

ENHANCED OIL RECOVERY GAS INJECTANTS

Before 1970, natural gas was the primary injectant used to maintain pressure in low gas to oil ratio reservoirs. By re-injecting natural gas into the reservoir, the oil producer was able to either increase or maintain current oil production rates. Afterwards, natural gas became unavailable in some areas as well as too expensive to be used for re-injection. However, natural gas is still being used when there is no economical way to recover it commercially.

Carbon dioxide (CO₂) is used in miscible (capable of being mixed with oil) flooding where its low miscibility pressure lowers the viscosity of the heavy oil and causes the oil to swell, leading to increased oil recovery. CO₂ is primarily used in the US because of the availability of large natural reserves and tax subsidies dating back to the early 1970's. The CO₂ is usually collected from natural gas reservoirs that have a high CO₂ content and then transported by pipelines to the injection wells. When CO₂ reserves are available locally, the production costs for CO₂ are relatively low. Unfortunately, large natural occurring reserves of CO₂ are far and few between.

Even though CO₂ is dry, it will pick up moisture in the reservoir and increase the possibility of corrosion in the oil production equipment. In addition, as the CO₂ breaks through in the oil and then appears in the associated gas, it will increase the volume of produced gas that must be treated to remove the CO₂ prior to sales.

Nitrogen has been used successfully for more than 20 years in pressure maintenance and has now gained prominence over the last decade as the injectant of choice for enhanced oil and gas recovery. Applications include using nitrogen as a driving force for costly and limited carbon dioxide, and in some cases for miscible displacement. The displacement of gas cap gas, the production of attic reservoirs, the cycling of condensate reservoirs, reservoir pressure maintenance, "huff and puff" cyclic process, dilution of high BTU natural gas, and many other applications that are currently under consideration. Nitrogen can be produced at almost any reservoir site using proven non-cryogenic technology and various energy sources. This proven technology, integrated with gas turbine drive compression equipment has resulted in a highly efficient nitrogen generation system. This system uses proven technology and equipment for the lowest possible gas injection cost. In addition, nitrogen provides a higher reservoir displacement volume per standard volume of nitrogen than any other gas injectant; that is, it provides the lowest volume requirement for pressure maintenance.

The injected nitrogen will not react with the reservoir fluids or compressor lube oils to produce undesirable by-products and precipitates. Moreover, the formation of anaerobic material in the formation is minimized, thereby reducing the need for biocide inhibitors.

Nitrogen is also non-corrosive. Therefore, no special metallurgy is required for the injection equipment, no corrosion inhibitors are needed to protect the existing equipment, and no materials must be replaced on the existing production equipment. It is environmentally compatible and does not contribute to the greenhouse gas effect when injected and released to the atmosphere. It is also readily available from air, and a nitrogen generator can be located almost anywhere. Non-

cryogenic air separation via Membrane or Pressure Swing Adsorption (PSA) has been a proven technology now for more than 40 years.

Because of the inert and non-corrosive nature of nitrogen, on-stream availability for these plants range from 98 to 99 percent including down time resulting from performing scheduled preventative maintenance. This makes nitrogen a very reliable source as a pressure maintenance injection gas. The use of nitrogen as an injection gas instead of associated natural gas frees additional gas for sale. For some reservoirs, water injection may be required for reservoir-mobility control. A single distribution injection system for both nitrogen and water can be used because the gaseous nitrogen is bone dry (-60° F dew point or better) when it is produced and will remain inert if water is reintroduced.

Eventually, nitrogen will break through into the produced associated gas. A nitrogen rejection unit (NRU) will then be needed to ensure the product gas is marketable. This breakthrough generally occurs later than if CO₂ had been used. Based on available nitrogen rejection studies, these facilities add approximately 50 to 60 cents/Mcf to the cost of using nitrogen. Even with the added cost for future nitrogen rejection facilities, the nitrogen injection option is still less expensive than injection of any other kind of gas.