Produced Water Management

Reducing Cost Through Evaporative Disposal

Produced Water Case Study

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Case Study

Background

- Location: North East Marcellus
- Number of wells: >500 Wells
- Water Production: Most of the wells ~ 1 BPD
- Type: 45% of the wells - High TDS
- Flowback Phase: 0 – 2,500 BPD
- Frac Volume: 100 - 500K BPW
- Fracking: Fresh/Produced/Flowback
- Disposal Cost: $8 - 15/bbl

Objective: Reducing Water Disposal Costs
Technology - Carrier Gas Concentrator (CGC™)

Alternative to Expensive Trucking, Salt Water Disposal or Evaporation Ponds

NO CONTACT BETWEEN COMBUSTION FLAME OR FLUE GASES AND PRODUCED WATER TO BE EVAPORATED

Ambient air from blower

Technology - Carrier Gas Concentrator (CGC™)
CGC Design

Evaporation Capacity: 500 BPD

Footprint: 60’ X 70’
CIP Process and Boiler pump system
Influent, Recirculation and Effluent pump system
CGC Bubble column
Natural Gas Boiler and Air compressor

Interconnecting piping and power leads

Influent Water TDS
Variable

Operating Conditions
- Top Brine Temp: 200 F
- Air flow: 4,000 scfm
- Thermal Consumption: 0.5 Mcf/bbl

Effluent Water
200,000-250,000 ppm
Technology - Carrier Gas Concentrator (CGC™)

Features for Cost Savings:

- **Compact:**
  - Multi-stage bubble column humidification
  - High heat and mass transfer rates

- **Automated:**
  - Proprietary control algorithm

- **Minimal Pretreatment:**
  - Robust internal design

- **Lower Energy Consumption:**
  - High energy effectiveness because of efficient multi-stage design

- **Lower emissions**
  - No direct contact

- **Reliability:**
  - Developed out of MIT
  - Lab tested for over 5 years
  - Commercially operated in the oilfield using various produced waters over 2 years

Application:

- Greenfield development
- Disposal constrained regions
- High trucking costs
- Enhancing evaporation pond or SWD capacity
Technology - Carrier Gas Concentrator (CGC™)

- **Permitting:**
  - PA DEP
  - Air Emissions (TPY)

- **Spills:**
  - Handled as per operator’s SOP. No major potential due to
    - Lower volume
    - Nature of process – Automated

- **Influent and Effluent Testing on site:**
  - Stack Testing

- **Waste: Heavy Brine**
  - Can be made a ZLD process

- **Potential Impacts – Methanol**
Case Study: Set-up

- **Heat Source**
- **Saturated Brine**
- **CGC**
  - Basic Filtration
  - Single Antiscalant
- **Water Vapor**
- **Produced Water**
  - Wellhead
  - Or Trucking

**SCADA Connectivity**
Case Study: Reducing Trucking Cost Through Evaporation

**Graph:**
- **Title:** Case Study - Reducing Cost
- **X-axis:** Number of Days
- **Y-axis:** Volume (bbls)
- **Legend:**
  - Inlet Volume
  - Evaporated Volume

**Table:**

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<th>Evaporated Volume</th>
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**Graph Description:**
- The graph illustrates the change in volume over time, showing the inlet volume and the evaporated volume.
- The number of days is shown along the x-axis, ranging from 1 to 69.
- The volume is shown on the y-axis, ranging from 0 to 1600 bbls.

**Conclusion:**
- The graph shows how the evaporated volume decreases as the number of days increases, indicating an effective method for reducing trucking costs through evaporation.
Case Study

- Influent Average Salinity > 83,000 ppm
- Generated Heavy Brine Salinity > 221,000 ppm
Case Study: Reducing Trucking Cost Through Evaporation

- **45% Cost savings compared to trucking**
- Consistent Operation – Water Evaporated
  - Influent
  - Evaporated water
- Clean vapor
- Robust System: Varying Influent TDS
- Minimal Pre-Treatment
- Ambient Pressure
- Low Operational Temperature
- Operated November ’16 – February ’17
  - Winterization
- Temperature profile throughout column is monitored to ensure consistent performance.
- For smooth operation, consistent temperatures are a crucial parameter.
- Ensures consistent production and energy usage.
- Data points show a 30 minute average during steady state operation.
Scale accumulation on HX plate

THERMAL RESISTANCE IN HX, 1/(UA) [K/KW]

12-HOUR SHIFT #

Clean heat exchanger slow scale build-up

Scale buildup phase with up to 15% reduction in heat transfer coefficients

Cleaned heat exchanger with renewed heat rates

CRITICAL SCALE THICKNESS REACHED
SCALE CLEANED
Lessons Learnt/Challenges

- Emissions
  - Source or Centralized
  - VOC’s – Air Stripper
    - Modelling
    - Methanol
- Water Chemistry
  - Defoamers, Gas Hydrate Inhibitors
- Stack Testing
  - Cost
- Natural Gas
  - Availability
- Regulations
  - PM 10, PM 2.5
  - TPY
Acknowledgements

Chesapeake Energy Corporation
Q&A