Cavern Storage of Feedstock for Synthetic Natural Gas Plant

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ABSTRACT

Construction of a synthetic natural gas plant created a need for the storage of large volumes of light hydrocarbon feedstock. Esthetic, as well as economic considerations, indicated salt cavern storage to be more desirable than surface tanks.

A variety of feedstocks plus different delivery rates required multiple caverns plus two distinct types of displacement mechanisms. Three caverns are dry storage type with product removal by a secondary frac-connected well equipped with a submergible pump. The remaining six are conventional brine displacement caverns.

A series washing technique was used to minimize the fresh water and brine disposal requirements. Weak brine from a single pass wash stream was circulated through a second cavern to increase the saturation. This technique allows a faster development schedule.

Brine disposal is accomplished by sending most of the brine to Morton Salt Company as feedstock and injecting the remainder underground.

PROJECT DESCRIPTION

The nation's first large-scale synthetic natural gas plant is presently under construction by Consumers Power Company at Marysville, Michigan. The plant uses the Catalytic Rich Gas Principle developed by the British Gas Council.

The site selected for the plant lies within the corporate limits of the city and environmental considerations were very important in maintaining good community relations.

The ultimate output from the plant will be 200 MMcfd of synthetic natural gas. Feedstock requirements will be 50,000 barrels of natural gas liquids per day.

A large volume of feedstock storage was required to assure an adequate supply to the plant and also to be ready to accept the volumes in the process of delivery from a transcontinental pipeline. The volume of storage deemed necessary was 2,000,000 barrels to satisfy both requirements.

Surface storage in a tank farm was considered; however, it would have been esthetically undesirable and expensive. Underground storage in salt caverns was investigated and found to be feasible and more economical. Fenix & Scisson, Inc. was then contracted for the design and construction of the cavern washing facility and to assist in the development.

Feedstock for the plant is composed primarily of natural gas condensate and the fractionated components of this condensate, which are primarily LPGs and pentanes—plus condensate material.

The fractionated portions of the feedstock are delivered at low rates of 1,000 to 1,500 barrels per hour and are stored in six conventional brine displacement caverns. The natural gas condensate is delivered from a transcontinental pipeline at rates up to 23,000 barrels per hour. Storage in brine displacement caverns at these rates was not economical due to the large displacement horsepower required. These liquids are therefore stored in dry caverns operated at the vapor pressure of the liquid, which is approximately 100 psi.

Feedstock withdrawal from the dry caverns is accomplished by a submergible pump placed in a secondary well drilled next to the cavern well. Communication to the cavern well is established by hydraulic fracturing.

Geology of salt horizons

The plant location is underlain by several salt beds. The particular bed used for developing the caverns was the Salina "B" Salt, which is Silurian in age. This salt lies approximately 1,950 feet deep and is 300 feet in total thickness. Only the lower 250 feet was used for cavern development as the upper 50 feet was interbedded with several shale and anhydrite stringers (Fig. 1). Some shale stringers were also present in the remainder of the salt; however, it was felt these would not present major problems.

The salt matrix is relatively pure and is the same salt used by local salt companies as feedstock for commercial salt plants.

The "B" Salt was chosen over the deeper A-2 Salt because of its greater thickness. It was felt this thickness would allow room for future expansion if necessary.

Development methods

A spacing pattern of 600 feet was used in drilling the cavern wells. Maximum diameters of 150 feet were anticipated, thus allowing a minimum of 450 feet of salt between individual caverns.

The caverns are all individual well developments using bottom circulation. This produces the most stable shape and has worked quite well. The fresh water input tubing is placed near the bottom of the cavern interval and the brine return tubing is placed at the desired cavern top.

The initial washing technique was to place the brine return string at the ultimate cavern roof and wash the entire interval at once. The first cavern was developed this way and no trouble was experienced. However, this cavern was only developed to 165,000 barrels and the washing was rapid and continuous. Subsequent caverns were larger in volume and caving problems developed. The reason for the caving problems was the extraction of the salt from between the insoluble layers in the upper portion of the cavern. When the support was removed, these layers collapsed. Unfortunately, the most competent layer was the lowest one at approximately 2,100 feet (Fig. 1), so all the upper debris collected on this ledge. The sloping surface formed directed future cavings toward the tubing string.

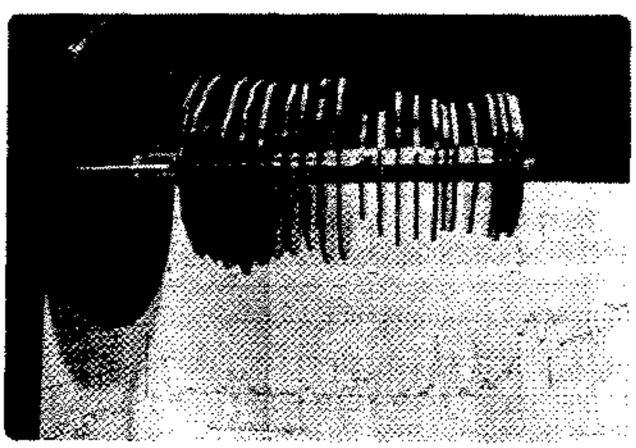

Figure 1. Sonar model and neutron log of typical well.

The tubing was bent or completely broken off when struck by the cavings.

The problem was further aggravated by shutdowns of the wash facility. It appears that gravity segregation occurred in the cavern, thus causing increased leaching of the upper salt during this shutdown period. At each occurrence of a shutdown, at least one breakoff was experienced.

The problem was solved by placing the brine return string just above the thick layer at 2,100 feet and washing the lower portion of the cavern first. This caused the layer to collapse first and created a window for the upper debris to fall through. After a satisfactory volume was developed in the bottom, the brine tubing was raised and the upper portion was washed. Also, every effort was made to maintain circulation through the caverns. This technique proved very successful and eliminated the tubing breakoff problem. A further benefit of the technique was that rubble was not concentrated in the center of the cavern but was spread over a greater area of the cavern floor. This reduced the height of the rubble pile and increased the effective cavern depth. A greater usability factor results since the brine string can be placed deeper into the cavern upon completion.

Propane was used as a blanket material to protect the cavern roof and the casing seat. It was selected for its volatility and local availability.

The brine resulting from a single pass through a cavern was not completely saturated. This weak brine was returned to a header system and directed to a second cavern. This technique minimizes the fresh water and brine disposal requirements by developing higher saturations.

Fracture communication of the withdrawal wells

The wells containing the submergible pumps were communicated to the cavern well by fracturing along the salt-dolomite bedding plane at the base of the "B" Salt at 2,250 feet. The location of the fracture at the base of the Salt is verified by the fact that the volume of brine removed by the submergible pump was within 0.6 percent of the calculated volume.

The fracturing was done immediately prior to beginning washing operations of the cavern well. Communication time across the 90 feet of distance varied from 15 minutes to 1 hour. The volume of fluid required varied from 15 to 300 barrels of saturated brine. Saturated brine was used as a fracturing fluid to minimize leaching and to allow the radial portion of the fracture to heal. All three of the fracture jobs were felt to be very successful and no communication with other wells was observed.

Brine ponds

The brine from the washing operation was directed to two surface brine ponds (Fig. 2). The ponds are capable of holding 700,000 barrels of brine each and were designed as reservoirs for the brine used for feedstock displacement. During the washing phase, the ponds act as intermediate storage for the brine prior to disposal.

The ponds are of clay construction and were lined with a plastic liner for leak prevention and bank erosion control. The clay would normally have been a sufficient seal itself; however, the presence of occasional sand and silt stringers raised the possibility of leakage to surface water. In addition, berm erosion over the life of the plant presented a maintenance problem.

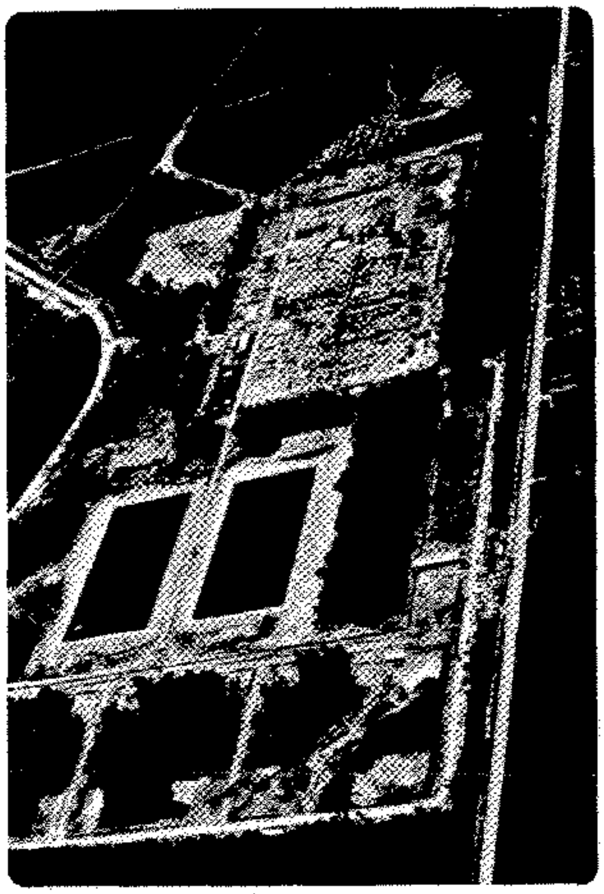

Figure 2. Aerial photo of site showing brine ponds and cavern area at bottom of photo.

Brine disposal

Disposal of the brine developed by the washing posed one of the larger problems of the entire project. Underground disposal zones are at a premium in this area and the only one available to us would accept just a portion of the brine. A local salt company was approached and subsequently an agreement was reached whereby they would accept a majority of the brine as feedstock for their plant. Two disposal wells were also drilled as permanent sources of brine disposal and are being used as supplementary disposal sources during the development.

SUMMARY AND CONCLUSIONS

Storage of large quantities of hydrocarbons is more economical and much more esthetically appealing when placed in salt caverns instead of surface tank farms.

Problems created by caving insolubles in this bedded salt were solved by washing the caverns in two stages instead of one. Higher usability factors and lower rework costs were the result.

Inter-well communications was achieved by hydraulic fracturing across the basal salt-dolomite bedding plane using saturated brine. Through careful design and control of the fracturing technique, communication with the target well was achieved very satisfactorily.

ACKNOWLEDGMENTS

The assistance of personnel from Fenix & Scisson during the design of the facility and the preparation of this paper is gratefully appreciated.

I also wish to thank Consumers Power Company for permission to publish this paper.