

# UNDERSTANDING NATURAL GAS HYDRATES

Instructed by John Carroll, PhD, PEng, Gas Liquids Engineering Ltd.

## COURSE DESCRIPTION

Gas hydrates are ice-like solids that form at temperatures above the freezing point of water. They are frequently encountered in the natural gas industry where water and hydrate forming molecules are in mixtures under pressure. However they are also found in other processes such as the olefins and other chemical process and in nature. The hydrates are notorious for plugging flow lines and damaging equipment. One must be careful when handling hydrate plugs or death could result!

This course covers many topics related to gas hydrates including: What are gas hydrates? Under what conditions do they form? What can be done to prevent them? How do you safely deal with them?

This intensive course is designed for engineers and scientists who work in the natural gas industry and other industries where water is present under pressure. Senior operating personnel may also benefit from attending. Those in attendance will receive a set of notes and the option to buy the book “Natural Gas Hydrates: A Guide for Engineers” at a discounted price.

The instructor has experience with hydrates in the lab and in the field and is the author of the book “Natural Gas Hydrates: A Guide for Engineers”.

Time spent in the course is eligible for Profession Development Hours and a certificate will be issued after the course is finished, signed by the instructor and the organizer.

## COURSE INFORMATION AND REGISTRATION

**Date:** December 8<sup>th</sup>, 2016, Thursday

**Time:** 8:00am - 5:00pm

**Location:** Northcote, Bow Valley Square

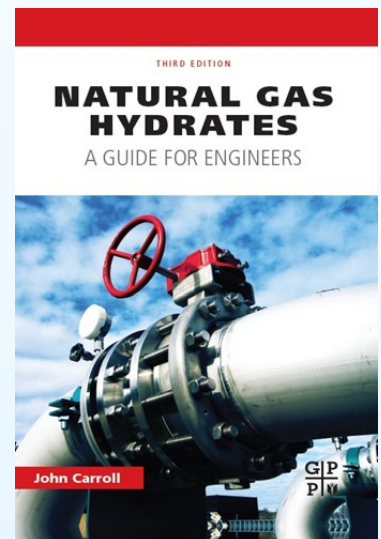
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**Contact Phone:** 1 403 619 6215

**Email:** [alicewu@spheretechconnect.com](mailto:alicewu@spheretechconnect.com)

**Online Registration:** [www.spheretechconnect.com](http://www.spheretechconnect.com)



## INSTRUCTOR



**John J. Carroll, PhD, PEng** is the Director, Geostorage Process Engineering for Gas Liquids Engineering, Ltd. in Calgary, Canada. Dr. Carroll holds bachelor and doctoral degrees in chemical engineering from the University of Alberta and is a registered professional engineer in the provinces of Alberta and New Brunswick. He has more than twenty five years' experience in the areas of thermodynamics, phase equilibria, and physical property calculations, particularly in areas of interest to the petroleum and natural gas industries and sour, those containing hydrogen sulfide, systems in particular. He has worked as a process engineer on more than 25 gas plants and troubleshooting.

Dr. Carroll is the author of the book Acid Gas Injection and Carbon Dioxide Sequestration published by Scrivener Publishing and Natural Gas Hydrates: A Guide for Engineers published by Gulf Professional Publishers (now in the third edition). In addition he has contributed to more than 50 papers, in both scholarly journals and technical magazines, and contributed to approximately 60 conference presentations.

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## COURSE OUTLINE

1. The water molecule and the hydrogen bond
  - 1.1 Water is different (Periodic table)
    - ◆ boiling point
    - ◆ enthalpy of vaporization
    - ◆ expansion upon freezing
  - 1.2 The structure of ice
  - 1.3 Sublimation
  - 1.4 Is “free water” necessary for forming hydrates?
2. What is a hydrate?
  - 2.1 The three criteria for hydrate formation
3. Hydrate and non-hydrate formers
  - 3.1 Type I
  - 3.2 Type II
  - 3.3 Type H
  - 3.4 Structures of the hydrates
  - 3.5 How the size of the molecule effects hydrate formation
4. Hydrate compositions
  - 4.1 Theoretical composition
  - 4.2 Actual compositions
5. Calculation of hydrate forming conditions
  - 5.1 Hand calculation methods
    - ◆ Gas gravity methods
    - ◆ K- Factor methods
    - ◆ Bailie-Wichert
  - 5.2 Advanced calculation methods (software calculations)
    - ◆ van der Waals and Platteeuw
    - ◆ Parish and Prausnitz
    - ◆ Ng and Robinson
6. Combating hydrate formation
  - 6.1 Chemicals
    - ◆ Thermodynamic inhibitors
      - Hammerschmidt equation:
      - Carroll methods
      - Ionic solutions (brine)
    - ◆ Low-dose inhibitors
      - Kinetic inhibitors (KI)
      - Anti-agglomerates (AA)
      - Inhibitor losses
    - ◆ Other inhibitor considerations
  - 6.2 Heat
    - ◆ line heaters
    - ◆ heat tracing
  - 6.3 Dehydration
7. Water content of gas
  - 7.1 Sweet gas
  - 7.2 Sour gas
  - 7.3 Acid gas
8. Phase Diagrams
  - 8.1 Use of phase diagrams to interpret processes
9. Advanced topics

**Note:**

Case studies will be throughout this course.



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## Registration Information

<b>Name</b>		<b>Title</b>	
<b>Direct Phone</b>		<b>Cell Phone</b>	
<b>Company</b>			
<b>Billing Address</b>			
<b>Contact Email</b>			
<b>How many people registered together?</b>			
<b>Signature</b>			

1. Are you a student in University? Yes / No

2. Do you want the book “Natural Gas Hydrates: A Guide for Engineers”, Third edition, authored by John J. Carroll Yes / No

## Payment Method

**VISA**

**Master Card**

**American Express**

**Company Cheque**

<b>Card Number</b>			
<b>Expire Date</b>		<b>Card Holder Name</b>	
<b>Signature</b>			