

# Flow Assurance Overview and Challenges in Oil & Gas Production

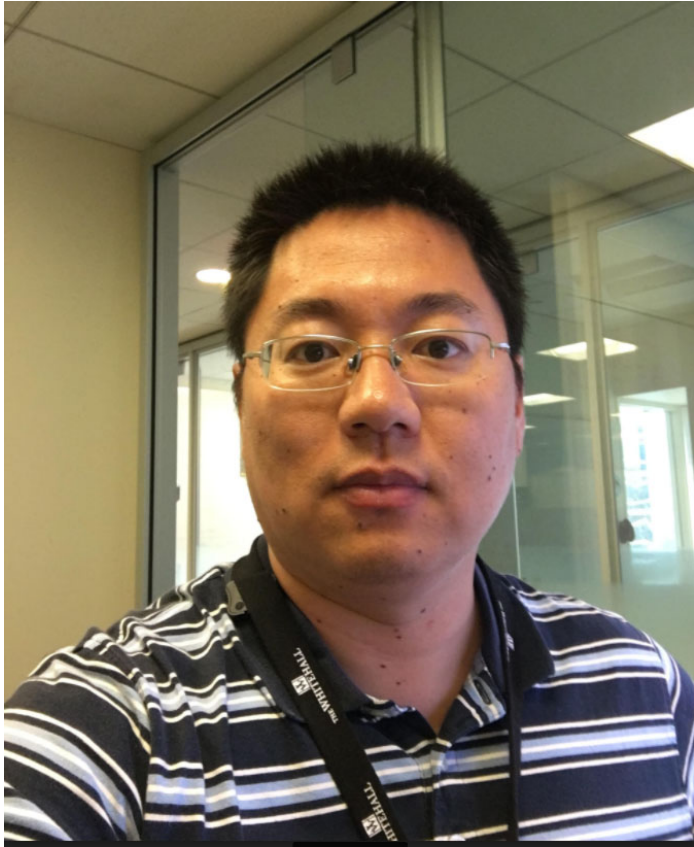


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Houston, Texas



# Introduction



Senior Flow Assurance Engineer  
Flow Assurance Chapter  
Chevron Technical Center

## Biography

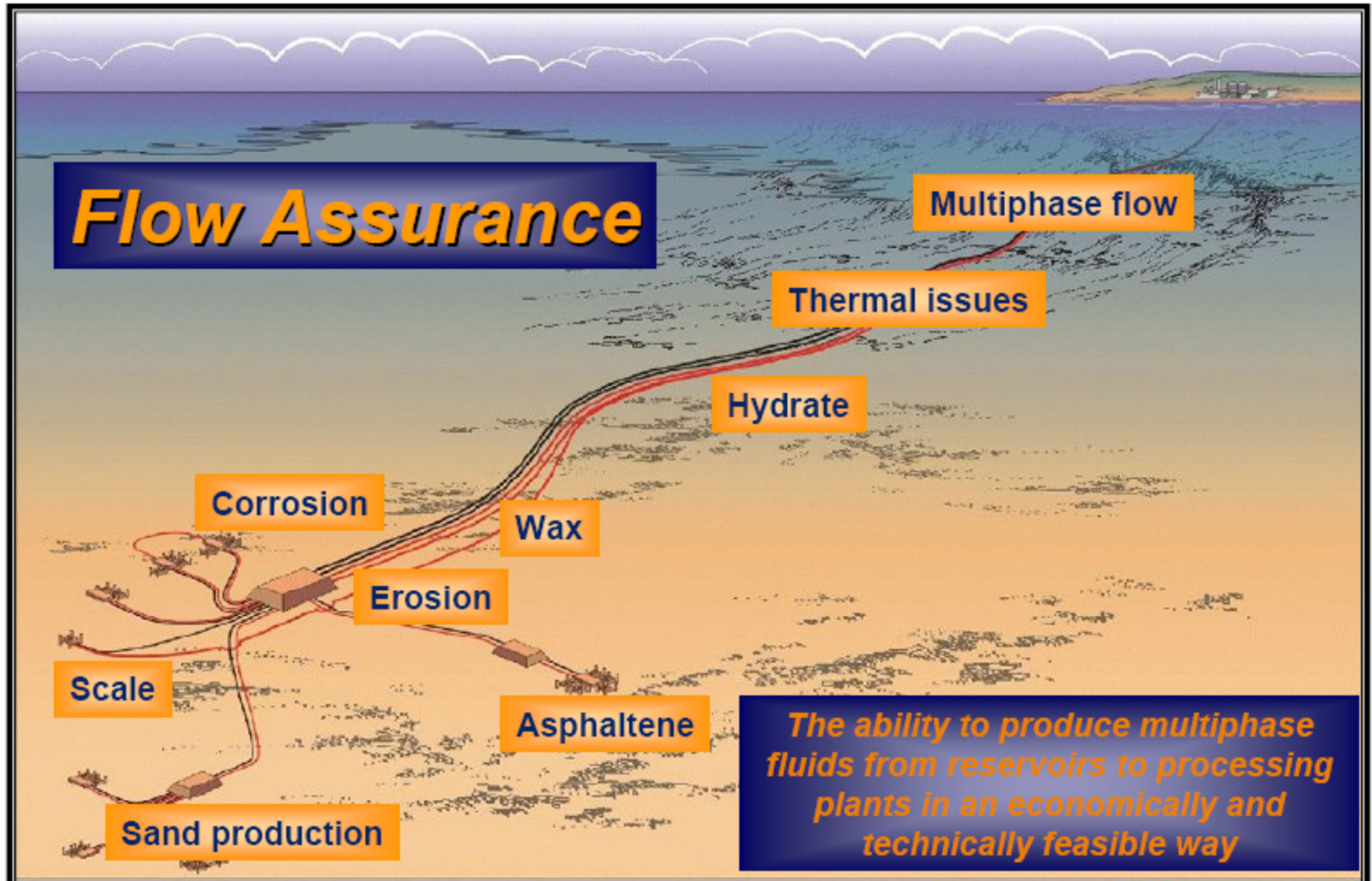
- Ph.D. in Chemical Engineering
- 11 years industry experience oil and gas industry.
- Research interests in modeling and experiments on multiphase flows, solids transport, sand erosion, etc.

# What is Flow Assurance?



- ❑ Combination of production chemistry, multiphase flow, and heat transfer studies:
  - to ensure safe, reliable and economical transport of oil, gas, and water from reservoir to the recipient facilities.
  
- ❑ Production Chemistry: Hydrates, wax, asphaltenes, inorganic scale, corrosion, sand transport, emulsions, naphthenates ...
  
- ❑ Multiphase Flow: Understanding the interplay between complex **flow patterns** in two and three-phases flow and complex **phase behavior** of oil, gas, and water. Transient Operations as well as steady state.

# Flow Assurance Challenges



# Scope of Flow Assurance



- Reservoir Fluids
  - Sampling, lab analysis, development of predictive models
- Multiphase Flow
  - Rheology, flow modeling
  - Pressure loss, diameter of tubing & flowlines
  - Slugging and liquid surge
- Heat Transfer
  - Insulation, heating
- Solids
  - Hydrates, wax, asphaltenes, scale, naphthenates, etc.
  - Flow restrictions or blockages



# Scope of Flow Assurance - continued



- Internal Corrosion
- Emulsions
- Sand
  - Sand transport / deposition
  - Erosion
- Production Chemistry
- System Operability
  - Various operating modes: normal operation, shutdown, startup, well testing, turndown/rampup, pigging, etc.
- System Integration

# Reservoir Fluids

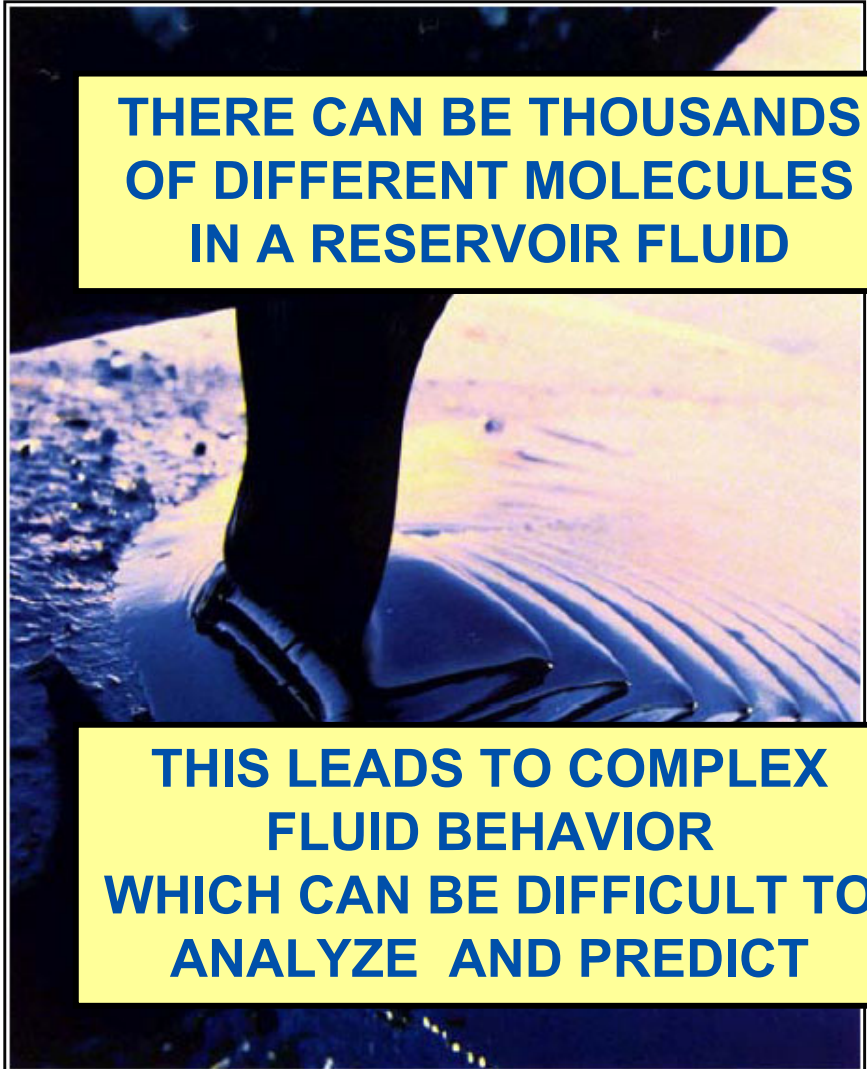


## ■ Hydrocarbons

- Saturates / Paraffins / Alkanes
- Aromatics
- Resins
- Asphaltenes

## ■ Non-hydrocarbons

- Water
- Mineral salts
- CO<sub>2</sub>, H<sub>2</sub>S, mercaptans, N<sub>2</sub>, He
- Metals
- Microorganisms



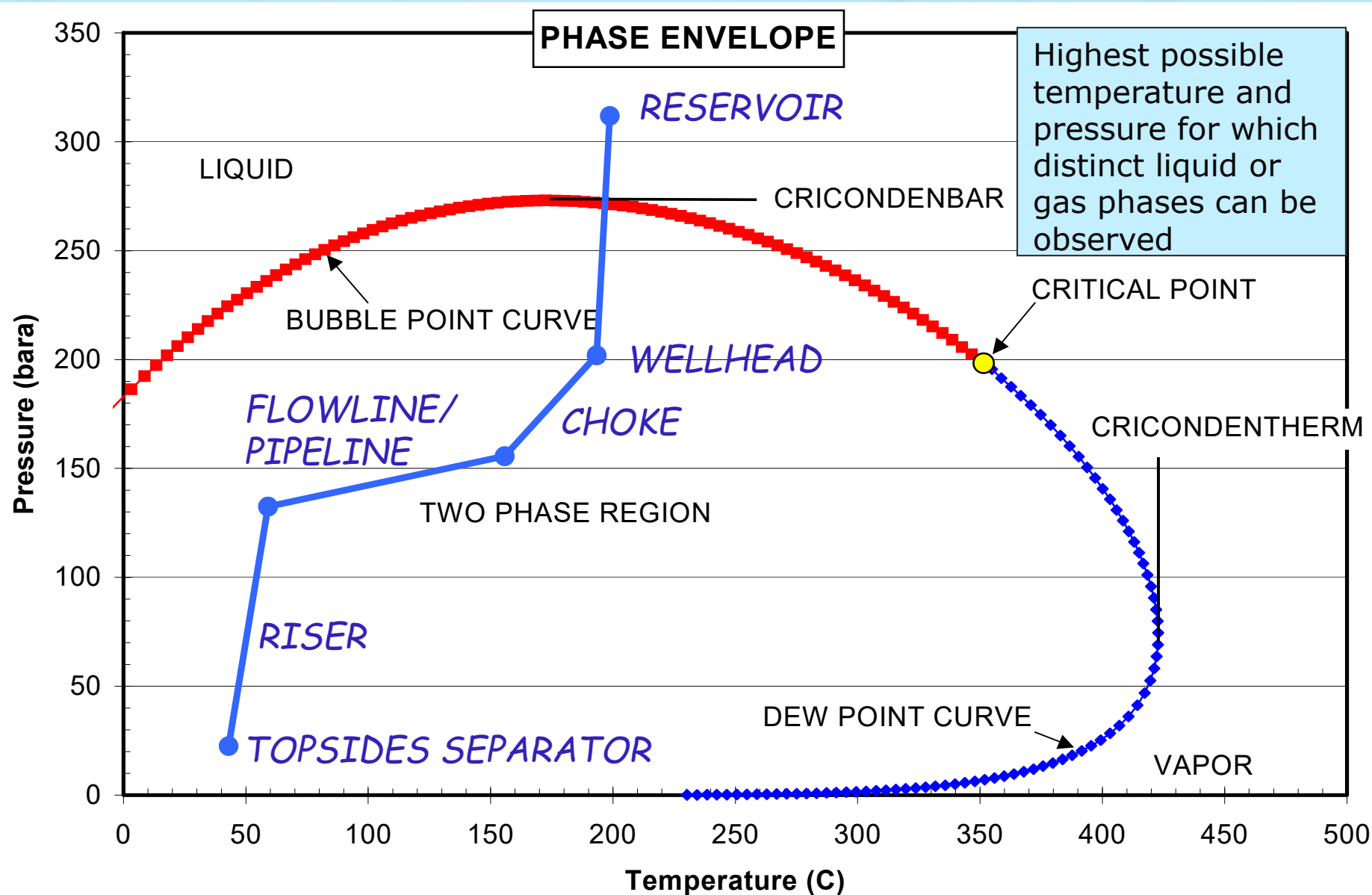
**THERE CAN BE THOUSANDS  
OF DIFFERENT MOLECULES  
IN A RESERVOIR FLUID**

**THIS LEADS TO COMPLEX  
FLUID BEHAVIOR  
WHICH CAN BE DIFFICULT TO  
ANALYZE AND PREDICT**

- Basis for Flow Assurance and other design work
- PVT
  - Describes the thermodynamic relationship between pressure, volume, and temperature for all phases
- Phase Behavior
  - Phase refers to the state of matter: gas, liquid, solid
  - Temperatures & pressures the different phases form, and the relative quantities of each phase
- Fluid Properties
  - Chemical composition
  - Parameters related to solids formation



# Fluid Phase Diagram



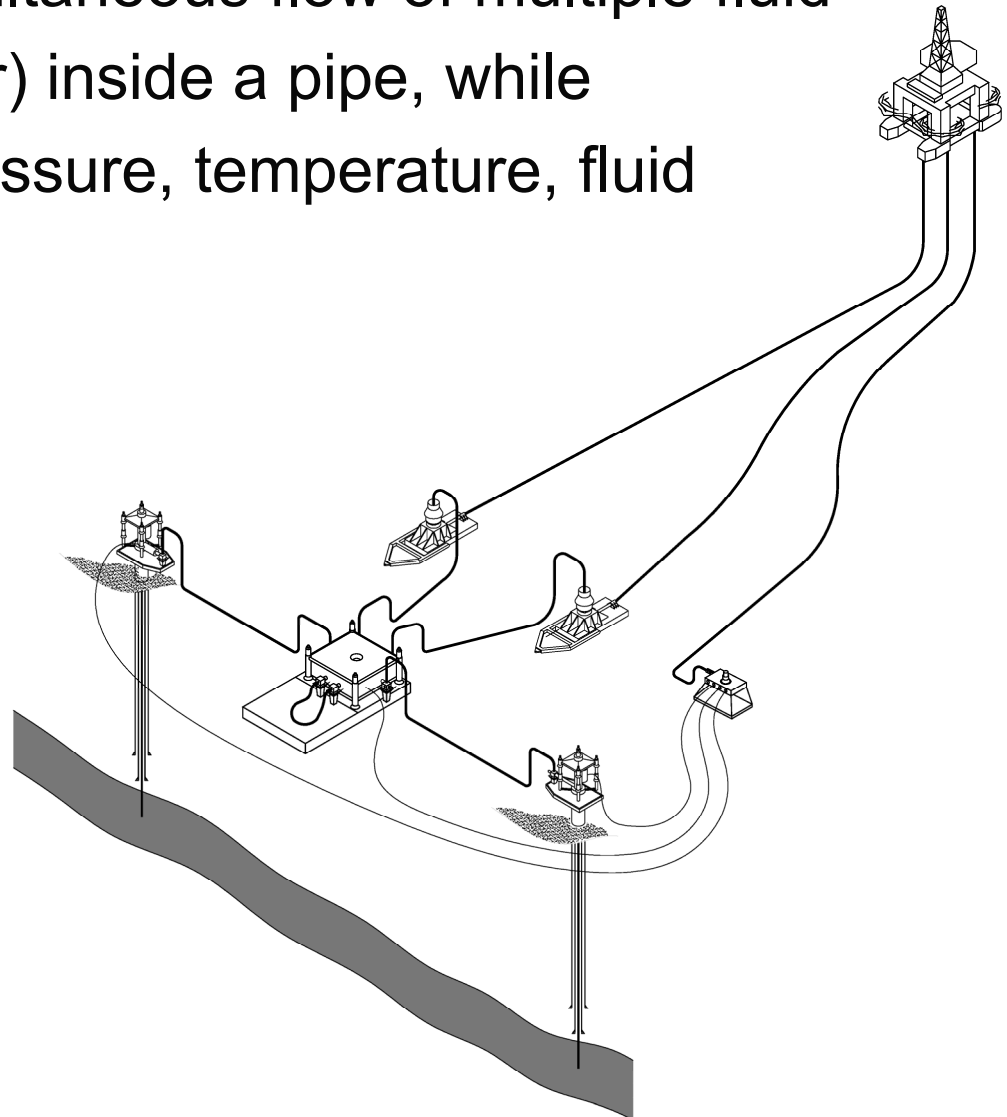
# Multiphase flow



❑ Multiphase flow is the simultaneous flow of multiple fluid phases (gas, oil, and water) inside a pipe, while undergoing changes in pressure, temperature, fluid properties, etc.

❑ The flow can be in:

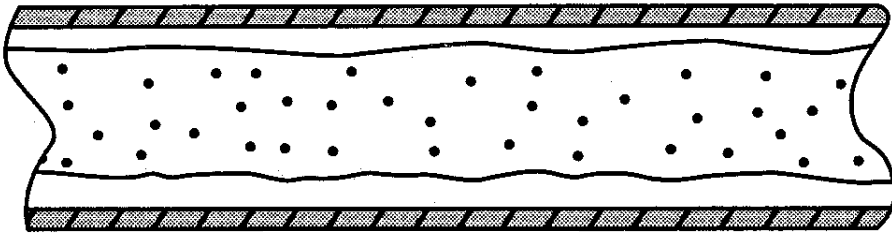
- Reservoir
- Wellbore
- Flowlines
- Risers
- Export pipeline



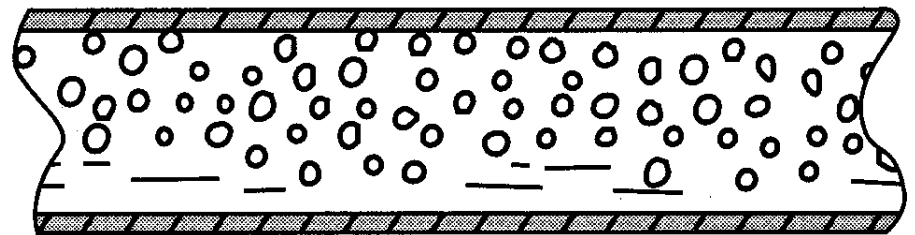
# Multiphase Flow Regimes in Horizontal Pipe



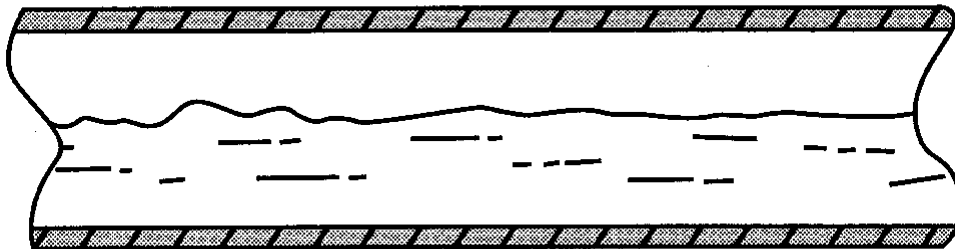
- ❑ The challenge with multiphase flow is that it does not follow one flow regime.
- ❑ Describes how the gas and liquid are distributed within a horizontal pipeline.



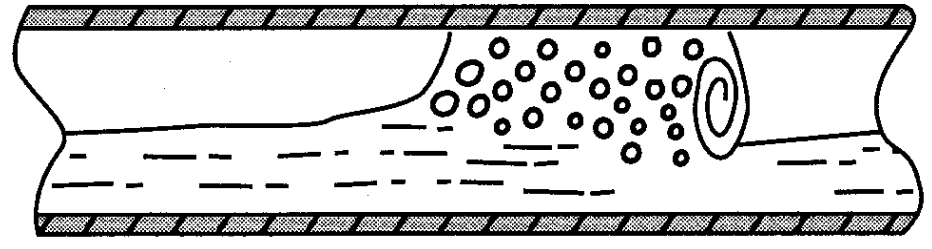
Annular Flow



Dispersed Bubble Flow



Stratified Flow



Slug Flow

# Slug-Induced-Vibration

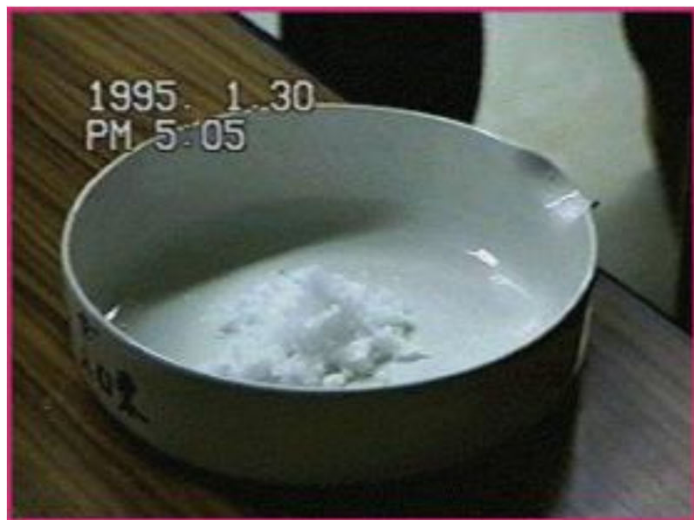




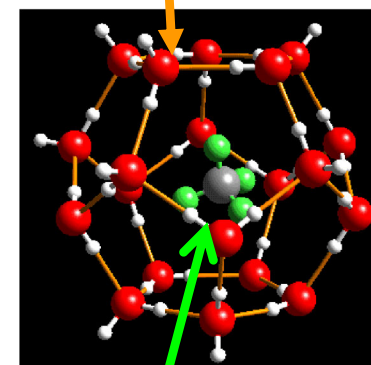
# Hydrates



## ■ “Ice that burns”

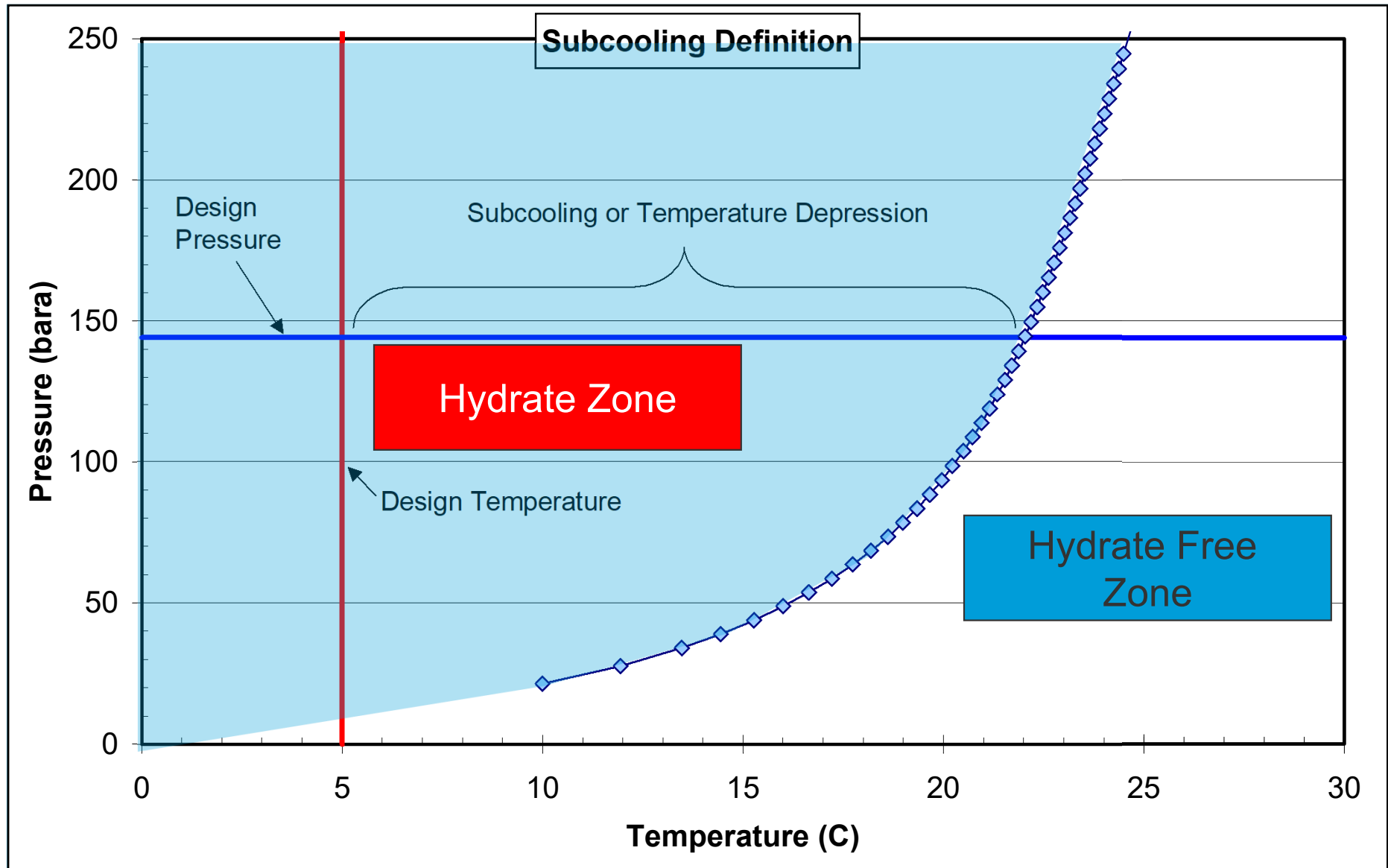


Water molecules



Methane molecule

# Hydrates





# Hydrates



- Extracting a hydrate plug from the production facility.
- Offshore Pipeline (plug can be many meters long and in many sections of line)

## ■ Hydrate prevention - Chemical Inhibitors

- Thermodynamic (shift chemical equilibrium)

- ▶ Methanol

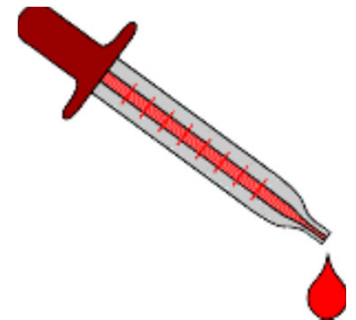
- ▶ Glycols (MEG, DEG, TEG, others)

- ✦ Salt (brine)

- Low dosage (a.k.a. LDHI)

- ▶ Anti-agglomerants (prevents accumulation)

- ▶ Kinetic inhibitors (delay nucleation)



# Wax/Paraffins



- ❑ Wide range of high molecular weight paraffins (alkanes or saturated hydrocarbons) in crude oil.
- ❑ Wax Appearance Temperature (WAT) or Cloud Point is the temperature at which the first wax crystals form.
- ❑ Pour Point is the lowest temperature at which an oil can be poured under gravity.



# Wax/Paraffins



❑ Three major concerns:

- **Wax deposition** on tubing or pipe walls during normal operation
- **Gelling of the oil** during shutdown and subsequent restart
- **Increases in viscosity** due to wax particles suspended in the oil during normal operation, low flow or turndown operation, or restart





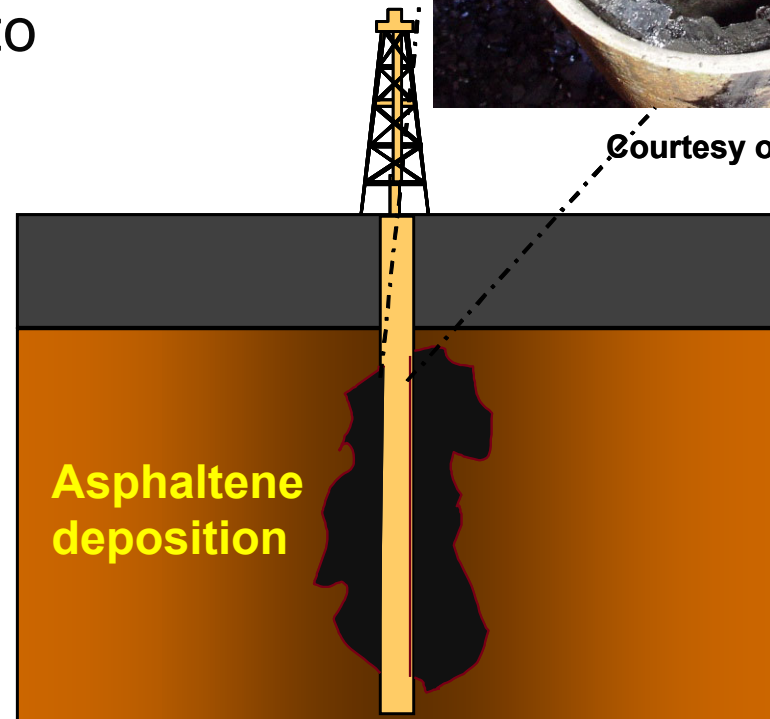
# Asphaltenes



- ❑ Heavy molecules, highly heterogeneous.
- ❑ Difficult to predict, particularly deposition.
- ❑ Asphaltenes can deposit in formation, wellbore tubing, flowlines, and topsides.
- ❑ Asphaltenes can precipitate due to
  - Drop in pressure
  - Mixing of two different fluids
  - Gas lift
- ❑ Asphaltenes can cause emulsion problems



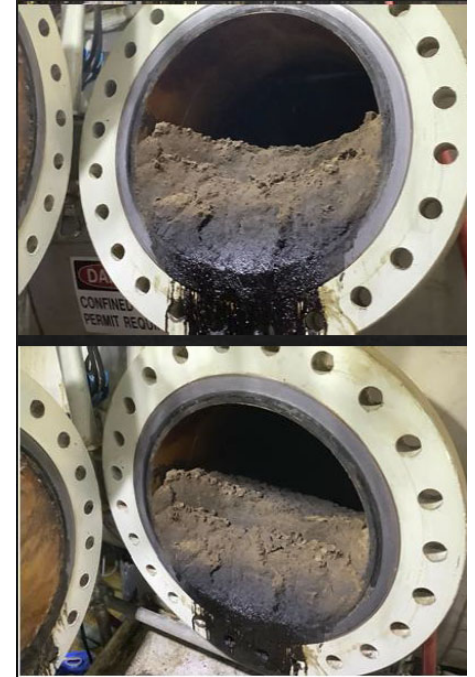
Courtesy of BakerPetrolite



# Sand



- ❑ Small quantities of sand are typically produced from oil and gas reservoirs
- ❑ Sand can have detrimental impacts on production
  - Erosion
  - Increase corrosion
  - Can form restrictions or plugging
  - Settle in topsides equipment
- ❑ Sand transport
  - Defines the minimum velocity can be defined for keeping the sand flowing with the produced fluid

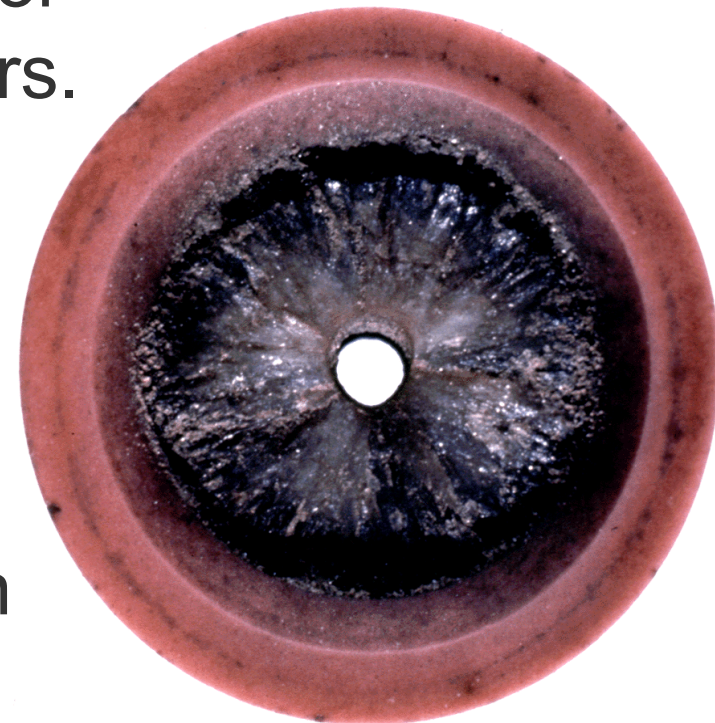




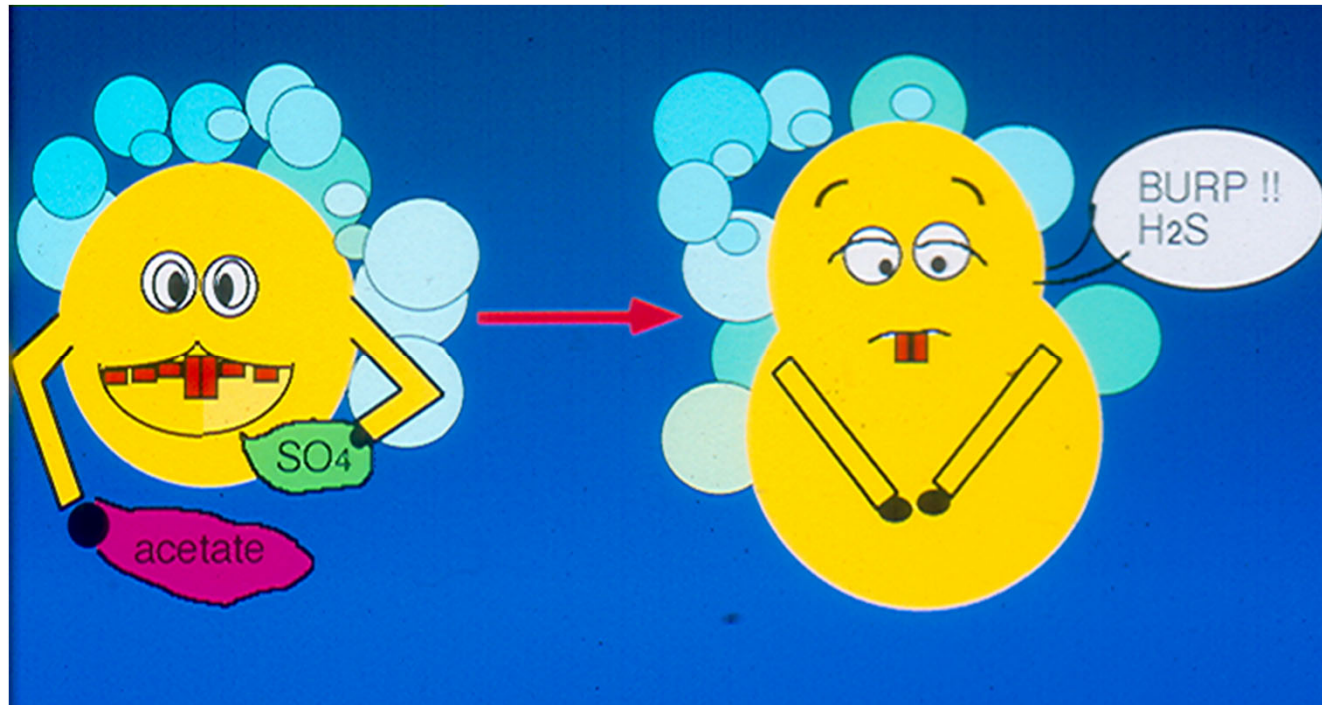
# Scale & Formation Water



- ❑ Deposit of inorganic compounds from formation water that becomes supersaturated due to P-T changes, or from the mixing of incompatible waters.
- ❑ Generally inorganic salts such as carbonates and sulfates of the metals calcium, strontium and barium
- ❑ May also be the complex salts of iron such as sulfides, hydrous oxides and carbonates



# Reservoir Souring by Sulphate-Reducing Bacteria (SRB)



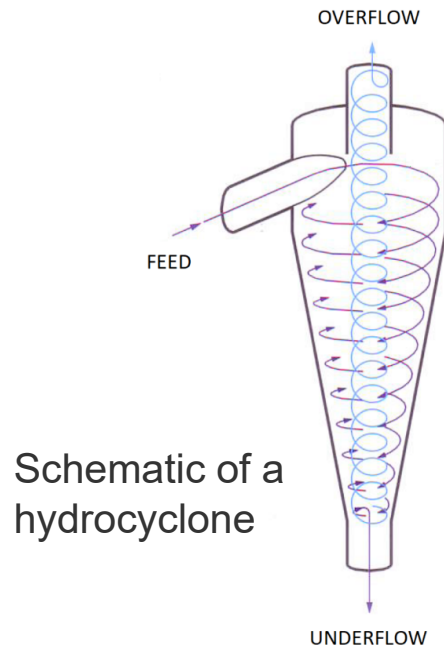
Bacteria come in contact with injected seawater and thrive with sulphate in seawater

**Reduce sulphate ( $\text{SO}_4^{2-}$ )  $\rightarrow$  Sulphide ( $\text{S}^{2-}$ ,  $\text{H}_2\text{S}$ )**

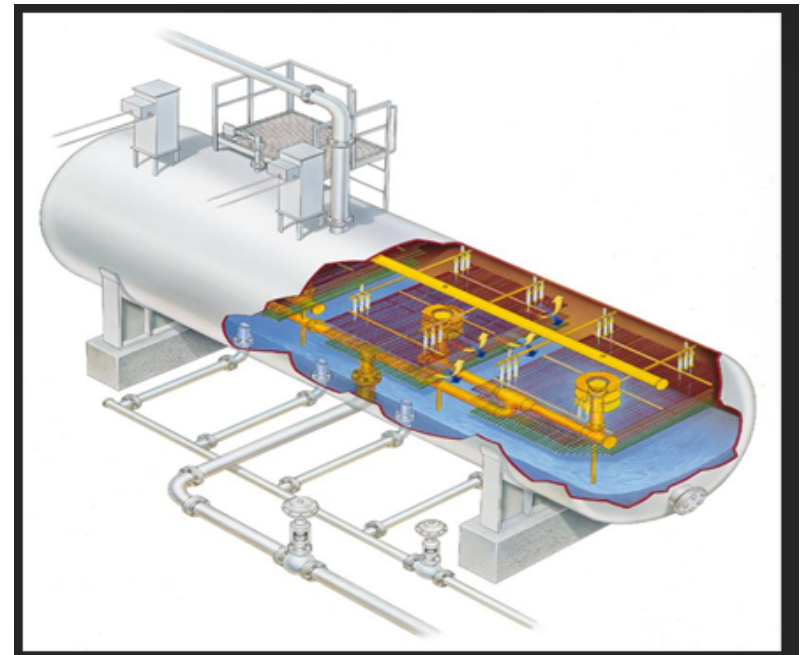
# Separation Challenges



- ❑ Gravitational Separator – using gravity to separate gas/oil/water/solids
- ❑ Hydrocyclone – using centrifugal force, G-force, to separate gas/liquid/solids
- ❑ Electrostatic coalescer – using electrical charge to induce the coalescence of small droplets onto the water/oil interface



Schematic of a horizontal separator with electrostatic coalescer





# Final Thoughts, Is this Flow Assurance?



Pipeline or  
Walkway  
Blockage?