BP

Jonah Field, Wyoming

Desiccant Use for Dehydration

"The Issues"

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Jonah/BP DESI-DRY History

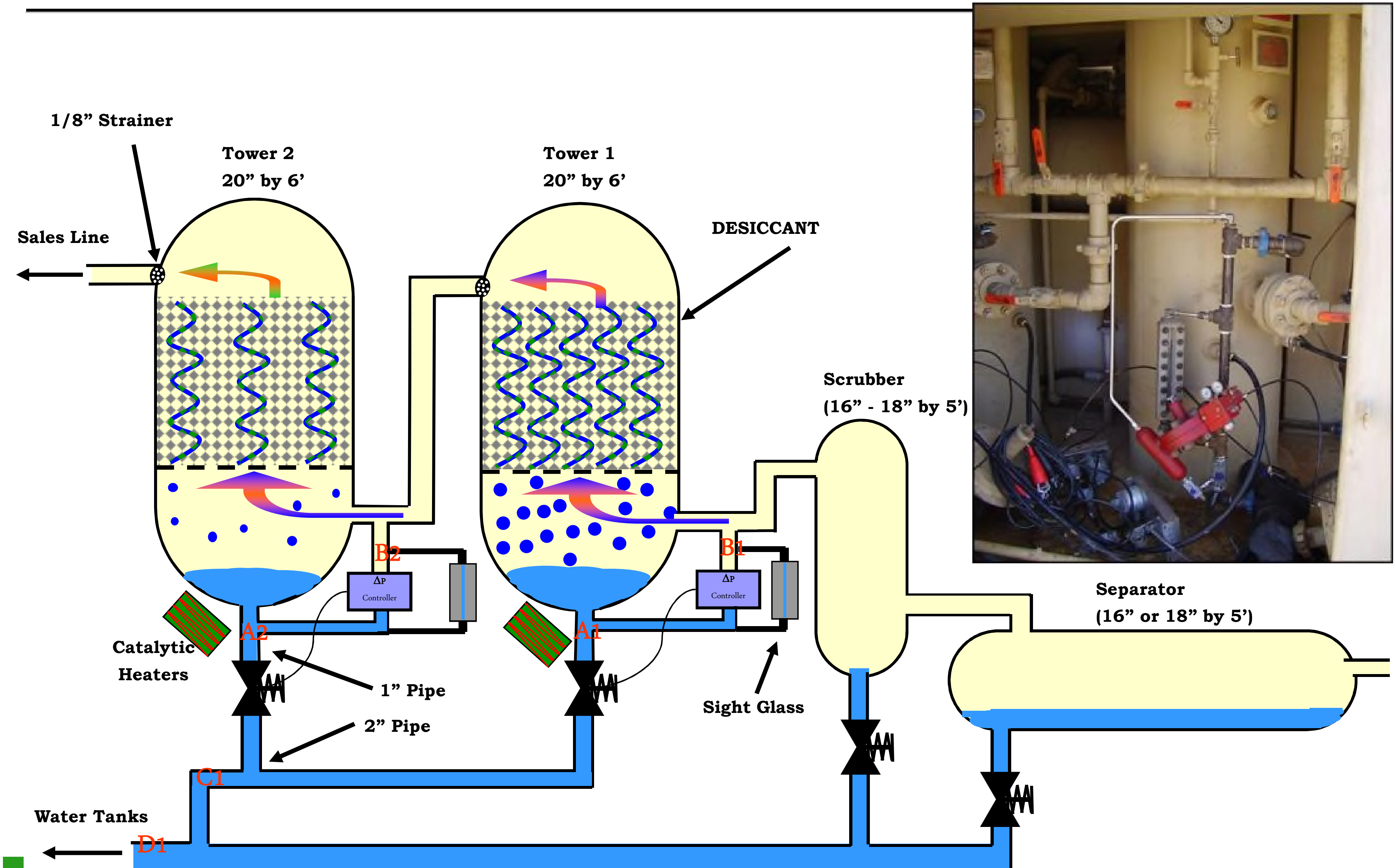
- Proposed the use of their DESIDRY Gas Dehydration system in May 1999.
- Two (2) units were installed in September 1999 at Jonah for evaluation purpose.
- Test results yielded satisfactory results.
- Subsequent economic analysis showed that the emissions and the Present Value Costs (PVC) of DESIDRY units is lower compared to typical TEG unit. Consequently DESIDRY units were implemented in Jonah for future gas dehydration in favor of TEG.
- Today BP installed about 90 DESIDRY units in Jonah field

How DESIDRY units work:

1. Wet gas flows upward through one or a series of vessels that contain deliquescing beds filled with solid desiccant pellets (0.75”-1.00” Dia).
2. As wet gas contacts the desiccant tablets, moisture is removed from the gas and accumulates on the surface of the tablets. Eventually, enough water accumulates to cause a droplet of brine to form. In time, the brine makes its way down to a brine sump in the bottom of a vessel, collecting even more moisture in the process.

3. Periodically, the brine is purged and stored on well site with produced water. There is no need for regeneration of desiccant (sacrificial). New desiccant tablets are used to replenish the beds at a rate proportional to gas inflow rate.

DESIDRY Schematic



The Benefits

- ***Emissions reductions – B-tex and fuel gas***
- Lower Present Value Costs (PVC) of DESIDRY units is lower compared to typical TEG unit.
- Less problems that TEG units (expected)

The Problems

- **Operational issues:**
  - Dump (level) Control
  - Green Completion Operation
  - Temperature Control
- **Pipeline pluggage problems**

The Operational Problems

Dump Control

- Early models of the DESIDRY systems utilizes a timer based system that cycles the dump valve of the process vessel on fixed frequency basis. This lead to poor control of dump cycles and to venting of very large natural gas volumes to the atmosphere (~2.5 MMSCFD).
  - **Action:** The fixed frequency controllers were replace with a fixed volume controller. This controller measures the static head inside the DESIDRY tower directly via differential pressure. The "upgrade" project was completed in October of 2004
  - **Evaluation:** The diaphragm of the dump controller was not function well as it is very sensitive to moisture build-up (from wet-gas precipitation). The field operators have been struggling to keep the system working effectively. After 8 month of operations this "upgrade" should be considered unsuccessful.
- Float control –
  - **Action:** currently have several DESIDRY units being modified to operate on float level control. We are also installing a high level float which will shut in the well in the case of a high level. These are to be installed and tested in the next several weeks.

The Operational Problems

Green Completions –

- Started using DESIDRY in Green Completion but backed off because we needed 2 Desi's in parallel and we had no large Desi units. Had some issues with operational control –
  - during Green Completions DESIDRY units were operated incorrectly (exceeding max flowrate, manually shut-in dump valves). This resulted in flush-out of salt. We addressed this issue with completions team and consequently updated training/awareness. Completed June 2004.
- Currently using 10 MM Dehys on green completion and designing a system to equally split the flows between two Dehy/Desi units.

The Operational Problems

Temperature Control

- ***On 'HOT' Wells Desi units may not be "the ticket" as high temps melt the CaCl.***
- In the winter "Poor" gas temperature control over heats the gas causing excess salt consumption and additional line pluggage. (This occurs when the operators turn up the glycol temperature to prevent freezing and the inlet gas temp control does not work well.)
  - Improving the three way valve temp control on the inlet gas
  - Installing some stand alone glycol heaters to service the peripheral equipment, not using the glycol unit in the Desi Dry.
- "HOT" water has the capacity to hold about 99.3 lbs/ft3 of CaCl while "COLD" water can only dissolve 45.5 lbs/ft3. During the winter time the cold weather forced the brine that has build up in the bottom of the DESIDRY process tower to precipitate out of solution. This causes plugging of vessel drain and subsequent liquid buildup until the DESICANT is renders it ineffective.
  - Added heat tracing to dump lines maintaining a "HOT" temperature to keep solubility high
  - Added Catalytic heaters to the bottom of the DESIDRY tower to maintain "HOT" temperatures to keep solubility high
  - **RESULTS:** These 2 actions helped reducing plugging occurrences.

The Pipeline Problems

- Pipeline company has experienced plugging of their compressor inlet filter with a substance that appears to desiccant used by BP
- BP has experienced a considerable increase in desiccant consumption due to vessel "washouts" – The dumps are not working properly.
- TEPPCO has pigged pure CaCl out from pipeline laterals into which BP "DESIDRY" wells deliver gas

Pigging of Jonah Pipeline Laterals

Pigging station clean out

- Solids shown are predominantly CaCl and Iron Oxide
- BP has seen emptied DESIDRY towers and assumed unloading into the gathering pipeline.
- It seems that most solid CaCl will be deposited in the pipeline laterals near where the “dump” occurred due to its weight.
- The Bottom-Left picture shows CaCl from an known upset at Antelope 5-5. This is pure desiccant (CaCl)

Baker Petrolite Analysis

1. **Phase I Analysis:**
   A. Baker Petrolite Analyzed solid deposits found at the inlet filter for the lumen compressor station.
   B. Desiccant used by BP: 97% CaCl & 3% LiCl
   C. Solids at filter station: 52% CaCl, 26% Organics (TEG) & 21% Iron Oxides (Rust)
   D. 78% of deposits are composed of a CaCl•TEG•H2O compound and not the pure components itself
   E. Formation of this coound was successfully duplicated in laboratory conditions. For this CaCl solved in H20 was mixed with TEG at an elevated temperature. Subsequent cooling allowed the CaCl•TEG•H2O complex to precipitate out.
   F. The exact mechanism is not presently understood, nor is there any understood mechanism for preventing its formation.
2. **Phase II Analysis:**
   A. Second sample from compressor station in-let filter confirms the existence of the CaCl•TEG•H2O compound. Composition of this sample is 35% CaCl, 50% Organics (TEG) & 15% Iron Oxides (Rust)
   B. Substance from 2 pipeline laterals was recovered after pigging activities. Both samples show CaCl with Water and not the CaCl•TEG•H2O compound.
   C. These results lead to believe that the solids formation is happening directly at the inlet filter where the filter removes water and forces precipitation of the CaCl•TEG•H2O complex.
3. **Phase III Analysis:**
   A. BP requested from Baker Petrolite to test if the CaCl•TEG•H2O compound can be formed in given typical process pressures (650 psi) and temperature (75° F to 95 ° F). Their findings:
   B. Adding TEG solids precipitated at either temperature and all of the following molar ratios: 2:1:1, 2:1:2, 1:1:2, 1:2:4 and 1:4:8 (CaCl•TEG•H2O respectively)
   C. Studies would have to be performed to determine if the complex could be broken up.
   D. The obvious option would be removal of either of the 3 components from the pipeline stream.
   E. Analysis of produced water from several wells showed only minor traces of CaCl (ave: $6.5X10^{-6}$ lbs/ft^3) naturally occurring.
   F. No significant amount of CaCl exists in either BP's or EnCana's completions fluids.
4. **Phase IV Analysis:**
   A. Evaluation of the alternative salt desiccants LiCl or NaCl for similar reaction behavior.
   B. It was found that LiCl and NaCl once dissolved in water, remain in solution when TEG was introduced to the system. No solids were formed.

Discussion of Results

- The cause of filter plugging at the Lumen compressor station is not a result of CaCl desiccant only!
  1) The solids are a chemical complex consisting of CaCl•TEG•H2O that crystallizes out of liquid phase
  2) It seems that the complex formed is a result of "unfortunate mixing" and "reactions" in the system
  3) The solids found contain only between 35% to 52% CaCl

- The cellulosic in-let filter at Lumen may contribute to crystallizing the CaCl•TEG•H2O complex out of solution though removal of water.
  1) The CaCl•TEG•H2O complex has not been found anywhere else in the pipeline system (always pure component of either CaCl, TEG in combination with H20).
  2) Thorough mixing of CaCl, TEG and H20 may happen at the slug catcher after which the solution goes through the inlet filter.
  3) There were no operating issues prior to installation of inlet filters with the compressors itself.

Bottom Line

- **There is a lot of potential for Desiccant Drying**
- **There are several mechanical/operational issues that significantly impact the Desi operation:**
  - **Level control (dumping)**
  - **Temperature Control**

They can work in given applications