



OTC 18534

Removal of Water From Wellhead Natural Gas: Implications for Gas Separation and Compound Hydrate Formation and Dissociation

Michael D. Max, John P. Osegovic, Shelli R. Tatro, Leslie A. Brazel, and Kathryn M. Sheps, MDS Research

Copyright 2007, Offshore Technology Conference

This paper was prepared for presentation at the 2007 Offshore Technology Conference held in Houston, Texas, U.S.A., 30 April–3 May 2007.

This paper was selected for presentation by an OTC Program Committee following review of information contained in an abstract submitted by the author(s). Contents of the paper, as presented, have not been reviewed by the Offshore Technology Conference and are subject to correction by the author(s). The material, as presented, does not necessarily reflect any position of the Offshore Technology Conference, its officers, or members. Papers presented at OTC are subject to publication review by Sponsor Society Committees of the Offshore Technology Conference. Electronic reproduction, distribution, or storage of any part of this paper for commercial purposes without the written consent of the Offshore Technology Conference is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of where and by whom the paper was presented. Write Librarian, OTC, P.O. Box 833836, Richardson, TX 75083-3836, U.S.A., fax 01-972-952-9435.

Abstract

A hydrate containing only one hydrate-forming material in addition to water may be formed and dissociated by selecting conditions with reference to a single pressure-temperature-concentration boundary. In contrast, compound hydrate, which is composed of more than one hydrate former, has a phase boundary that is sensitive to the kinetics of dissociation and the history of the material. The growth and dissociation phase boundaries for compound hydrates may be quite different depending on the composition of the surrounding gas during each process. The relative proportion of hydrate formers taken up during formation will affect the conditions required for dissociation depending on various kinetic factors. In order to dissociate a compound hydrate, it may be necessary to induce pressure – temperature conditions different from the formation phase boundary.

Introduction

Single hydrate-forming gases form a pure species of hydrate but two or more hydrate forming gases form compound (also called complex) hydrate. Because natural gas is usually a mixture of hydrocarbon and other gases, a wide range of compositions of hydrate may form as preferred hydrate formers are selectively removed from the gas mixture (in the presence of abundant water). Depending on the available hydrate formers, the phase boundary for the compound hydrate growth may be significantly different than the phase boundary conditions of dissociation pressure and temperature. This is because the compound hydrate takes up preferred hydrate formers into the growing hydrate in a much greater proportion than their relative abundance in the gas mixture. The most preferred hydrate former will tend to be removed first, followed by the next most preferred hydrate former present.

A simple table of hydrate forming preference (Table 1) is related to two factors: the relative abundance of the various hydrate formers, and the relative stability of the simple hydrate of each former (Fig. 1). In some cases, a preferred former can be completely extracted from a mixed gas and incorporated within compound hydrate (Uchida 2004). Of the common pollutants associated with natural gas, hydrogen sulfide and sulfur dioxide are the most preferred hydrate formers. Carbon dioxide is the next most common pollutant (Table 1).

Because the phase boundary of a given compound hydrate is sensitive to both the hydrate composition and the composition of the surrounding gas, it is necessary to know the concentration of each hydrate former within the hydrate in order to predict the position of its dissociation phase boundary.

Preference	Gases	Effect of Removal
Most Preferred	Hydrogen Sulfide	Sweetening
	Sulfur Dioxide	Sweetening
Least Preferred	Propane	Concentrated
	Ethane	BTU value
	Carbon Dioxide	Sweetening
	Methane	Separation
	Nitrogen	Sweetening
Least Preferred	Oxygen	Sweetening
	Argon	Sweetening

Table 1. Preference of Common Natural Gas Components

We wish to bring the unique characteristics, challenges, and advantages of compound hydrates to the attention of the gas hydrate community, which commonly has dealt with oceanic hydrate as essentially pure methane hydrate. We suggest that the type of hydrate observed in regions of low permeability or slow groundwater movement may at least reflect a paragenesis that has allowed nature to separate methane hydrate according to a natural process. We also suggest that these natural processes may well have industrial analogues that can be used to purify or remove water from natural gas and to promote flow assurance in gas and possibly oil pipelines. To industrialize the processes of gas dehydration and separation using gas hydrate, new apparatus