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Treating Oil, Gas, and Water - More on GOSPs

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Topic: Supply/Production
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This is another in my series of Sunday tech talks. At the end of the last tech talk, I was commenting on the amount of water that usually comes out of the ground whenever we extract fossil fuels. Once it gets to the surface the questions become two-fold:

(1) How do we separate the different components of the fluid, so we can separate out what we would like to have (the fuel/fuels)?

(2) What do we with the parts of the mix we don't want?

The simple answer (as in easy to write) to the separation of the different components of the fluid is the Gas Oil Separation Plant. However, as you can imagine, if you are tasked with separating, for the sake of example, the liquids and hydrogen sulphide from a gas flow of 1.5 billion cf/day, which is coming from some 87 wells that concurrently produce some 300,000 bd of Arabian Light crude, the actual design of such a plant is anything but trivial. Even the sulfur that is drawn off, at some 90 tons/day, needs to be provided for in the design of the plant.

First, as the gas is produced from the wells, it must be collected into a common feed line, through a connector, called a manifold, that takes in the various smaller pipes from the individual wells, and feeds the result out in a larger pipe to the GOSP. Because the pressure that the fluid retains is useful as part of the separation process, we don’t want to lose any more of it than we have to in overcoming the friction in the pipes that it is passing through. (I have a couple of horror stories from my past about occasions when folk who should have known better used pipes that were too small, and ended up reducing both the flow rate and available pressure at the delivery end of the line). The pipes that carry the flow must, therefore, be large enough to carry the flows, through many miles of pipe to the GOSP. Thus we find, at Haradh, that the initial flows were collected into three different manifolds, and that they in turn carried the mix to the GOSP through five pipes which are, depending on flow, either 20 or 30-inches in diameter. (Different pipes are needed to continue to separate the sour (hydrogen sulphide containing) gases from the sweet before it gets to the GOSP.)

To construct the plant required at Haradh:

> The main plant is made up of 100,000m^3 of concrete, 22,000t of structural steel, 410,000 welded joints, 4,000km of cabling, 540km of plant piping, 1,400 items of engineered equipment and 750km of line piping, ranging from 18in to 56in in diameter.

The construction was also expensive of manpower:

> For the construction of the facilities, the companies used 32,000m² of office and workshop space, a residence camp for 1,000 men and supporting facilities and a Boeing 737-qualified airstrip, 8,000ft in length with day and night operations. Support systems included 2,500 telephone exchange lines and video conferencing, data networks for 470 users, ground-to-air radio, 306km of fibre-optics and five communications towers.

It cost $2 billion and at peak construction had some 10,600 men working. It took 3 years to build (coming on stream in January 2004).

To sweeten the gas (get rid of the sulfur), it is generally bubbled through columns containing an absorbent liquid (typically sulfur-attracting amines) which remove the sulfur (which can then be recovered by heat in a stripping column, while the amine is then recycled).

The recent Khurais addition added 1.2 mbd of Arabian Light crude and GOSPs to support the new capacity. In the new GOSP construction which came onstream this year, there was an additional consideration. In order to help get the oil out, Aramco is simultaneously injecting 4.5 million bd of treated seawater. The main treatment plant at Qurayyah can process more than 13 million bd. The treatment involves removing particulate solids, ensuring that the oxygen content is below detection (this is needed to prevent corrosion), that there be no scaling products in the water and that there is a minimum amount of microbial content that could lead to biofouling of both the distribution pipeline and the injection wells. (Note that many of these concerns also relate to cleaning up the produced water from the wells before it is re-injected.) The volumes that are treated are expensive, and thus there has been a recent move to simplify this treatment. Getting the solids out is relatively straightforward. Horizontal sand filters (albeit some 11 ft in diameter, 40 ft long) can treat up to 125,000 barrels of water a day bringing the particulate matter down below 0.2 mg/L. (On a personal note, again, sand filters work very well as long as there is no clay in the water--it takes just a few minutes for clay to coat and plug the top of the filter and make life really, really interesting).

At the same time, to ensure that there is no corrosion in the pipelines that carry the water (perhaps over 150 miles to a well in a journey that might take 36 hours) the pipes themselves are given a special internal coating to try and retain water quality integrity and to ensure that the injection wells do not become plugged. The pumps and equipment are powered by gas turbines.

And speaking of gas, the recovery of the oil at Khurais is also expected to generate some 0.3 bcf of a sour natural gas that will be sent to Shedgum to have the sulfur removed, and 70,000 bpd of NGL.

Getting the gas out of the oil occurs very easily (as both Darwinian and idontno commented after my last post appeared on The Oil Drum):

> Very basic, the oil, gas, water, and sometimes sand enter a hydrotreater. The flash gas compressor takes suction from the hydrotreater to remove the gas. The hydrotreater normally will have an electric grid that helps to corral the gas at the top of the hydrotreater. The gas is drawn off and flows to the flash gas compressor. The water and oil separate in the hydrotreater. There's usually two hydrotreaters and sometimes

> three to separate the oil from the gas. The velocity of the fluid as it passes through the treaters is critical since if flow is too high there will not be enough time for the oil and water to separate. The water is drawn off for further processing. The sand is separated in the sand separators and bagged for deposit ashore. The oil is processed to get the salt down to specification. Nalco, one manufacturer who fabricates different kinds of production equipment, has a very good web site to visit. They include flow diagrams.

Depending on the gas and oil mix the process of getting the gas out can pass through more than one stage where the pressure in the vessel is dropped, and at the lower pressure the gas bubbles out of the oil. (As noted, just as carbon dioxide bubbles out of soda when the can is opened).

In order to accelerate the separation of the water from the oil (remembering that oil floats on water), the vessel is often now heated, so as to speed the process up. Sand in the fluid is going to be an increasing problem as wells get deeper and more of them are horizontal, but separation can be accomplished as exemplified by the way in which the oil and sand are separated up at Fort McMurray. For that, there is a video.

This is part of a series, and I am grateful for the help that is given both by those asking questions, and those with practical experience that help with replies.