Reducing Storage Tank Emissions Without Compromising Operational Performance

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Vice President of Sales & Marketing, HMT Inc.
Presentation Overview

• **Tank Emissions Mechanisms**

• **Tank & Floating Roof Types**
  – And their impacts on emissions

• **Design Strategies for Low Emissions**
  – (Floating roof tank options)

• **Other Minor Strategies**
Operational Performance Factors

- Working Capacity
- Heel Reduction
- Safety
- Accessibility
- Fire Protection
- Maintenance (painting, drains, water removal, snow, etc.)
- Durability & Useful Life
- Installation (ease, speed, cost)
- Ease of Cleaning and Inspection
- Initial Cost (project cost and cost per barrel of capacity)
Reducing Storage Tank Emissions Without Compromising Operational Performance

Regulatory Considerations

- These are general design concepts presented here
- Your regulations and specific situation may vary
- Check with your environmental group to verify requirements

The ever-changing regulatory world
(chart already obsolete...for illustration purposes only)

* Chart courtesy of Rob Ferry, the TGB Partnership
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Tank Emissions Mechanisms
Mechanisms for Evaporative Loss

- **Working (or “filling”) losses** – Cone Roof Tanks

**INFLUENCED BY**
- Average temp
- Temperature changes
- Tank cycle frequency
- Vapor pressure
- Tank diameter and height
- Tank color
Mechanisms for Evaporative Loss, continued

• Withdrawal losses – Floating Roof Tanks

INFLUENCED BY
• Tank cycle frequency
• Tank shell condition
• Viscosity / clingage factors
• Floating roof seals
• Tank diameter and height
Mechanisms for Evaporative Loss, continued

- **Breathing losses** – Cone Roof Tanks

INFLUENCED BY

- Average temp
- Temperature changes (especially from sunshine and cloud patterns)
- Vapor pressure
- Tank diameter and height
- Tank color
Mechanisms for Evaporative Loss, continued

- **Standing losses** – Floating Roof Tanks
  - From rim seals, deck appurtenances and deck seams

INFLUENCED BY
- Average wind speed (for EFRTs)
- Average temp
- Temperature changes
- Vapor pressure
- Fixed roof (IFRT) vs. none (EFRT)
- Floating roof type
- Deck penetrations
- Floating roof seals
- Tank color
Where can we make an impact?

- Working losses
- Breathing losses
- Withdrawal losses
- Standing losses
Standing Losses – Design / Selection Factors

• **Fixed roof over the floating roof**

• **Floating roof penetrations and features**
  - Perimeter seal types
  - Deck seams (for bolted construction IFRs)
  - Appurtenances
    - Columns penetrations
    - Adjustable leg penetrations
    - Gauge pole / ladder penetrations
    - Manways
    - Pressure / vacuum release vents
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Tank & Floating Roof Types and Impact on Emissions
Floating Roof Tank Types

**Traditional EFRT**
Leg-supported Pontoon EFR

**Domed EFRT**
Leg-supported Pontoon EFR, Retrofitted w/Geodesic Dome

**Traditional IFRT**
Leg-supported IFR under Steel Cone Roof

**Suspended IFR**
Suspended IFR under Steel Cone Roof

**IFRT with Dome**
Leg-supported IFR under Aluminum Geodesic Dome

**Suspended IFR + Dome**
Suspended IFR under Aluminum Geodesic Dome
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Internal Floating Roof Types

- **Steel Pan**
- **Steel Bulkhead**
- **Steel Pontoon**

- **Conventional Skin & Pontoon**
- **Heavy Duty Skin & Pontoon**
- **Bolted-seam Panel Construction Full Contact**
- **Welded-seam Panel Construction Full Contact**
- **Composite (GRP) Full Contact**
Impact on emissions:
Presence of a fixed roof

- Eliminates wind effect
- Also reduces liquid surface temp

**Difference of 12,859 lbs per year**
Based on 120’ diameter tank in Houston storing RVP 10 Gasoline; 24 cycles/year
Impact on emissions:

Cone roof vs. self-supported fixed roof

- Column penetrations vs. none

**Difference of 2,986 lbs per year**

Based on 120’ diameter tank in Houston storing RVP 10 Gasoline; 24 cycles/year
Impact on emissions:

Leg-supported vs. suspended IFR

- **Adjustable leg penetrations vs. none**

**Difference of 2,940 lbs per year**

Based on 120’ diameter tank in Houston storing RVP 10 Gasoline; 24 cycles/year
Impact on emissions: Bolted vs. Welded Construction

- **Bolted Construction**
  - Skin & Pontoon AIFR
  - Bolted sheet Construction
  - Bolted Full Contact AIFR
  - Bolted panel Construction

- **Welded Construction**
  - Steel IFR or EFR
  - Welded Construction
  - Welded Full Contact AIFR
  - Welded Construction
  - Composite (GRP)
  - One-piece Construction

• **Welded (one-piece) construction eliminates deck seam emissions**
Impact on emissions:
Bolted vs. welded (one-piece) IFR construction

Skin & Pontoon
Sheet-construction
(Bolted)

Full Contact
Panel-construction
(Bolted)

Any Welded or
One-piece IFR

Emissions along each
deck seam

5,136 lbs/yr

8,475 lbs/yr

0 lbs/yr

Assumptions: 120’ x 48’ tank, 2’ freeboard, Gasoline RVP 13, Houston, 24 turnovers/year.
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Design Strategies for Low Emissions
First design choice: EFRT or IFRT?

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Higher emissions</td>
</tr>
<tr>
<td>Easier to achieve longer out-of-service inspection intervals</td>
<td>Bulky EFR profile doesn’t optimize capacity</td>
</tr>
<tr>
<td></td>
<td>Painting/coating required</td>
</tr>
<tr>
<td></td>
<td>Drain maintenance</td>
</tr>
<tr>
<td></td>
<td>Limited material choices</td>
</tr>
<tr>
<td></td>
<td>Snow / ice hazards</td>
</tr>
<tr>
<td></td>
<td>Rainwater gets in product</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower emissions due to elimination of wind</td>
<td>Cost</td>
</tr>
<tr>
<td>More IFR type and material choices</td>
<td>10-year seal inspection</td>
</tr>
<tr>
<td>No drain maintenance</td>
<td></td>
</tr>
<tr>
<td>Low-profile IFRs can gain significant capacity</td>
<td></td>
</tr>
<tr>
<td>No snow / ice hazards</td>
<td></td>
</tr>
<tr>
<td>No rainwater in product</td>
<td></td>
</tr>
</tbody>
</table>
Second design choice: cone roof or dome?

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good for sealed / pressurized applications</td>
<td>Higher emissions (from column penetrations)</td>
</tr>
<tr>
<td>Shallow pitch is easier to walk on</td>
<td>Columns create other issues (corrosion, settlement, out-of-plumbness)</td>
</tr>
<tr>
<td></td>
<td>Painting/coating required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower emissions</td>
<td>Visually taller profile</td>
</tr>
<tr>
<td>No columns to maintain</td>
<td>Steeper pitch at perimeter more difficult to walk on</td>
</tr>
<tr>
<td>No paint to apply or maintain</td>
<td></td>
</tr>
<tr>
<td>Capacity gain at top (foam chambers or rafter clips)</td>
<td></td>
</tr>
</tbody>
</table>
## Third design choice: suspended or legs?

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>No tank entry required to change IFR positions</td>
<td>Not practical with steel IFRs</td>
</tr>
<tr>
<td>Lower emissions due to elimination of leg penetrations</td>
<td>Evaluation of designs recommended</td>
</tr>
<tr>
<td>Eliminates maintenance, inspection, repair issues</td>
<td>Suspension from existing dome may not be possible</td>
</tr>
<tr>
<td>associated with legs</td>
<td></td>
</tr>
<tr>
<td>Multiple positions can be set for flexibility</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank entry required to set IFR positions</td>
<td></td>
</tr>
<tr>
<td>Higher emissions (from leg penetrations)</td>
<td></td>
</tr>
<tr>
<td>Legs create additional inspection / corrosion points</td>
<td></td>
</tr>
</tbody>
</table>
### Fourth design choice: IFR Type

<table>
<thead>
<tr>
<th></th>
<th>Skin &amp; Pontoon AIFR</th>
<th>Bolted Full Contact AIFR</th>
<th>Steel IFR</th>
<th>Welded Full Contact AIFR</th>
<th>Composite (GRP)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emissions</strong></td>
<td>Fair</td>
<td>Poor</td>
<td>Good</td>
<td>Best</td>
<td>Best</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>Best</td>
<td>Best</td>
<td>Fair</td>
<td>Best</td>
<td>Best</td>
</tr>
<tr>
<td><strong>Speed of Install</strong></td>
<td>Best</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Durability</strong></td>
<td>Fair (^1)</td>
<td>Fair/Good (^2)</td>
<td>Best</td>
<td>Good</td>
<td>Best</td>
</tr>
<tr>
<td><strong>Corrosion Resistance</strong></td>
<td>Poor to Good (^3)</td>
<td>Poor to Good (^3)</td>
<td>Poor to Good (^3)</td>
<td>Poor to Good (^3)</td>
<td>Best</td>
</tr>
<tr>
<td><strong>Can be Suspended</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>$$ / $$$</td>
<td>$$ / $$$</td>
<td>$$$$</td>
<td>$$$$$</td>
<td>$$$$$$$</td>
</tr>
</tbody>
</table>

\(^1\) Skin & Pontoon IFRs come in a wide range of weights and qualities; heavy duty skin & pontoon IFRs with bi-directional structure and connections designed to handle high cycles, high flow rates, and dynamic loading can last longer than the tank without major maintenance required

\(^2\) Bolted full-contact IFRs also come in a wide range of qualities and designs; consult manufacturers for more information

\(^3\) Depends on product and whether steel roof is painted / coated
Alternate technologies have made significant advancements

• Talk to your IFR suppliers to learn more
Reducing Storage Tank Emissions Without Compromising Operational Performance

Emissions Comparison (lbs/year) for Various Tank Configurations and Various Major Markets

<table>
<thead>
<tr>
<th>Location</th>
<th>EFRT</th>
<th>Cone Roof Steel IFR Adj Legs</th>
<th>Cone Roof, Aluminum Skin &amp; Pontoon IFR, Adj Legs</th>
<th>Cone Roof, Aluminum Bolted Panel AIFR, Adj Legs</th>
<th>Dome Roof, Welded Panel AIFR Suspended (no legs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houston</td>
<td>20,896</td>
<td>8,037</td>
<td>12,960</td>
<td>14,423</td>
<td>1,464</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>17,701</td>
<td>7,196</td>
<td>11,594</td>
<td>12,902</td>
<td>1,327</td>
</tr>
<tr>
<td>New Jersey</td>
<td>20,653</td>
<td>5,834</td>
<td>9,383</td>
<td>10,438</td>
<td>1,090</td>
</tr>
<tr>
<td>Chicago</td>
<td>18,975</td>
<td>5,245</td>
<td>8,426</td>
<td>9,372</td>
<td>991</td>
</tr>
<tr>
<td>Tulsa</td>
<td>24,597</td>
<td>6,887</td>
<td>11,092</td>
<td>12,343</td>
<td>1,271</td>
</tr>
<tr>
<td>New Orleans</td>
<td>21,808</td>
<td>8,040</td>
<td>12,965</td>
<td>14,430</td>
<td>1,465</td>
</tr>
<tr>
<td>Singapore</td>
<td>18,837</td>
<td>10,553</td>
<td>17,046</td>
<td>18,977</td>
<td>1,891</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>41,181</td>
<td>11,445</td>
<td>18,495</td>
<td>20,591</td>
<td>2,058</td>
</tr>
</tbody>
</table>

Assumptions
- All tanks are 120’ diameter x 48’ tall with 44’ of working capacity (3,722,518 gal)
- Stored product is gasoline, RVP 10
- Each IFR equipped with primary mechanical shoe seal and rim-mounted secondary seal
- Each IFR with the exception of the welded IFR is equipped with adjustable deck legs
- Emissions based on 24 tank turnovers per year
- Bolted panel based on a 5’ x 12’ panel; bolted sheet is 5’ wide
- All deck fittings “Typical” except the suspended IFR, which has no leg penetrations
- Cone roofs have 7 columns
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Other minor strategies
Gauge Pole Sleeves

- Gauge Pole Wells are often overlooked as large sources of emissions and product loss
- Large liquid surface area
- An improperly sealed gauge pole can emit more than 25 times the VOCs as the entire primary and secondary seal systems combined
- Wind makes the problem worse
Gauge Pole Sleeves, continued
Roof Leg Socks
Tank Diameter

- **Smaller diameter = less emissions**

- **Strategy:**
  - Get soil analysis done early in the game to see if you can go up in height and reduce diameter
Summary of Strategies

• **Major design strategies**
  
  – Eliminate wind effect (cover the tank)
  – Eliminate columns (use a self-supported fixed roof)
  – Eliminate leg penetrations (suspend the IFR)
  – Eliminate deck seams (use welded or one-piece construction)

• **Other minor strategies**
  
  – Gauge pole sleeves
  – Leg socks
  – Tank diameter (early in design process)
Thank You

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www.hmttank.com