Beyond API 2000
Preventing Sudden Vacuum Collapse

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Sudden Vacuum Collapse
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Vacuum & Pressure Ratings

• Typical pressure rating of large tank is 1 psig
  (16 ounces per square inch, 6900 pascal)

• Vacuum rating might be as low as 1 ounce per square inch (431 pascal)
Pressure-Vacuum Relief Valve
Pressure-Vacuum Relief Valve
How do you size a vacuum vent?

API 2000
API 2000 Vacuum Sizing

1 to 2 SCFH of air per ft$^2$ of vessel area
($\sim 0.04$ Nm$^3$/hr)

Protects against severe weather change

$T < 120^\circ$F ($49^\circ$C)
API 2000 Key Points

• Heat loss is about 20 BTU per hour per square foot of surface
• Shell could be cooled as much as $30^\circ\text{F}$ ($17^\circ\text{C}$)
• Roof could be cooled as much as $60^\circ\text{F}$ ($33^\circ\text{C}$)
API 2000
Heat Transfer Coefficient

- $Q = U \ A \ \delta T$
- $A = 1$ square foot
- $Q = 20$ Btu / hour ft$^2$
- Delta T = $30^\circ F$ to $60^\circ F$

- $U = 0.33$ to $0.66$ Btu / hour ft$^2 \ ^\circ F$
  (2 to 4 watts/m$^2 \ ^\circ K$)
- if $T < 120^\circ F$

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API 2000 Warning

“An engineering review should be conducted for heated uninsulated tanks where the vapor space temperature is maintained above 120°F”
Steaming Out a Vessel
Rain
Vessel Wall With Non-Condensables

Outside Vessel

Inside Vessel

Vessel Wall

Non-condensable molecules
Condensable molecules

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Vessel Wall Without Non-condensable Molecules

Outside Vessel

Inside Vessel

Non-condensable molecules

Condensable molecules

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Consequences
Heat Transfer Coefficient (U) vs Condensables

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Are non-condensables gone?

• Temperature
• Time
Time Constant for Purging

Time constant = \( \frac{\text{Vessel volume}}{\text{Flow rate}} \)
Time Constant for Purging

75,000 gallon vessel (284 met3)

2000 lbs/hour of steam flow
(900 kg/hr)

Time constant = \[
\frac{10,000 \text{ ft}^3}{1000 \text{ ft}^3/\text{minute}}
\]

= 10 minutes

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Vapor Space Purging

Non-condensable Concentration

Time Constants

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Safeguards

• Check the vacuum venting requirements for the severe case
• Recognize when a vessel is vulnerable (time, temperature, no venting)
• Recognize the danger of sudden rain or deluge
• Introduce non-condensables
Conclusions

• API 2000 usually OK
• High temperature vapors can purge out non-condensables
• Purging with condensables can pose a sudden condensation risk
• Difficult to provide sufficient venting
• Introduce non-condensables
• Awareness is the best safeguard
Questions?
Thank you