Pressure Relief Reaction Forces – The Importance of Evaluating Existing Installations

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Saudi Aramco
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Agenda

- Installation Details
  - Inlet Piping Design
  - Piping Support
  - Administrative Controls
- Atmospheric Discharge
  - Dispersion Consideration
  - Liquids
  - Review Surrounding Areas

Installation Details

Inlet Piping Design – General Good Practices

- Limit the inlet line losses to 3%
  - Use full bore PSVs sparingly and knowingly
- Ensure relief valve accessibility for maintenance
- Ensure valves used for PSV isolation are full port
  - Consider gate valves instead of ball valves for PSV inlets/outlets
  - Audit the CSO/LO procedures
- Ensure the outlet piping is free draining
- Ensure that the outlet piping is supported
- Ensure that the valve is vertical
- Ensure that the valve disposition is
  - Pointed Up
  - At least 10’ away from anything

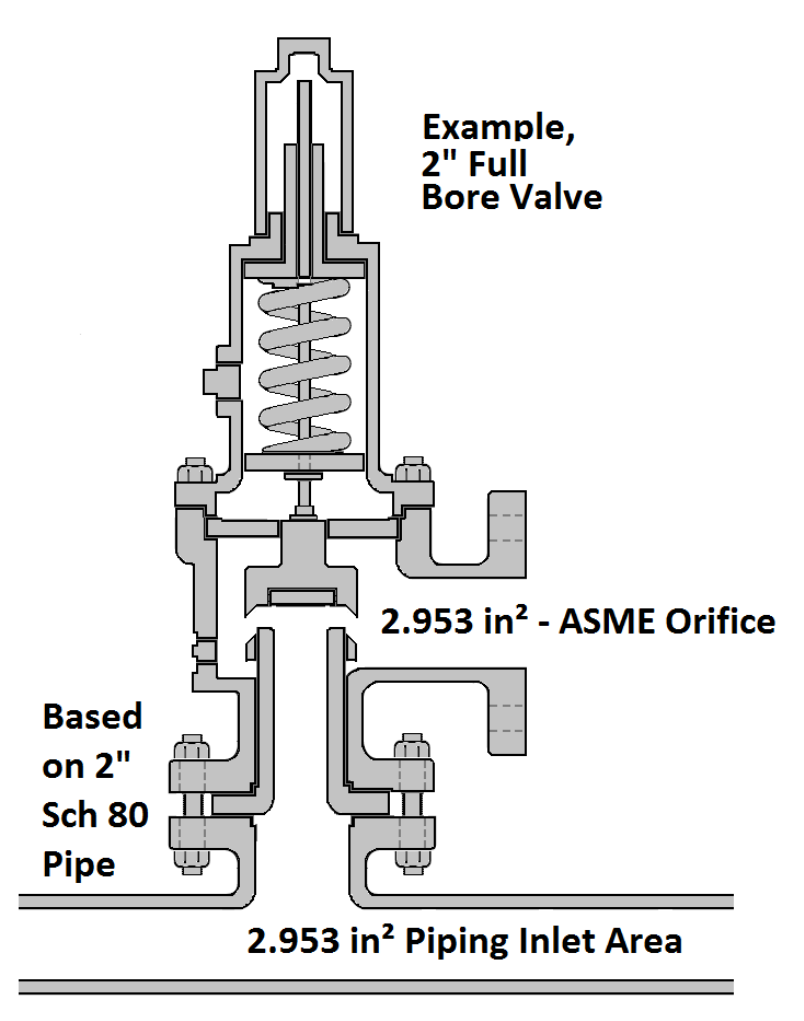
Installation Details

Inlet Piping Design – Pressure Losses

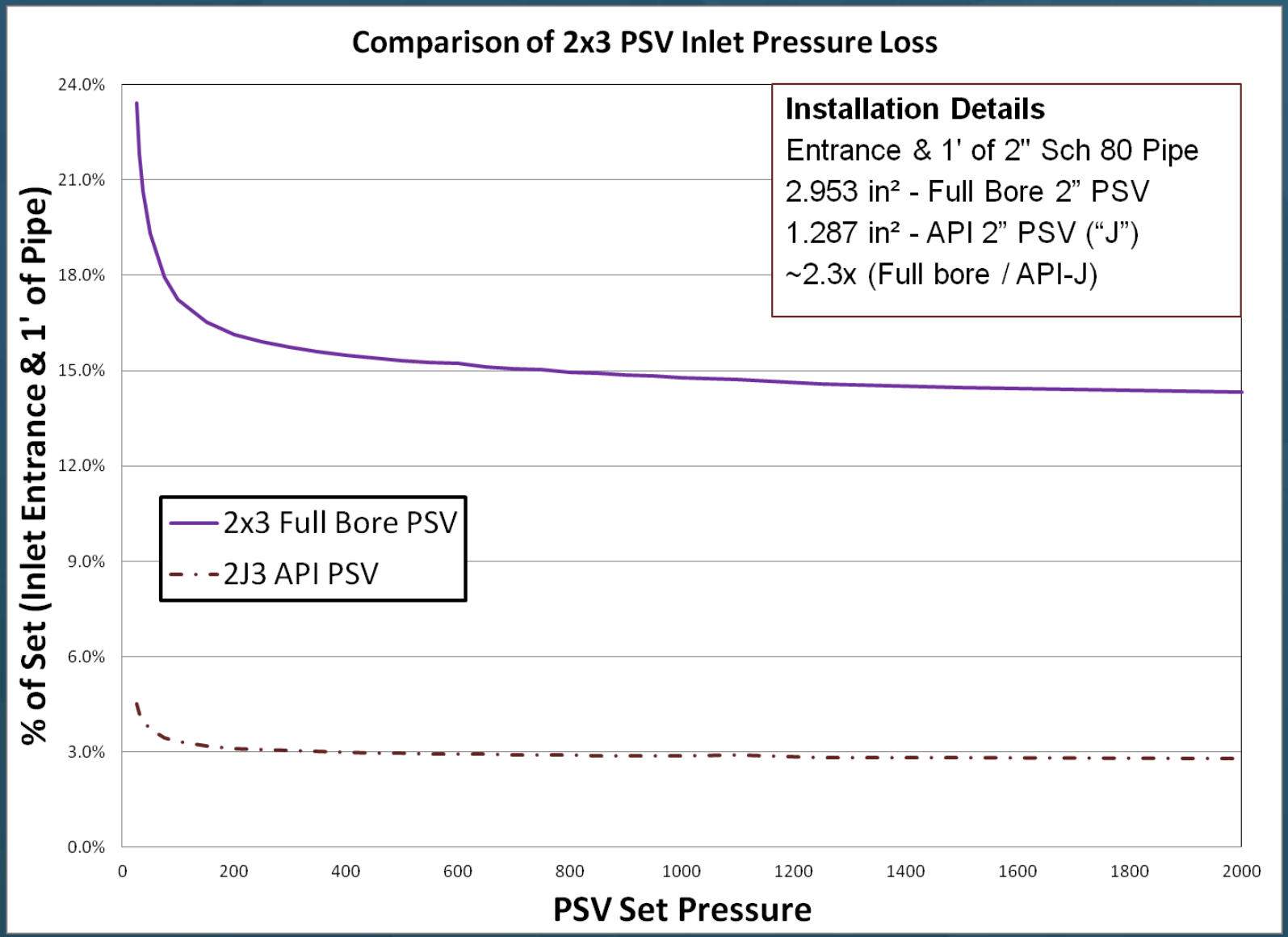
Use of Full Bore Relief Valves

- Good Engineering Practice
  - Inlet losses > 3% of set
  - Valve Stable
- Manufacturers concerns
  - Valves may fail at ~ 7% to 10%
  - Capacity may suffer

These valves are not typical in downstream applications



Installation Details



Installation Details

Inlet Piping Design – Pressure Losses

- The Piping Must Support the Reaction Forces

A chemical Plant was suffering from nozzle failures, so we reviewed 189 installations for structural adequacy.

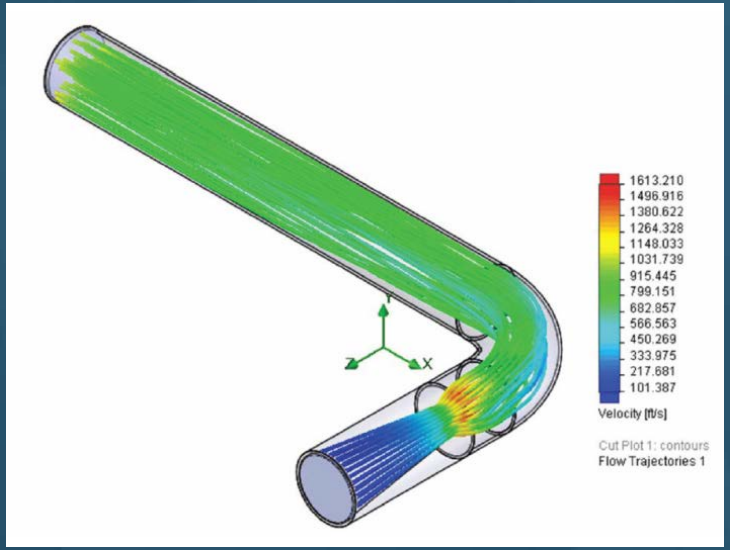
Material	Allowable Stress B31.3 Table A-1 (psi)	Allowable Stress Occasional Load (psi)	Yield Stress B31.3 Table A-1 (psi)	Tensile Stress B31.3 Table A-1 (psi)
A 234 (tee)	23,300	30,990	40,000	70,000
API 5L B (Pipe)	20,000	26,600	35,000	60,000
A105 (Flange)	21,900	29,130	36,000	70,000

The failure criteria used was 70% of the Yield Stress limit.

Installation Details

Inlet Piping Design – Pressure Losses

- Installations were modeled using both steady state and dynamic installation estimates.
- Caesar II v 5.3 was used to detail model ~ 15% of the valves.



Installation Type	# of installations	Requiring detailed analysis	Require Support
Typical	145	4	15
Complex	58	5	13
Total	189	9	28

⅓ of the valves required additional support, these were all API-526 Valves set below 500 psig.

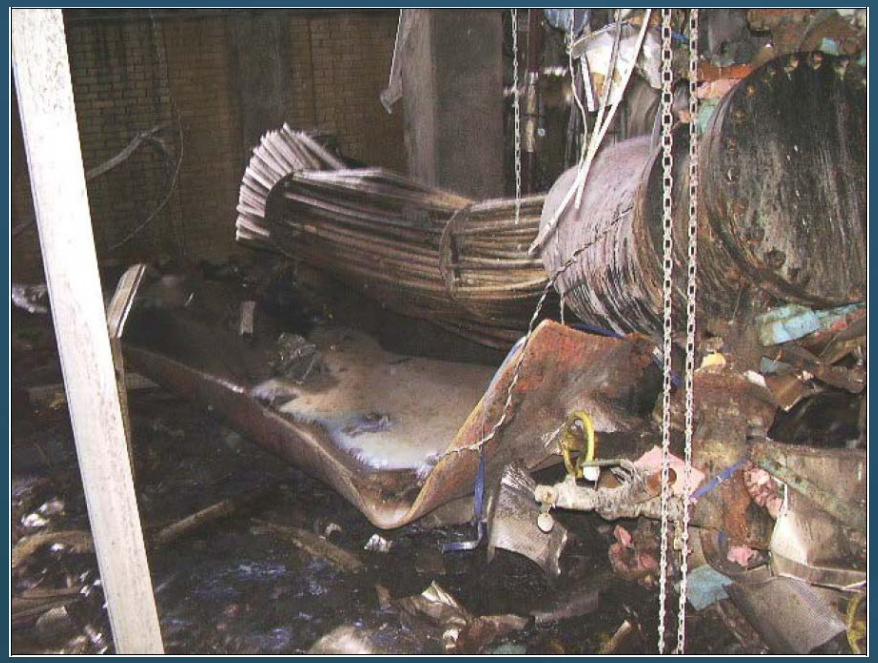
Installation Details

Inlet Piping Design – Administrative Controls

- *Undersized*
  - In 15 years of doing this work I have never seen an undersized relief device causing a loss of containment.
  - Vessel overpressure below hydrotest pressure typical
  - MIDAS DB Search returns 0 Cases (Around 2000/2001)

- *Isolated*
  - Overpressure potentially limitless
  - No capacity when isolated
  - Personal experience / knowledge is ~10 Cases
  - Seems to be increasing in frequency

Installation Details



A Case Study from the CSB.

- The rupture and release injured six employees.
- Operators closed an isolation valve between the heat exchanger shell (ammonia cooling side) and a relief Valve
- Maintenance workers replaced the rupture disk on that day; however, the closed isolation valve was not reopened.
- The pressure in the heat exchanger shell continued climbing until it violently ruptured

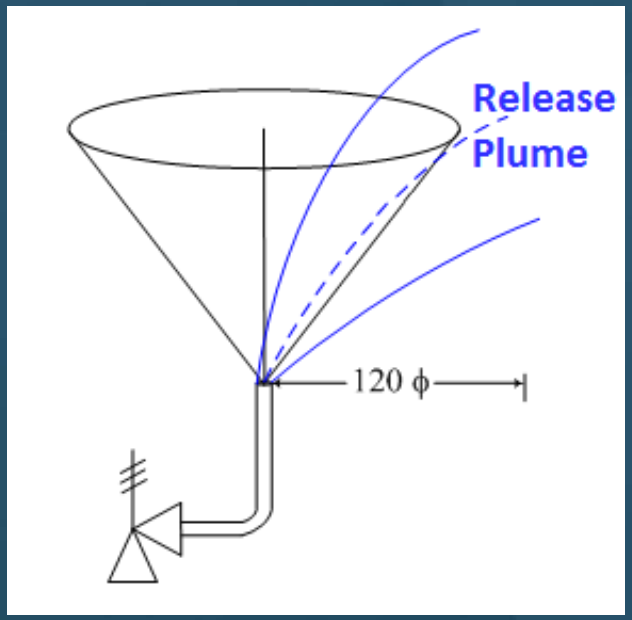
Atmospheric Discharge

General Considerations

- Dispersion
  - Dispersion characteristics need to be considered
  - Most liquids should not be discharged to atmosphere

- Review Areas Surrounding Vents
  - Thermal Radiation Potential
  - Noise
  - Pollution Requirements

Atmospheric Discharge



Dispersion Considerations - general

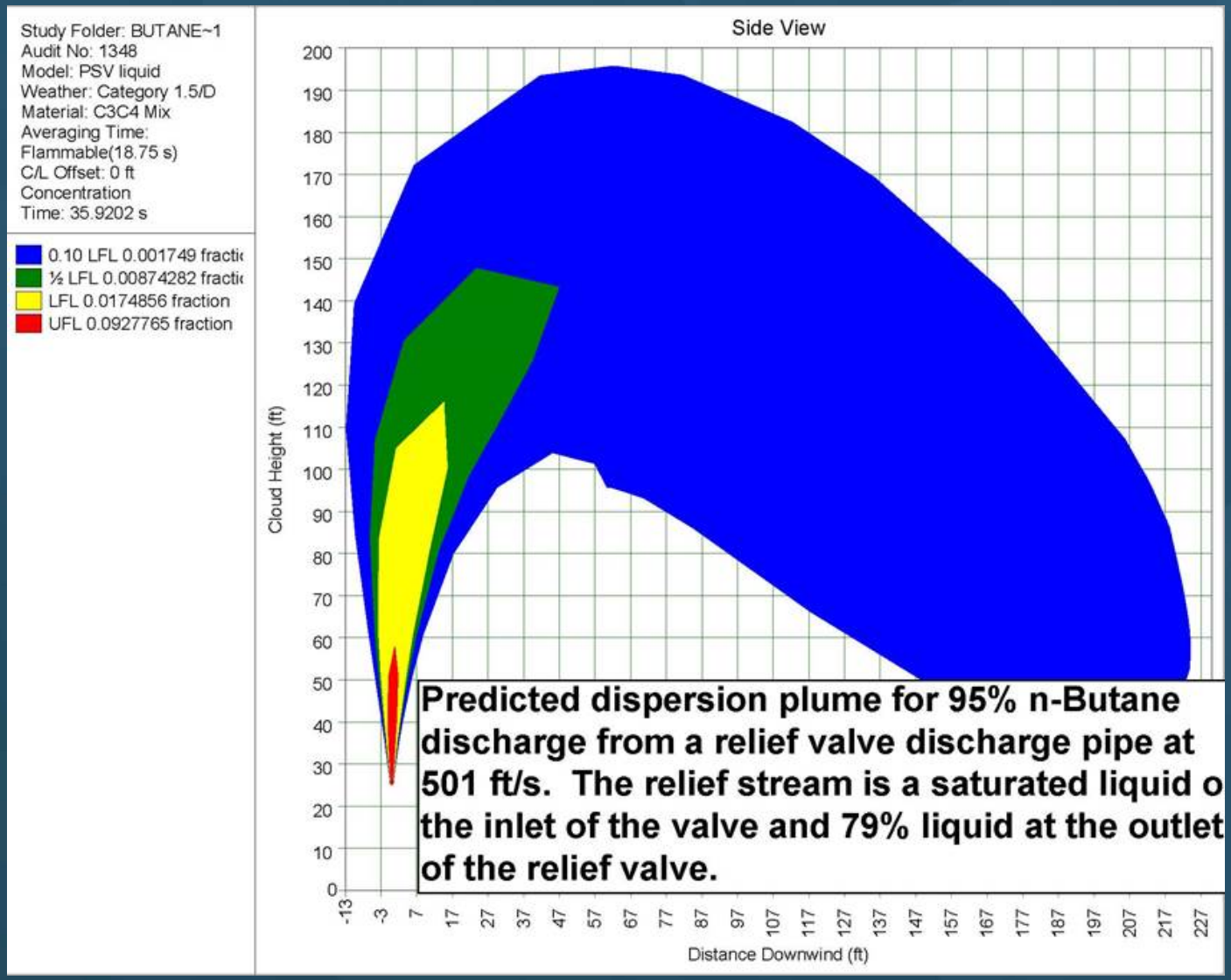
- Nothing within 10’
  - Electrical Area Classification Requirements
- Nothing within 120 diameters, for systems with:
  - Discharge point / PSV same diameter
  - Pop-Action PSVs
  - Limited Toxic Effects
  - MW < 50
- Toxic Considerations
  - 30:1 or 50:1 dilution @ 120 diameters
  - H_2S Concentrations above 0.5 mole fraction may dilute to above the IDLH (100 ppm)

Atmospheric Discharge

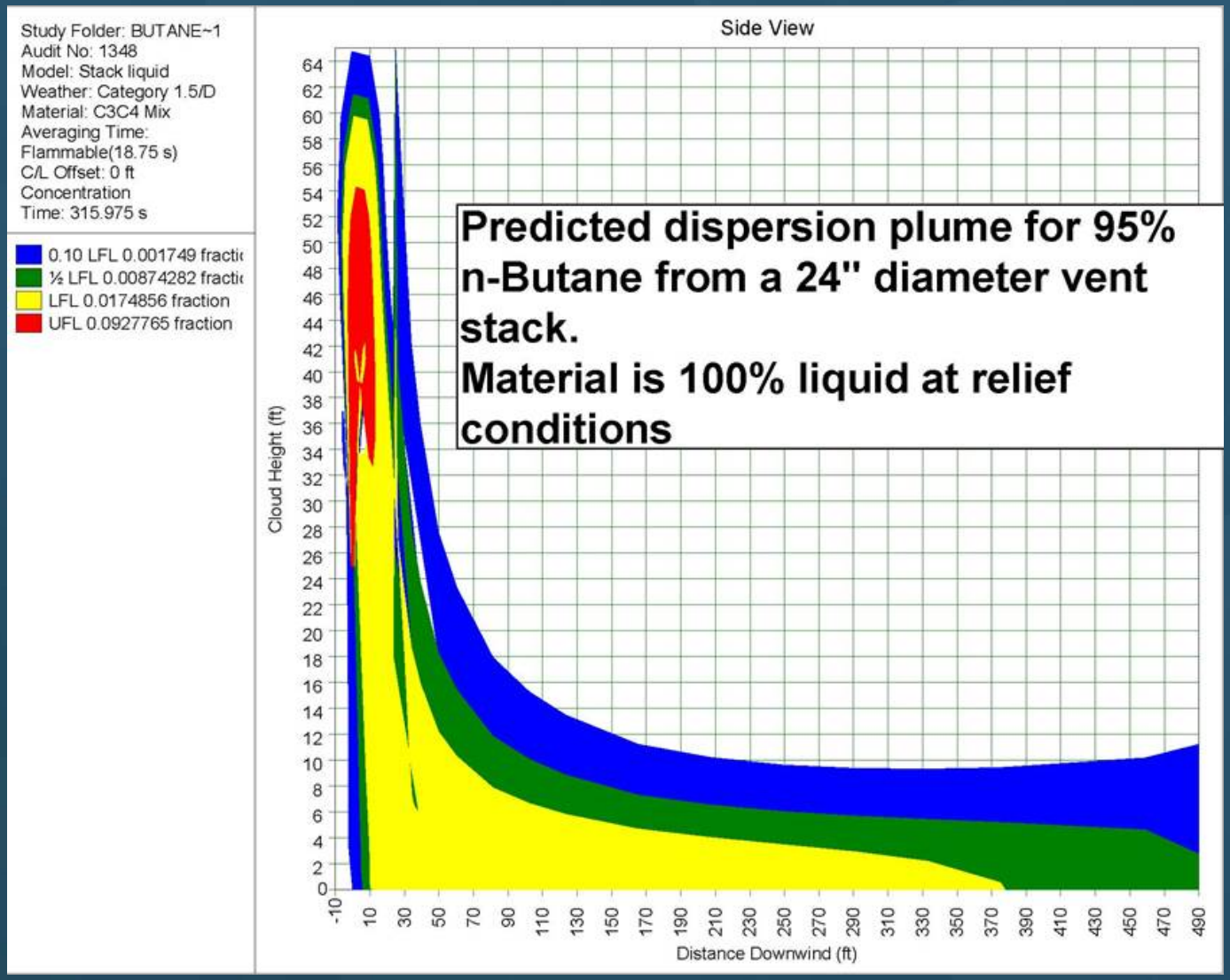
Dispersion Considerations - Details

- Dispersion modeling required if the API guidance is not sufficient
  - High concentrations of toxics (over 50x the limit)
  - Heavy gases
  - Low discharge velocities.
- Next Two Slides show the effects of Exit Velocity
  - Blue is “Okay”, between 10% and 50% of the LFL
  - Green “Concerning” between 50% of the LFL and the LFL
  - Yellow above the LFL and below the UFL
- High velocity discharge toxics may reach grade
  - ~500:1 dilution
  - H_2S Concentrations above 5% (molar) may exceed IDLH

Atmospheric Discharge



Atmospheric Discharge



Atmospheric Discharge

General Considerations

- Review Areas Surrounding Vents
  - Thermal Radiation Potential
  - Noise
  - Toxic Effects
  - Pollution Requirements
- Consider the following
  - Are vents in areas used often by personnel?
  - Are vents located near a property line?
  - If there were an emergency, could the vent block egress?
  - Is the other equipment in the vent system adequate?