Produced Water Treatment Using Gas Hydrate Formation at the Wellhead

by

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Project Team

- Sponsored by USDOE and Crystal Solutions, LLC
- Collaboration between
  - BC Technologies (BCT),
  - Oak Ridge National Laboratory (ORNL) and
  - International Petroleum and Environmental Consortium (IPEC)

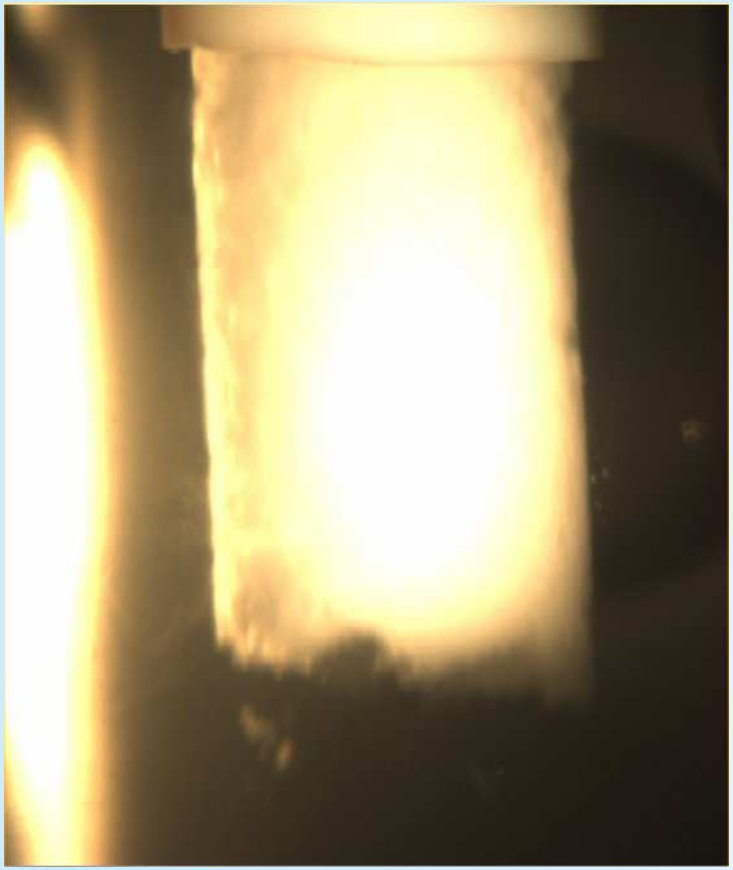
Background

- Water associated with CBM production is a significant and costly waste stream.
- Treatment at the wellhead can significantly reduce surface water handling costs.
- Economic treatment and/or disposal is the key to successful and profitable CBM production in the Greater Green River Basin.

Project Objectives

- To develop a new treatment method for produced water where a significant portion of the water is purified at the wellhead.
- To determine the effectiveness of hydrate formation through laboratory experimentation.
- To design a prototype-scale injector and test it under realistic wellhead conditions.
- To demonstrate the technology under field conditions.

Gas Hydrates



Picture of CO_2-hydrate composite particles coming out of ORNL's Continuous-Jet Hydrate Reactor

Photo courtesy of ORNL

Desalination Concept

- Gas hydrates contain concentrated gases such as methane or carbon dioxide and are a crystalline solid that consists of a gas molecule surrounded by a cage of water molecules.

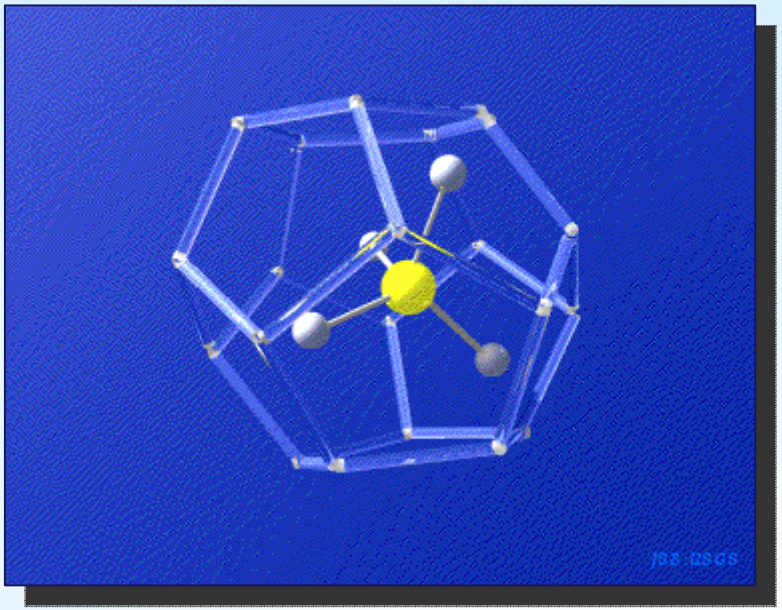


Photo courtesy of ORNL

Desalination Concept, continued

- Hydrates are solid crystalline compounds composed of cages of hydrogen-bonded water molecules that trap gases such as CO_2 and CH_4.
- The formation of hydrate excludes solids, dissolved species and most organic species.
- When hydrates form, the chemical structure excludes salts and other impurities.
- When the hydrate is dissociated, gas, purified water and stream with concentrated chemical constituents (brine) are produced.

Desalination Concept, continued

- It is possible to reduce water treatment costs by converting a portion of produced water from wells to gas hydrates at the wellhead, thereby reducing transportation costs for produced water disposal.
- The hydrate formation system uses ORNL's self-contained co-flow injection device for gas hydrate formation in a vessel operated at elevated pressures of 10 to 13 MPa and temperatures between 0 and 10^{o}C.
- The gas hydrates can then be disassociated by pressure reduction and separated into gas, purified water and brine at the wellhead.
- The gas collected is recycled, purified water is discharged and the brine is disposed of by conventional methods.

Gas Hydrate Produced Water Treatment Continuous Flow Prototype Reactor Development

ORNL's Batch Flow Hydrate Formation Reactor.

Photo courtesy of ORNL

Gas Hydrate Produced Water Treatment Continuous Flow Prototype Reactor Development

- Using the injector provided by ORNL, the system was scaled up to handle larger volumes of water produced.
- Hydrate formation and salinity reduction under continuous flow conditions were tested.
- A bench-scale (1-2 bbl/day) demonstration of the process was used to verify the scale-up (25-50 bbl/day are typical CBM flow conditions).

Gas Hydrate Produced Water Treatment Continuous Flow Prototype Reactor Development

BCT's Continuous Flow Hydrate Formation Chamber

Gas Hydrate Produced Water Treatment Continuous Flow Prototype Reactor Development

BCT's Continuous Flow Hydrate Formation Chamber

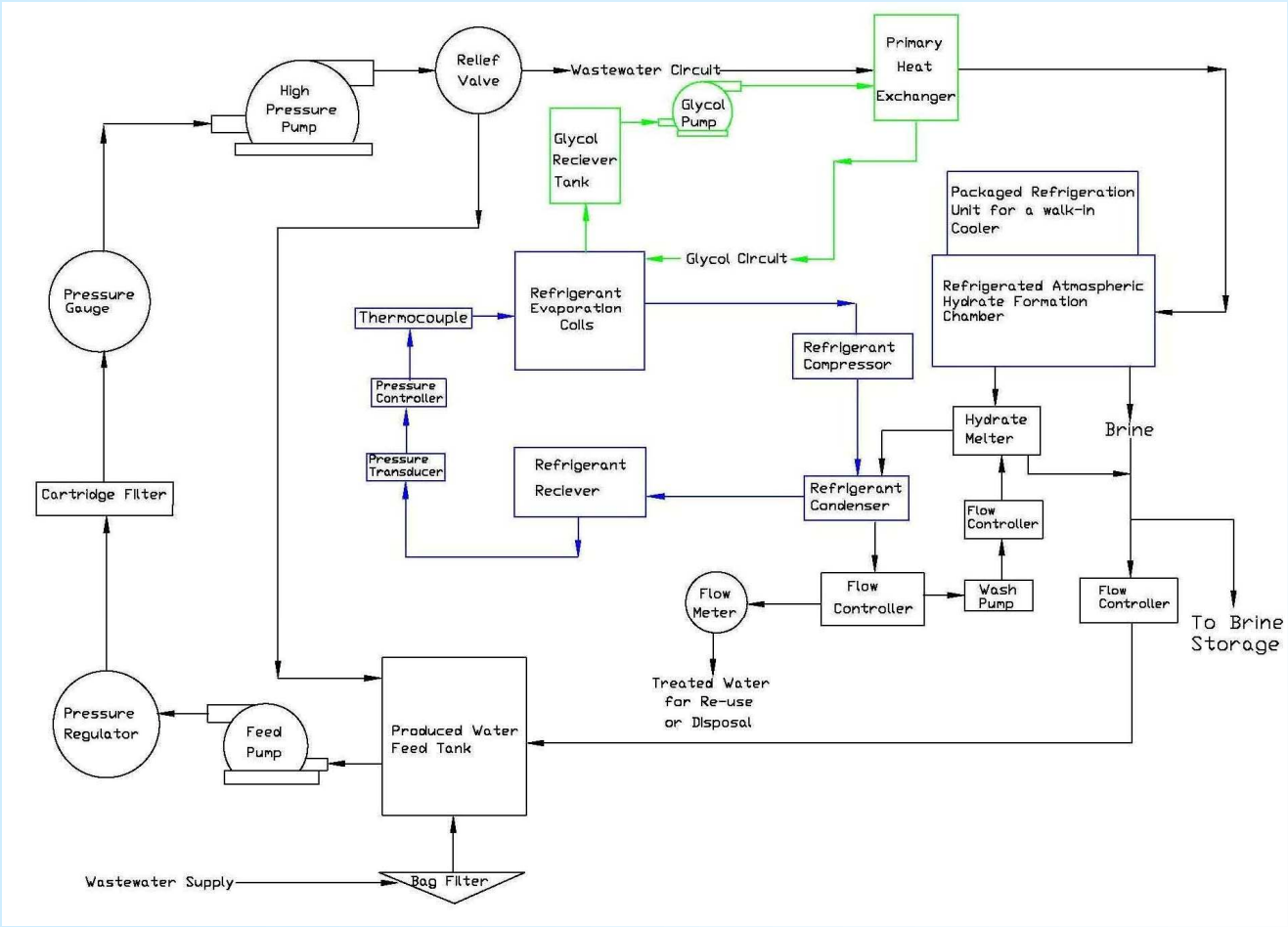
Gas Hydrate Produced Water Treatment Continuous Flow Prototype Reactor Development

Continuous Flow Hydrate Collection Chamber

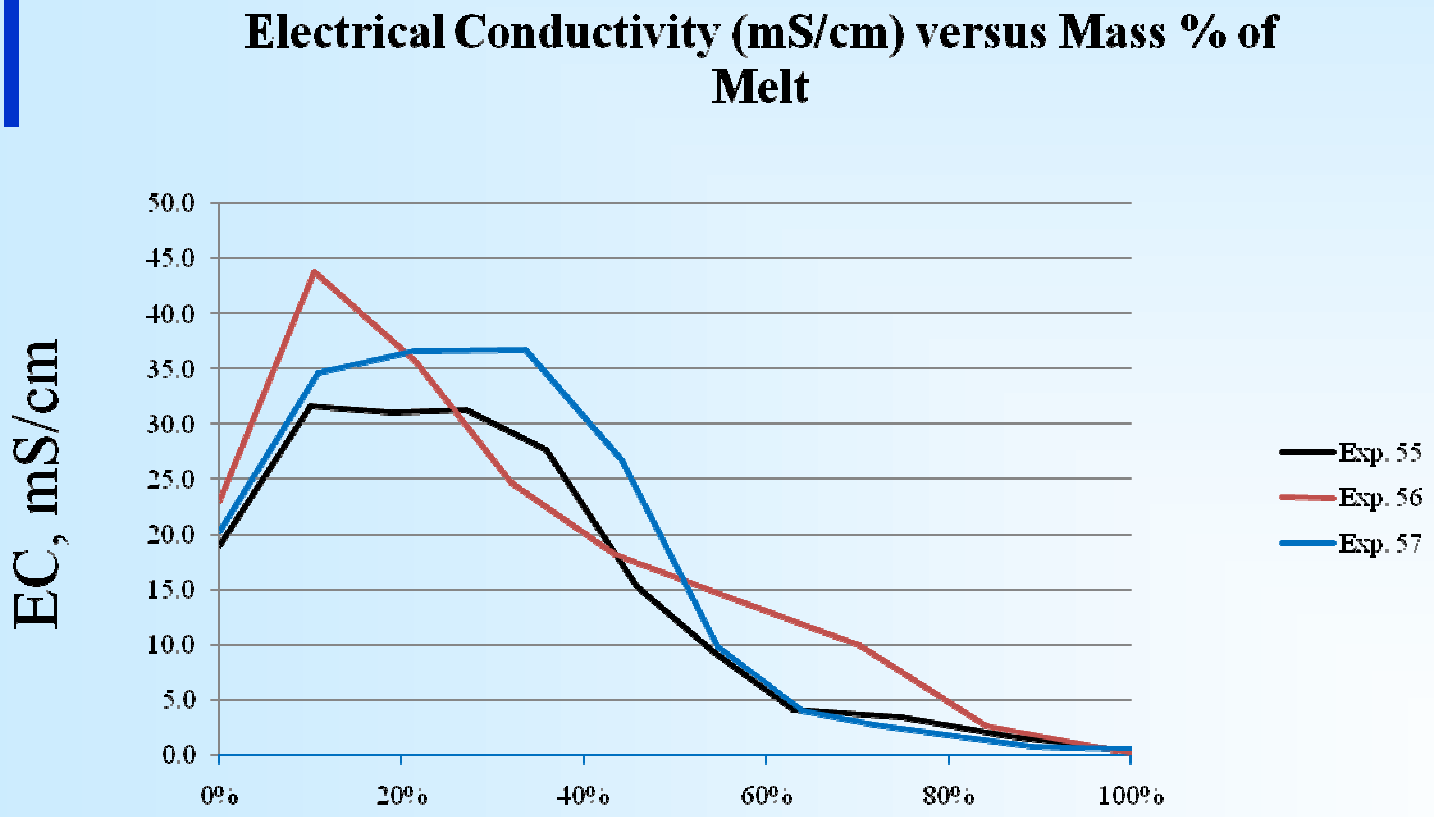
Gas Hydrate Produced Water Treatment Continuous Flow Prototype Reactor Development

Current Version

Gas Hydrate Produced Water Treatment Continuous Flow Prototype Reactor Development

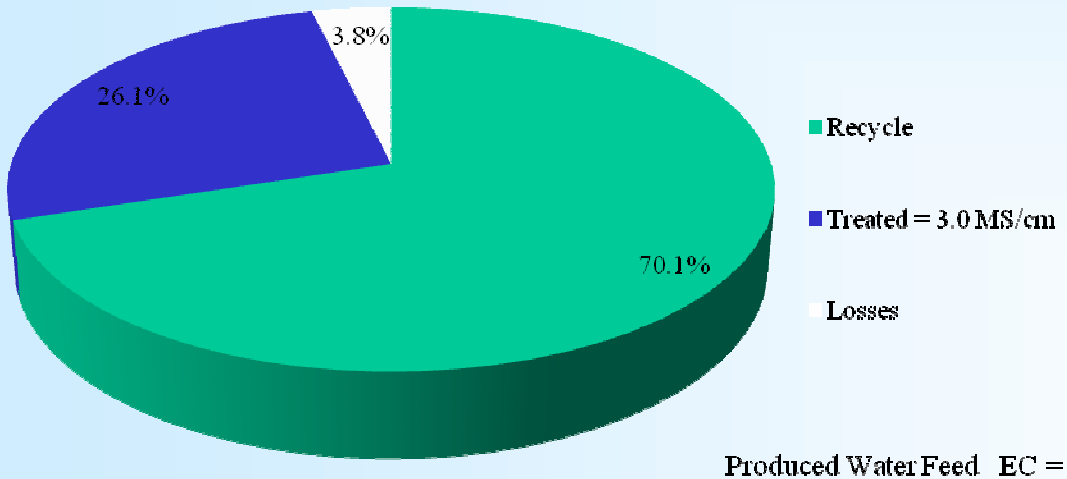


Gas Hydrate Produced Water Treatment Prototype Reactor Development



Gas Hydrate Produced Water Treatment Prototype Reactor Development

Experiments #s 55, 56 and 57 Combined Mass Yields as % of Feed



Produced Water Feed EC = 24.1 mS/cm

Field Test/Demonstration Unit Shakedown Results

- Bench-scale results using carbon dioxide indicate that 40 to 49% of the feed water to the hydrate formation reactor was converted to hydrate in a single pass.
- These results also indicate that 23 to 29% of the feed water to the hydrate formation reactor (56 to 60% of the hydrate formed) was converted to purified water of a quality suitable for discharge.

Gas Hydrate Produced Water Treatment Prototype Reactor Development

Produced Water Feed – Right

Hydrate Reactor Treated Water - Left

Gas Hydrate Produced Water Treatment Prototype Reactor Development

Sample of CO_2 Hydrate Made Using Produced Water

Gas Hydrate Produced Water Treatment Continuous Flow Prototype Reactor Development

Double Click on Box to Play Movie

Economic and Environmental Benefits of Technology

- Water can be treated at the wellhead to reduce surface handling costs.
- Reducing surface handling will also reduce environmental impacts such as fugitive dust created from truck traffic.
- Adverse impacts to sage grouse populations in southwestern WY will also be reduced with less truck traffic.

Questions?

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