Perspectives from Experience

PSV Installation & Discharge More Critical than Sizing

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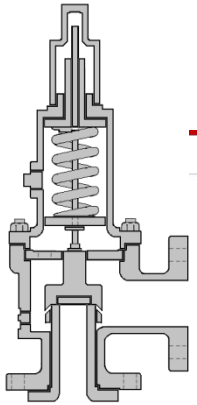
Overview

- Introduction
- Risk Assessments
- Types of Concern Mitigations
- Understanding the Problem
- Planning Ahead
- Case Studies
- Conclusion
- Questions



PSV Installation and Discharge

More critical than sizing

Agenda

Installation Details

- Inlet Piping Design
- Piping Support
- Administrative Controls

Atmospheric Discharge

- Dispersion Consideration
- Liquids
- Review Surrounding Areas

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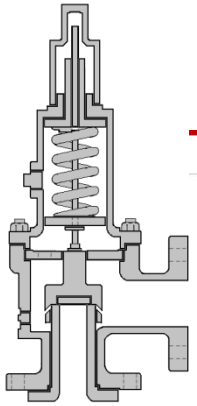
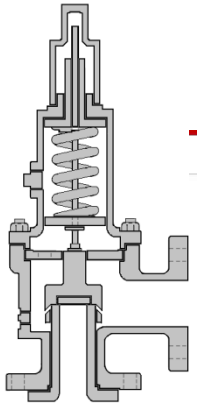


Installation Details

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

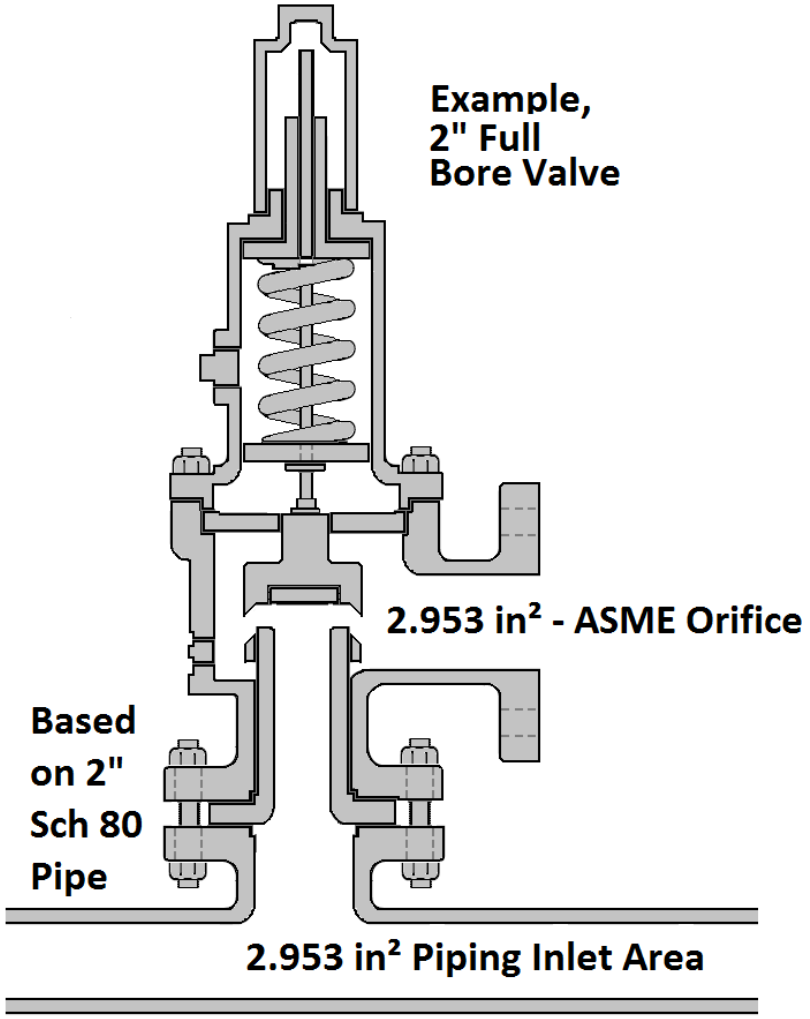
Inlet Piping Design – Pressure Losses

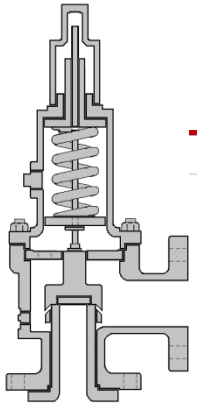
Use of Full Bore Relief Valves

•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





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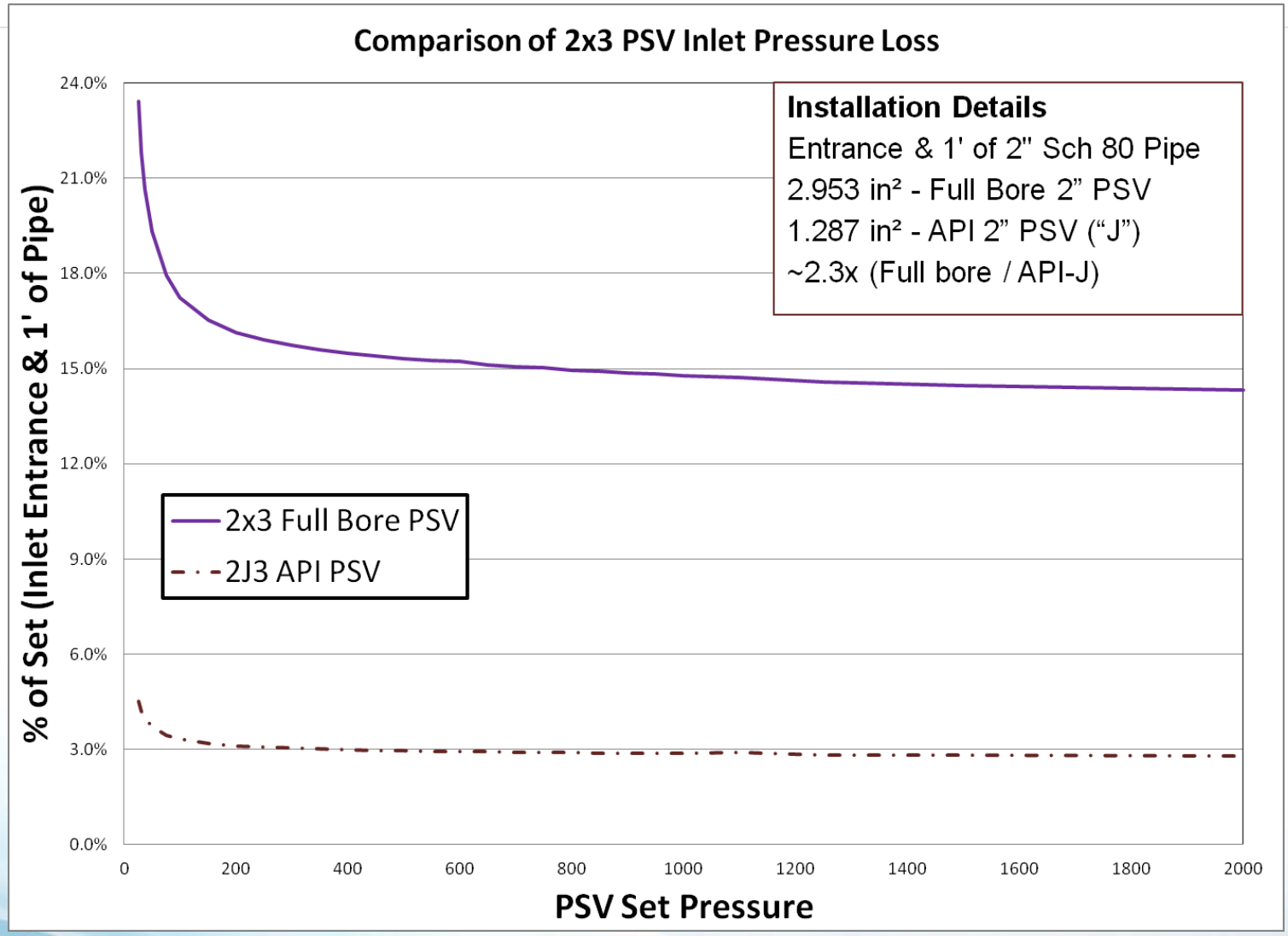

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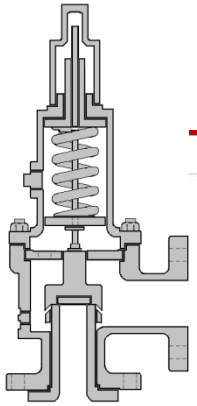


Installation Details

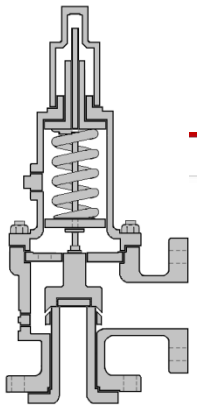
Inlet Piping Design – Pressure Losses

•The Piping Must Support the Reaction Forces

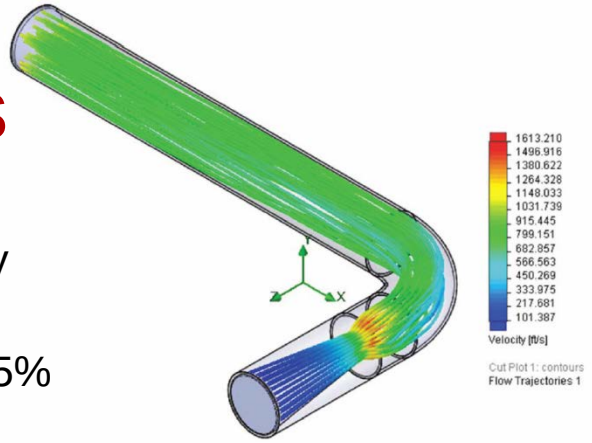
A chemical Plant was suffering from nozzle failures, so we reviewed 189 installations for structural adequacy.

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

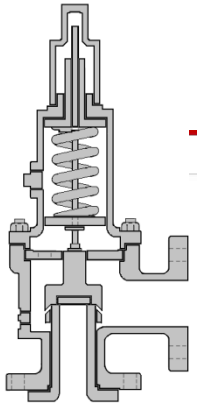


Inlet Piping Design – Pressure Losses

- 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

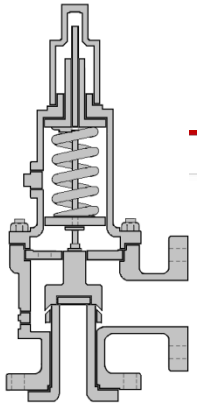
Inlet Piping Design – Administrative Controls

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

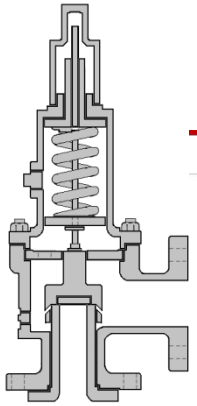
- Overpressure potentially limitless
- No capacity when isolated
- Personal experience / knowledge is ~10 Cases
- Seems to be increasing in frequency



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

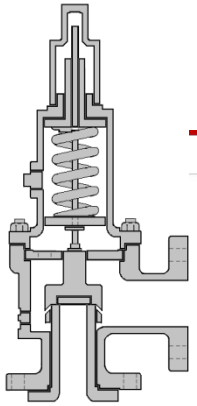
General Considerations

•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



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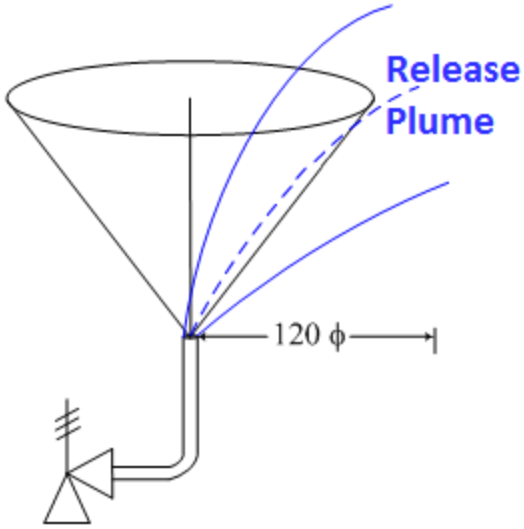


Dispersion Considerations - general

•Nothing within 10’

- Electrical Area Classification Requirements

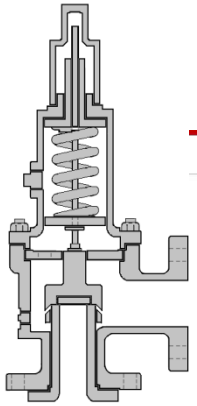
•Nothing within 120 diameters, for systems with:

- 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)

Source API STD 521 §6.3



Atmospheric Discharge

Dispersion Considerations - Details

•Dispersion modeling required if the API guidance is not sufficient

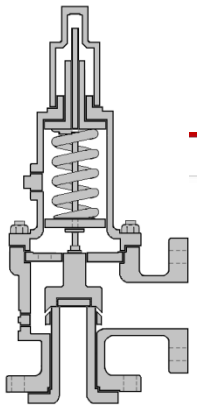
- High concentrations of toxics (over 50x the limit)
- Heavy gases
- Low discharge velocities.

•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



PSV Installation and Discharge

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Study Folder: BUTANE~1
Audit No: 1348
Model: PSV liquid
Weather: Category 1.5/D
Material: C3C4 Mix
Averaging Time:
Flammable(18.75 s)
C/L Offset: 0 ft
Concentration
Time: 35.9202 s

0.10 LFL 0.001749 fracti
½ LFL 0.00874282 fracti
LFL 0.0174856 fraction
UFL 0.0927765 fraction

Side View

Cloud Height (ft)

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

-13 -3 7 17 27 37 47 57 67 77 87 97 107 117 127 137 147 157 167 177 187 197 207 217 227

Distance Downwind (ft)

Predicted dispersion plume for 95% n-Butane discharge from a relief valve discharge pipe at 501 ft/s. The relief stream is a saturated liquid o the inlet of the valve and 79% liquid at the outlet of the relief valve.

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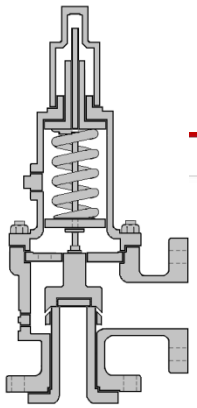
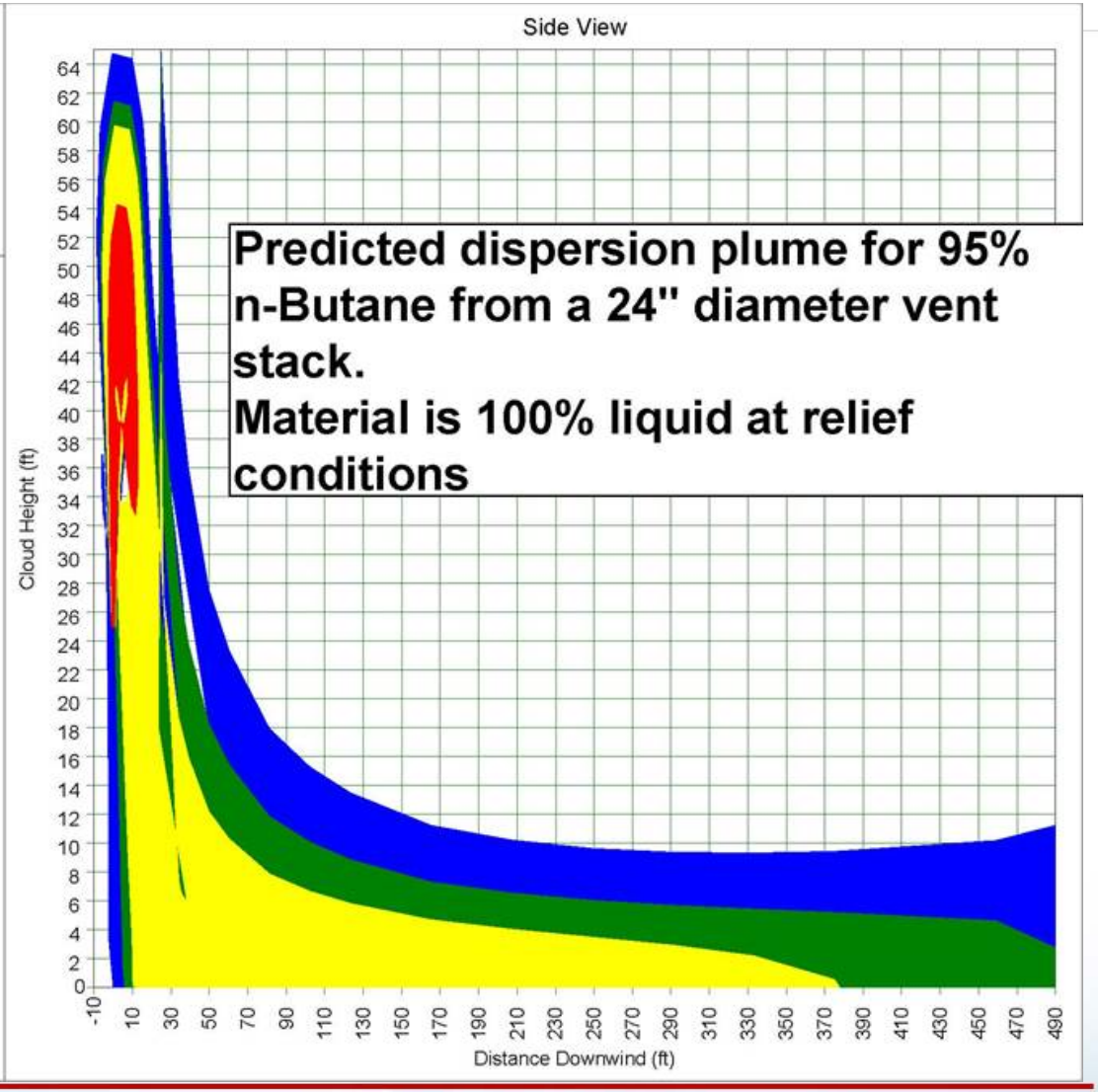


PSV Installation and Discharge

More critical than sizing

Study Folder: BUTANE~1
Audit No: 1348
Model: Stack liquid
Weather: Category 1.5/D
Material: C3C4 Mix
Averaging Time:
Flammable(18.75 s)
C/L Offset: 0 ft
Concentration
Time: 315.975 s

0.10 LFL 0.001749 fracti
½ LFL 0.00874282 fracti
LFL 0.0174856 fraction
UFL 0.0927765 fraction



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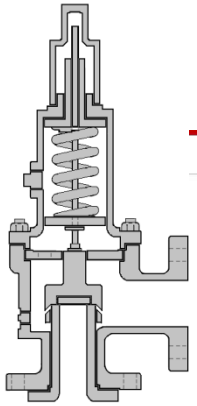

Atmospheric Discharge

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 adeqaute?