

1

2,991,624

UNDERGROUND STORAGE OF HYDROCARBONS

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1 Claim. (Cl. 61—5)

This invention relates to the storage of normally gaseous hydrocarbons in underground caverns and more particularly concerns a method of preventing or reducing leakage of such hydrocarbons when the adjacent formation contains small channels leading from the underground cavern.

The use of underground caverns for the storage of low boiling hydrocarbons such as ethylene, propane and butane has become a widespread practice in the petroleum industry. For this purpose caverns formed by washing out salt from a thick rock salt bed have been particularly satisfactory, since the salt bed is substantially impervious to hydrocarbons and leakage from the cavern through the adjacent formation does not occur. The use of washed out salt caverns is obviously limited, however, to areas in which suitable salt beds happen to occur. More recently, storage caverns have been prepared by mining out underground rock formations such as granite. While storage zones of this type are considerably cheaper than above ground storage tanks for storing low boiling hydrocarbons under pressure, they have not proved to be consistently successful due to leakage from the cavern through the adjacent rock. Rock beds often contain small channels through which the hydrocarbon can flow toward a zone of lower pressure. This not only causes loss of hydrocarbons but also may present a dangerous condition due to seepage of the hydrocarbon to the ground level.

The present invention is directed to a method of preventing or reducing the leakage of normally gaseous hydrocarbons from an underground cavern through small channels in the adjacent rock formation. The method is applicable for the storage of any of the hydrocarbons in the C_2 - C_4 range, namely, ethane, ethylene, propane, propylene, butane, isobutane and butenes. The C_2 hydrocarbons normally would be stored in the underground cavern under high pressure but in vapor phase while the C_3 and C_4 hydrocarbons normally would be stored in liquid phase. The method is applicable regardless of the phase in which the hydrocarbon is normally stored.

According to the invention the hydrocarbon, prior to its introduction into the underground cavern, is admixed with water in amount sufficient to insure substantial saturation of the hydrocarbon by dissolved water and the water-containing hydrocarbon is introduced into the cavern. Whenever leakage occurs through small channels in the adjacent formation, the hydrocarbon undergoes a progressive decrease in pressure which causes its temperature to drop. If the hydrocarbon has been stored initially in the vapor state under pressure, this temperature drop occurs progressively due to the expansion of the gas. If the hydrocar-

2

bon is initially in liquid phase, a temperature drop will begin to occur at some point in the leakage channels when the pressure becomes reduced sufficiently to permit vaporization. As flow continues through the channels, a temperature will be reached at which the hydrocarbon will form a hydrate with the water contained therein. These hydrates are in the form of fine crystals, being similar to snow, and function as plugging agents in the leakage channels. Hence, when the flowing hydrocarbon reaches a pressure-temperature state at which the hydrate will occur, the leakage channel will tend to become plugged and leakage will be reduced or stopped.

When the above-described process occurs, the wall of the leakage channel is cooled as the hydrocarbon temperature drops and will remain cool for a time due to poor heat transfer through the surrounding rock even when leakage is stopped altogether. This allows the hydrate crystals to exist for a substantial time. However, as heat transfer to the channel wall occurs, the temperature will tend to rise to a level where the hydrates melt. When this happens, further leakage of the hydrocarbon will take place and cause the temperature to drop again with resultant reformation of hydrocarbon hydrate. Hence, automatic replugging of the channel will occur. The overall effect is to minimize the amount of leakage that can occur from the storage cavern.

The pressure-temperature conditions that are required for the formation of hydrocarbon hydrates vary with the particular hydrocarbon involved. However, all of the C_2 - C_4 hydrocarbons are capable of forming hydrates when the proper conditions are reached in passing through a leakage channel. The distance from the storage cavern at which plugging will occur in the adjacent formation accordingly will vary depending upon the particular hydrocarbon being stored and the rate of pressure drop as it flows through a channel.

We claim:

In the storage of a C_2 - C_4 hydrocarbon under pressure in an underground cavern wherein leakage of such hydrocarbon occurs through small channels leading from the cavern through the adjacent underground formation, the method of reducing leakage which comprises admixing with the hydrocarbon, prior to its introduction into the cavern, water in amount sufficient to insure substantial saturation of the hydrocarbon by the water dissolved therein and introducing the water-containing hydrocarbon under pressure into said underground cavern, whereby, when leakage occurs from the cavern through the underground formation toward a zone of lower pressure, vaporization of hydrocarbon takes place in said channels with resultant formation of crystalline hydrocarbon hydrate which plugs said channels and substantially reduces leakage.

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