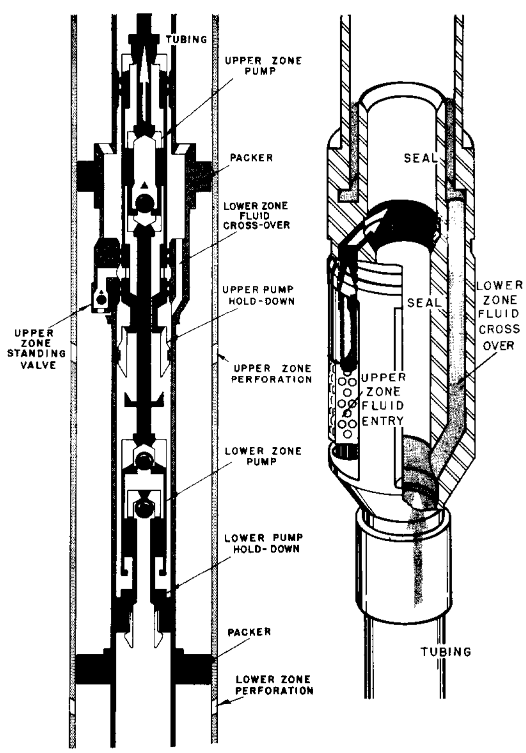

Fig. 1 - Single-tubing, Double-packer Dual-zone-pump Installation

All manufacturers of dual-zone (or two-zone) pumps now offer complete insert pump assemblies that may be repaired or replaced without pulling the tubing. Manufacturers differ in their approach to the rather knotty problem of the standing valve for the upper pump. Since the polished rod strokes through the space normally occupied by the standing valve, something other than standard practice must be used.

One manufacturer builds this standing valve in the form of a ring which controls fluid flow through an annular fluid passage surrounding the polished rod. Another runs an ingeniously arranged "traveling standing valve" which uses API balls and seats and controls fluid flow through a hollow polished rod. A third manufacturer utilizes standard API cages recessed into the crossover shoe. Since it would require a tubing job to pull and replace one of these valves, this manufacturer offers a compound-type upper pump, the upper valve of which takes over as a traveling standing valve if one of the valves in the shoe should fail.

Thus all manufacturers of the two-packer style of dual-zone pump now have all parts normally subject to periodic replacement arranged so that repairs can be made with a relatively simple rod job.

As mentioned earlier, the principal advantages of the two-packer installation are the fact that initial investment is low and the fact that no special tools and surface procedures are required in running the single tubing and the rod string. The biggest disadvantage is the lack of flexibility. No gas can be separated from either zone, and there is no possibility of treating either zone with hot oil, paraffin, solvent, or corrosion inhibitor.

One of the first deviations from the standard two-packer method was the elimination of the top packer. This was done by running a parallel string of tubing to the surface to conduct the lower-zone production to the wellhead and thus to leave the casing annulus free for the separation of gas and for any required treatment of the upper-zone production. This deviation can be accomplished with only minor modification of existing two-packer dual-zone tools -- usually by merely adding a parallel-string takeoff collar (Fig. 2).

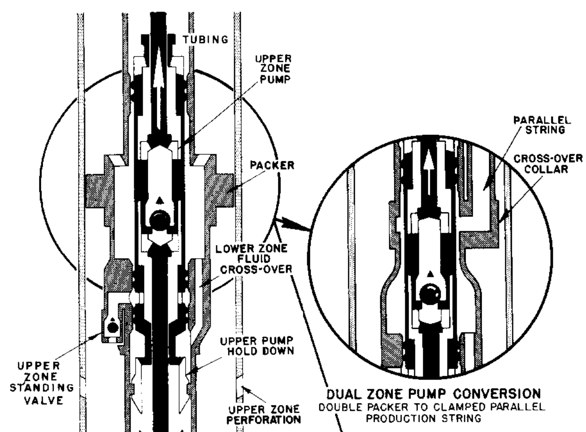

Fig. 2 - Dual-zone-pump Conversion, Double-packer to Separately Landed Parallel-production String.

The first takeoff collars were manufactured with screwed outlet connections which required that parallel string be run in with and clamped on to the main tubing string. The later design of these takeoff collars makes it possible to run the parallel string of tubing separately, eliminating the necessity for clamps and speeding up rig time. The fact should be noted that these take-off collars are used to modify existing two-packer installations, which will allow the operator to continue using his original equipment but as a single-packer installation. If he is equipping a new well, he should purchase one of the single-packer-model tools, which we shall discuss later.

Two other deviations from the two-packer method are also in use. In one, hollow sucker rods conduct the upper-zone production to the surface, while the lower-zone production is produced up the tubing. In the other, a "double crossover" arrangement permits the lower-zone fluid to be produced up the tubing while the upper zone is diverted out to the parallel string. This latter method is useful mainly where bad paraffin deposition from the lower zone makes it desirable to conduct it up the tubing where scraper-equipped rods, along with external hot-oil treatments, can be used.

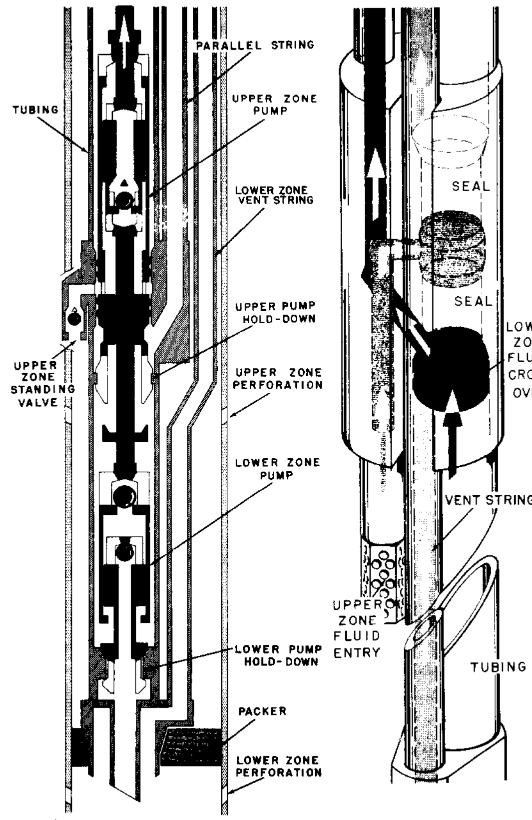

Fig. 3 - Single-packer Vented Dual-zone-pump Installation

The latest developments in rod-actuated dual-zone pumps are tools designed exclusively for use in single-packer installations. These are the most versatile installations of all because (1) one or both zones may be vented, (2) one or both zones may be treated, (3) production from one or both zones may be controlled, (4) one or both zones may be permitted to flow and may later be put to pumping without pulling the tubing, (5) tubing strings may be run in and pulled separately, and (6) equipment is simple, compact, and relatively low in cost.

The trouble-free operation of these new single-packer dual-zone tools is responsible for this type of installations becoming the most popular one during 1956.

The single-packer models are actually outgrowths of the parallel-string deviations from the two-packer model. But because they are designed specifically for single-packer use, they contain some unique features.

The first single-packer model was one designed for 5 1/2-in. OD casing to permit venting the gas from both zones. A single-production packer, constructed in such a way as to have an outlet for the lower-zone gas directly under the packer, is used. These packers are available in both hookwall and permanent-retainer type.

As illustrated in Fig. 3, the gas which would tend to collect beneath the packer can escape into the vent line, directly under the packer, while the production inlet may be extended well below the gas escape ports providing gravity separation.

In the case of the hookwall packer, the gas enters into an annulus provided between the packing element and the packer mandrel. From this annulus the gas enters the vent line connection and goes up through the vent line to the surface. Since the packer mandrel is full opening the lower pump may be installed well below the packer, or the perforations for the lower zone production inlet may be as low as the distance between the two zones will allow. The distance between the lower zone fluid inlet and the packer will provide gravity separation.

If a single retainer-type production packer is used, the gas which would tend to collect beneath the packer can escape through perforations into the annulus around the production tube, in the seal nipples, and up the vent line to the surface. The production tube is packed off under the gas perforations, allowing the production inlet to be extended below the packer as far as desired, thus providing an opportunity for gravity separation of the gas and the oil, with an escape for the gas.

The lower-zone production enters through the perforations in the flow tube below the packer, passes upward in the production tube through the seal nipples, and then enters the lower pump. The lower-pump seating shoe may be directly above the locator sub on the seal nipples.

In either of these installations, having passed through the lower pump, the lower-zone production continues up the 2 3/8-in. tubing to the tubing assembly, where it is transferred to a parallel string of 1-in. pipe and is produced through it at the surface.

The upper-zone production enters the upper pump directly through the standing valve on the tubing assembly and then continues up the 2 3/8-in. EUE tubing to the surface. The tubing assembly may be located below the upper-zone perforations in the casing, thus giving gravity separation for the upper-zone gas. The upper-zone gas is vented at the wellhead through the casing.

In most installations of this design for venting both zones in 5 1/2-in. OD casing, the tubing strings have been 2-in. EUE, 1-in. NU, and 3/4-in. EUE or NU. Each of the macaroni strings is clamped to the 2-in. and the paths of the fluid flow are as follows:

Phase	Path
Lower-zone oil	1-in. macaroni (crossedover just below the upper pump)
Lower-zone gas	3/4-in. macaroni
Upper-zone oil	2-in. tubing
Upper-zone gas	Tubing-casing annulus

The first installation of this type was made in early March, 1956, and at the time this paper was prepared, it had given continuous, maintenance-free-efficient operation. (Reference Oil & Gas Journal, July 23, 1956).

The biggest disadvantage of this design is the time consumed in running the three strings together. It takes an average of from 8 to 10 minutes per joint of 2-in. However, the producer has complete control over both zones as though they were single wells with all the advantages mentioned earlier for single-packer installations, except that the strings are clamped.

The tool gaining the greatest popularity during 1956 was one which permitted the macaroni string for the lower zone production to be run in separately, omitting the clamps. (Fig. 4).

In this installation, the lower zone pump seating shoe, the

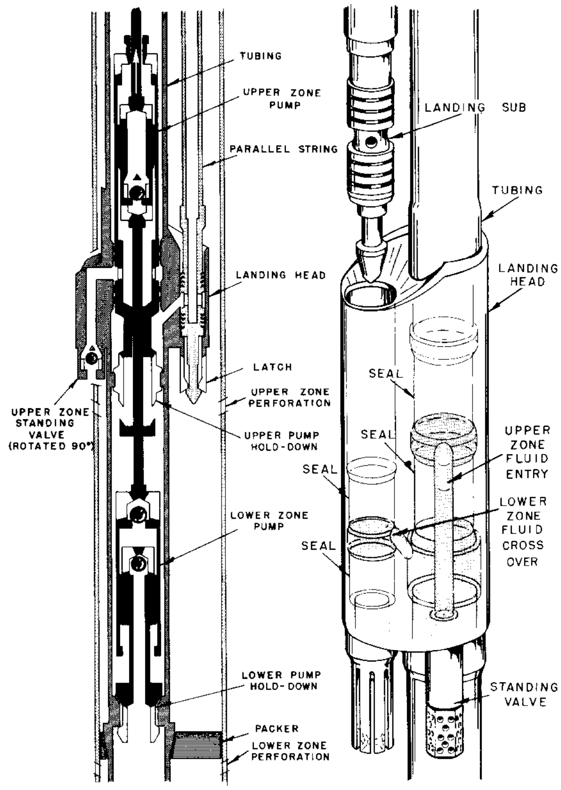

Fig. 4 - Single-packer Dual-zone-pump Installation, Parallel String Separately Landed.

packer, and the dual-zone tubing assembly, which incorporates the upper pump seating shoe, is run in on the tubing string. After the setting of the packer and the landing of the tubing, the parallel macaroni string is run in and is seated in the landing receptacle built integrally with the crossover shoe.

The integral landing receptacle is constructed in such a way as to nullify any unseating force of the macaroni string by pressure-balanced seals. This feature eliminates the necessity of having to use a latching device on the parallel string and requires only a vertical pull to unseat and pull this string of tubing. To facilitate running the tubing strings separately, the collars must be liberally beveled on one or the other tubing strings.

As previously described, the lower-zone production enters through the perforations, below the packer, and, having passed through the lower pump, continues up the tubing to the tubing assembly, where it is transferred to the parallel string and is produced through the macaroni string at the surface.

The upper-zone production enters the upper pump directly through the standing valves on the tubing assembly, goes through the upper pump, and continues up the tubing to the surface. The tubing assembly may be located below the upper perforations in the casing, thus giving gravity separation for the upper-zone gas, which is vented at the casing.

The above described equipment was primarily designed for 5 1/2-in. OD casing; however it may be adapted for 7-in. OD casing, which provides a greater variety of tubing strings that may be used.

The next to become available in equipment for sucker-rod-pumping of dual-completed wells were tools exclusively for use in 7-in. OD or larger casing. To date, two different tubing assemblies have been designed and manufactured. The first of these tools is a larger version of the single-packer model - - independently run parallel-string design described earlier. It is for 2 1/2-in. tubing and includes the landing receptacle built integrally with the crossover shoe for the pressure-balanced seal assembly run in on the paral-

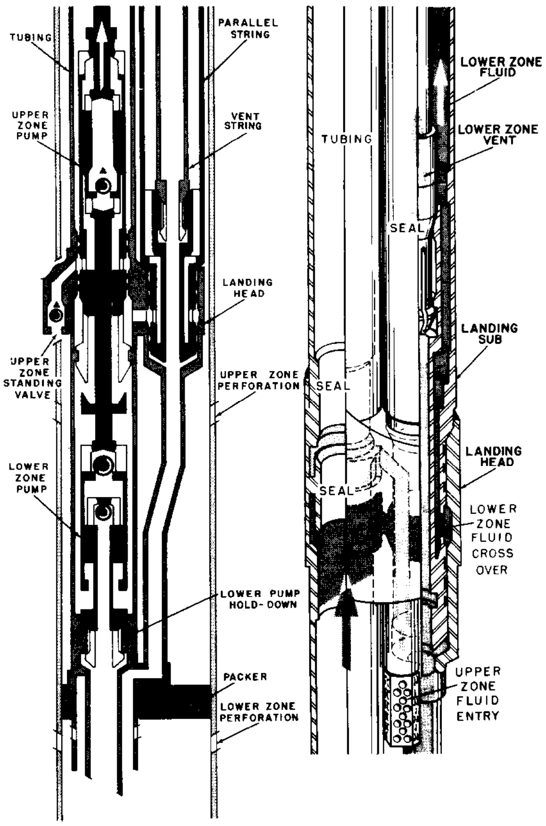

Fig. 5 - Single-packer, Vented Dual-zone-pumping Installation, Three Strings Separately Landed

lel string. However, the ID of the crossover shoe is 2 1/4-in. plus 0.040 in.; thus a 2-in.-bore insert pump may be installed to produce the lower zone. The fluid paths are the same as previously discussed, with the lower-zone being produced through the parallel string and the upper-zone being produced through the 2 1/2-in. tubing.

The second, and believed to be the ultimate in dual-zone pumping, is a tubing assembly designed for two strings of 2-in. EUE tubing* (as used in the two-pumping-unit method). The long string of 2-in. containing the seating shoe for the lower pump, the packer, and the dual-zone tubing assembly for 7-in. casing is installed. The short string of 2-in. tubing is then run in and is seated in the integral landing head of the crossover shoe. Then a third string of macaroni tubing is run into the short string of 2-in. This macaroni string is landed in a shoe in the 2-in. short string just above the crossover shoe. The macaroni string is connected to vent gas from the lower zone, the annulus between the macaroni and the 2-in. conducts the fluid from the lower-zone, the long string of 2-in. conducts the fluid from the upper zone, and the casing conducts the gas from the upper-zone. (Fig. 5)

This installation provides a means of venting the gas from both zones, as we described for the 5 1/2-in. tool, but all of the strings are independently run, eliminating the need for clamps. This installation provides the producer with every control and advantage in a dual producer that he has in a single well.

It was recognized that pumping dual wells, as well as pumping single wells, could not be accomplished with only one basic design tool. Well conditions, leading to failures or unsatisfactory field performance of early designs, has brought about the development of equipment to overcome these failures. Tubing and rod assemblies are now available to the producer for the wide variation of reservoir characteristics and well conditions.

*2 7/8-in. C.S. Hydril and 2 3/8-in. C. S. Hydril may be used.