Utilization of a Vapor Recovery Tower For The Reduction of Tank Emissions
Agenda

- Need & Concerns
- VRT Functionality
- Process Model
- Benefits of Limiting Tank Flash
- Benefits of Higher MAWP of VRT
- Considerations
- Summary & Conclusions
- Q&A
Need & Concerns

The Issues and Concerns That Exist Today
Need: Atmospheric Tank Design

- General design criteria: API 12F [1]
  - 90-500 BBL tanks design:

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<table>
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<tbody>
<tr>
<td><strong>Table 1: API 12F Tank Design Pressures</strong></td>
<td></td>
</tr>
<tr>
<td>Design Vacuum</td>
<td>$\frac{1}{2}$ ( \text{oz} ) ( \text{in}^{-2} )</td>
</tr>
<tr>
<td>Design Pressure</td>
<td>16 ( \text{oz} ) ( \text{in}^{-2} )</td>
</tr>
<tr>
<td>Emergency Venting</td>
<td>24 ( \text{oz} ) ( \text{in}^{-2} )</td>
</tr>
</tbody>
</table>

- Relief methods
  - Vent Line
    - Creates back pressure
    - Large line size
  - Thief/Gauge hatches
    - Sealing concerns: (reseating & wear)
    - Flame propagation
Need: Vapor Recovery Unit

- Operating VRU on tank vent line
  - Small suction pressure range
  - Potential to pull vacuum
  - Oxygen in tanks from tank breathing & gauging
    - Compressing air and gas
    - Oxygen in sales line

(Unimac Gas Compression Solutions)\(^2\)
Need: Operator Safety

- Tank gauging process
  - Open thief hatch
  - Lower tank gauge tape
  - Standing over/by hatch

- Operator exposed to flashed gas
  - Explosive, irritant, & asphyxiant
  - Possibility of $H_2S$
Need: New Regulations

- 40 CFR 60, Subpart OOOO
  - Tanks with more than 6 tons/year VOC

- Colorado:
  - CDPHE: Regulation 7
  - COGCC: Series 800
Vapor Recovery Tower

VRT: Functionality & Computer Models
VRT: Functionality

Separation mechanisms:
- Low pressure: Flashing of light ends
- Greater diameter than inlet: lower velocity lessens gas entrainment
- Vessel height: gravitational separation
- Mist pad: Liquid impingement

Stream destinations
- Gas: Combustion device/VRU
- Oil: Oil tanks
- Recycle: Separator inlet
VRTX: Functionality

Vessel construction

- Larger pressure operating range
  - Pressure vessel: makes higher operating pressure possible
  - Fluid driven by hydraulic head: Makes low-pressure operation possible
- No low-pressure/vacuum vents
  - No process gas to environment
  - No oxygen can enter
Process Model[3]: Without VRT

**Temp:** 120°F  
**Pressure:** 39.7 psia  
**API Gravity:** 51.1  
**Flow:** 1030 bbl/day

**Temp:** 108°F  
**Pressure:** 12.7 psia  
**API Gravity:** 49.6  
**Flow:** 1005 bbl/day

**Sales Gas Properties**  
**Temp:** 70°F  
**Pressure:** 39.7 psia  
**Btu Content:** 1397 btu/scf  
**Flow:** 704 Mscfd

*Note: Atmospheric pressure is based off of Denver, CO [12.2psia]*
**Process Model[^3]: With VRT**

**Sales Gas Properties**
- **Temp:** 70°F
- **Pressure:** 39.7 psia
- **Btu Content:** 1397 btu/scf
- **Flow:** 704 Mscfd

*Note: Atmospheric pressure is based off of Denver, CO [12.2psia]*

[^3]: Atmosphere
Process Analysis

Table 2: Tank Flash Gas Comparison

<table>
<thead>
<tr>
<th></th>
<th>With VRT</th>
<th>Without VRT</th>
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</thead>
<tbody>
<tr>
<td>Initial Production Rate</td>
<td>1.4 (Mscfd)</td>
<td>35.9 (Mscfd)</td>
</tr>
<tr>
<td>Yr. 1 Average Rate</td>
<td>0.7 (Mscfd)</td>
<td>17.95 (Mscfd)</td>
</tr>
<tr>
<td>Yr. 1 Total Volume</td>
<td>255.5 (Mscf)</td>
<td>6,552 (Mscf)</td>
</tr>
<tr>
<td>Yr. 1 Total VOC</td>
<td>4.5 tons</td>
<td>115 tons</td>
</tr>
</tbody>
</table>

Assumptions:
1. 35 lb/Mscf VOC emissions factor
2. Decline rate based of unconventional decline curve and equates to the average first years production being 50% of initial production
3. Based on 1000 bbl/day initial production
VRT: Benefits of Installation

- Limits volumetric gas flow through tanks
  - Less back pressure on tanks
    - Keep thief hatches from opening
      - Lower uncontrolled emissions
      - Increase process/operating safety (ignition potential)
  - Manual tank gauging
    - Limits emissions while hatch is open
    - Reduces operators risk
      - Explosion/fire
      - Operator exposure/H₂S hazard
  - May allow vent line size reduction
    - Lower material cost
    - Lower labor cost
    - Lower construction time
  - Quad O
VRT: Benefits of Installation

- Allows for higher working pressure of gas
  - Easier measurement if desired
    - Flow meter can be allowed to create lbs. of back pressure
    - Measurements can be more accurate
  - Higher pressure to combustor
    - Move more gas volume
    - Higher burner tip velocity
      - Better fuel air mixing
      - Better combustion of heavier components
  - Protection for tank overpressure
    - Oil dump valve sticking open
    - High oil dump rate
  - Higher VRU suction pressure
    - May simplify controls
    - Protect from pulling vacuum on tanks
VRT: Added Benefits

- Additional point for separation
  - Water off the bottom of the tower
  - Mist pad to coalesce entrained liquid in gas

- Liquids surge vessel
  - More continuous flow to tanks
  - Help eliminate liquid slugging in tanks
  - Lessen pressure spikes due to filling tank
VRT: Special Considerations

- Stake holder view/height restriction
- Additional capital cost
- Lightning strike concerns
- Process considerations
Summary & Conclusion
Summary/Conclusions

- Installation of a VRT can be used as an engineering solution to reduce VOC emissions
- Installation of a VRT can help to improve operator/process safety
- Installation of a VRT gives you additional overpressure/vacuum protection for atmospheric tanks
- Installation of a VRT would lessen the likelihood of gauge hatches unseating and thus lower the chance of infractions
- Cost, stakeholder perspective, lightning risk, and process conditions must be examined when considering VRT installation
Questions & Answers
Special Thanks & Citations

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— Steve G. Bradford, Engineering Manager
— Milind J. Bhatte, Manager of L48 Environmental & Sustainable Development
— Ken T. Powers, Superintendent of Niobrara Operations
— Terry L. Parker, Facilities Engineer
— Seth Lovelady, Facilities Engineer
— Maria A. Torres, Environmental & Regulatory Supervisor
— Beth Aldrich, Environmental Coordinator

Citations:

Biography

Bachelor of Science in Mechanical Engineering
  - Texas A&M: graduated *magna cum laude*

Research Positions
  - High temperature metallic/ceramic compounds: 2yr
  - Down-hole shaped charge design: 1yr

Oilfield Positions
  - Downstream refining
    - Projects engineer: 2010
    - Maintenance engineer: 2011
  - Exploration & production
    - Facilities engineer: 2012-present