Panel Discussion

Operation And Control Of Water Injection Projects

Moderator, MARSHALL W. KEATHLEY
Forest Oil Corp.

Preparation Of Wells

By WILLIAM E. FICKERT
Ryder Scott Company

Soon after a reservoir study has been finished and the decision is made to undertake a waterflood or pressure maintenance program, plans must be made to prepare certain wells for injection service. Some thought must also be given to the preparation of wells which are to remain as producers in the project. Whereas preparation of injection wells deals largely with the control of the injected water for efficient injectivity, producing well preparation concerns the size of equipment necessary to lift the produced fluids to the surface.

In many projects additional wells are required to serve as injectors or producers either to complete the desired pattern arrangement or to attain a better sweep efficiency. Some operators prefer to reduce pattern size by infill drilling and to use the new wells for injection service. However, because of the lower development cost, alternate producing wells are normally converted to injection service. The use of converted wells involves the necessity of controlling the injected water in wells which were completed with little or no regard for the needs of secondary recovery methods.

Since oil was first found in West Texas some 30 yr ago, well completion techniques have varied tremendously. In the early days no thought was given to secondary recovery. Even with the advanced completion practices of today and the knowledge that additional oil can be recovered by injecting water, very little thought is given to the needs of secondary recovery methods when the well is completed for primary operations. Thus water injection projects of today and those in the future will involve the use of wells which were completed for another purpose. Considerable thought and planning are necessary when preparing wells for secondary recovery operations to achieve the desired results with a minimum of expense.

The whole gamut of past completion methods must be dealt with in 1 project or another. For example, early cable tool drilled wells seldom penetrated the entire pay section; for secondary operation this type of well must be deepened. Also, wells drilled with cable tools or rotary tools which were shot with explosives at completion generally have the pipe set and cemented 30 to 60 ft above the pay. This type of completion often exposes a barren section of shale or sandy shale. In an injection well this type zone may break down under continued injection pressure, begin taking water, and thus act as a thief zone. Depleted gas zones, water bearing intervals or barren porous and permeable strata can also constitute water thief zones which, as the name implies, will either absorb trementdous quantities of water and have no effect on producing rates or will channel water to producing wells without stimulating oil producing rates. Many wells will be encountered which are producing from carbonate reservoirs with pay zones scattered throughout large gross sections where barren zones are possibly exposed. In wells which have pipe set through, thief zones also could be exposed because of the practice of using an excess of perforations which has many times allowed communication to occur behind the casing during stimulation treatments.

From the problems presented it can be seen that the injection of water into the proper zones is often a difficult task. In the early stages of planning, a detailed study of well records and completion methods will often indicate the problems to be encountered. A discussion of injection problems with operators of other projects in the same reservoir will be most helpful in preparing wells for injection service. In any event, once injection has taken place and injection rates have levelled off, injection profiles should be determined. If determined in time, many problems can be solved before extensive damage is done or before a large volume of water is lost. Several good injection survey methods are available. Since the validity of the injection survey often depends upon the type of completion and upon the injection rates and pressures being used, all available survey methods should be investigated to determine which will give the most useful results. With proper planning, the correct size and length of down hole equipment -- such as tubing, type of protective coating, packer and length of tailpipe -- can be tailored to the survey method selected. In this way some of the survey expense can be eliminated. Caliper surveys to determine hole size are very often useful in interpreting surveys in open hole zones; this survey can be taken while the well is being prepared for injection service to eliminate pulling costs once the well is on injection.

Once a thief zone is found, several corrective measures are available to eliminate the problem depending upon the type of completion and where this zone is located in relation to the producing interval. In open holes, a liner can be set and cemented through a thief zone if the undesirable zone is above the productive one or else a liner can be set and cemented through the entire open-hole section. The latter method requires perforating the productive zone, but this method is useful to combat thief zones immediately above or below the productive zone. Other remedial measures might include plugging back to just below the productive zone or squeeze cementing and reperforating. On the other hand, if a dense zone of near true hole size exists between the thief zone and the productive zone, setting a formation packer on tubing may be the necessary solution. As can be seen, the use of these remedial measures depends upon the particular problem and the type of completion involved which may vary from well to well in the same project. Since water flow-back interferes with most remedial work where cementing is involved, established thief zones should be determined early in the life of a project and dealt with during well conversion.

In order to deliver the water from the surface down to the zone to be flooded, water injection often takes place down tubing set on a packer. This protects the casing which is usually in questionable condition due to corrosion which has taken place both inside and outside the casing. For further protection against corrosion the packer can be plastic coated and the tubing can be lined with either cement or plastic, depending upon the corrosive nature of the water to be used. Very often the annulus between the tubing and casing is filled with treated water to protect against corrosion. As mentioned previously, the needs of the various injection surveys should be considered during this stage of preparation.

The above ground equipment necessary for proper injection well operation include a well head, pressure gauge, choke valve, meter, check valve and gate valve. The well head should be of sufficient size to accept survey tools and be in a condition that will allow the well to be closed in when necessary. Injection pressures and rates can be determined with the pressure gauge and meter while the choke valve is available to control injection rates. Placement of the above ground equipment in the order listed with use of union fittings will allow the isolation and easy removal of the meter when repair is required. Some operators prefer to centralize metering and valve equipment; however, in West Texas where there is considerable distance between wells, best results are achieved when each well is equipped as stated. This assures that the field man is in a position to inspect the well site when reading the meter. A very important but often overlooked feature in designing waterflood facilities is the winter proofing necessary to prevent freezing. The above ground equipment can be located for easy insulating during winter weather.

In projects where new wells are drilled specifically for injection service the down-hole and aboveground equipment should be similar to that described previously Experience in the area or the operator's preference will usually determine whether the new wells are to be completed open hole or set-through and perforated. Use of the cased hole allows for control of the injected water with selective perforating and treatment while the open hole method eliminates well-bore damage caused by the cement.

The discussion so far has dealt only with the injection well side of the story. This was not accidental since in too many cases the preparation of injection wells is haphazard at best. At the producing well all oil zones to be flooded must be open to the well bore. With open hole completions, wells may need deepening; in cased holes, additional perforating may be required. The use of acidizing or frac treatments is often necessary to eliminate restrictions near the well bore. Proper sizing of lifting equipment is essential. The use of large tubing and down hole pumps with corresponding sized pump jacks will help insure that all fluid produced into the well bore is lifted to the surface. Keeping the well pumped off, below the producing interval if possible, eliminates back pressure and well bore damange if the well produces water. If there is a question concerning sufficient lifting capacity, fluid levels can be determined with sonolog measurements. As can be seen, slim hole type completions will severely limit equipment size and produced volumes and are not recommended where secondary recovery methods are to be employed.

Most reservoirs being produced today will more than likely be considered for a secondary recovery method in the future. The success of these projects will depend upon the thought and planning which go into the preparation of each well for the job it is expected to perform.