AIChE®

Continuing Education Course

Design Considerations for Overpressure Protection

February 17, 2011

American Institute of Chemical Engineers
Delaware Valley Section

Overpressure Protection

Course Contents

- Introduction to relief systems
- Applicable codes and standards
- Work process for relief system design
- Relief device terminology
- Causes of overpressure & determination of relief loads

INTRODUCTION
TO
RELIEF SYSTEMS

Relief Systems

Relief devices are considered the <u>last line of defense</u> against catastrophic failure of mechanical equipment.

The function of relief devices is to:

- ▶ **Prevent an overpressure scenario in the plant**
- ▶ **Protect equipment & piping**
- ▶ **Protect personnel**
- ▶ **Prevent loss of production time**
- ▶ **Prevent loss of material**
- ▶ **Prevent an environmental release**

Relief valves are mandated by:

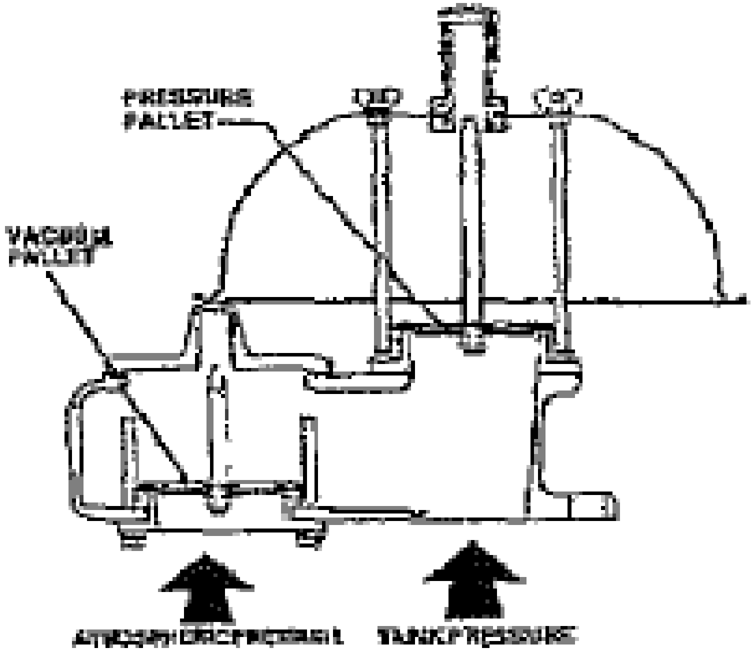
- National, state and local requirements
- Industry codes and standards
- Client and Corporate requirements

Relief Systems

- **Some examples of relief devices are:**
  - Pressure/vacuum valves (a.k.a. conservation vents)
  - Pressure relief valves
  - Rupture disks
  - Emergency vents

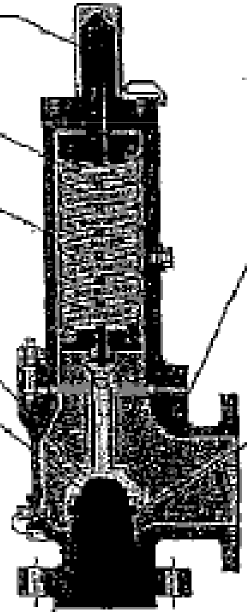
Pressure/Vacuum Vents (a.k.a. Conservation Vents)

Pressure/vacuum valves, also known as conservation vents, are reclosing devices for the protection of low pressure tanks (constructed for internal pressures less than 15 psig) against overpressure and undervacuum, including that which occurs normally as a result of liquid movement into or out of such tanks.



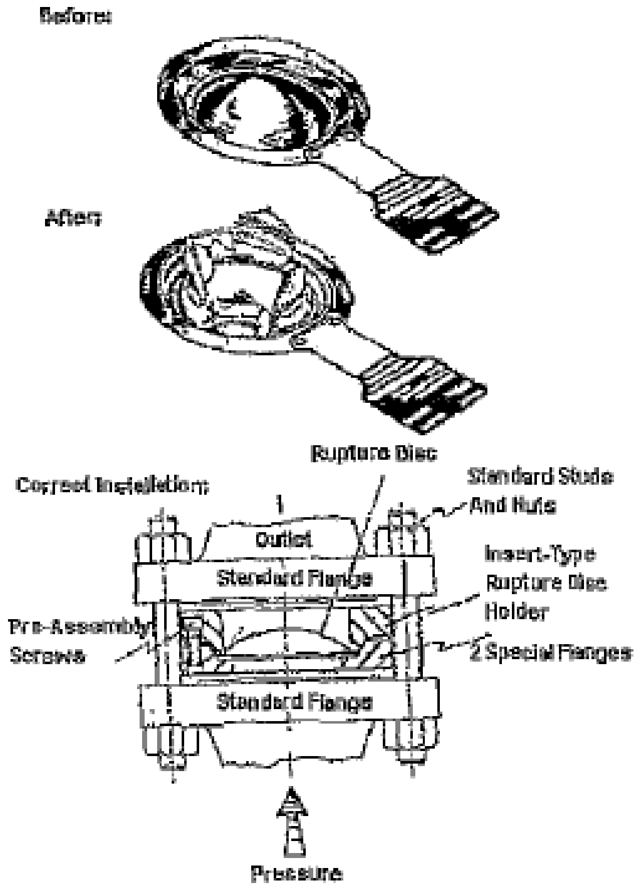
Pressure Relief Valves

Pressure relief valves are reclosing devices for the protection of pressure vessels, boilers, and related systems (constructed for internal pressures of 15 psig or greater) against overpressure.



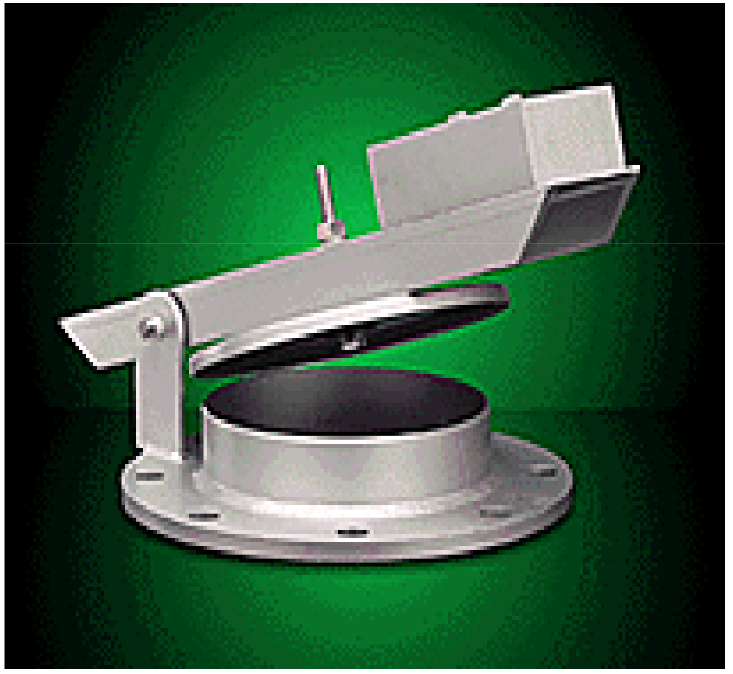
Rupture Disks

Rupture disks are non-reclosing devices for the protection of pressure vessels and related systems (constructed for internal pressures of 15 psig or greater) against overpressure.



Emergency Vents

Emergency Vents are devices for the protection of low pressure tanks (constructed for internal pressures less than 15 psig) against infrequent overpressure emergencies.



Relief Systems

Relief system discharge

- Open Discharge
  - Relieves to atmosphere
  - Non-combustibles and non-toxic
- Closed Discharge
  - Relieves to flare or process
  - Process fluids

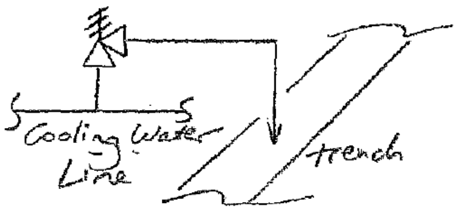
Open Discharge

Open discharge refers to a relief path directly to the atmosphere via an open vent or drain line. This type of discharge is recommended only for non-flammable and non-toxic services.

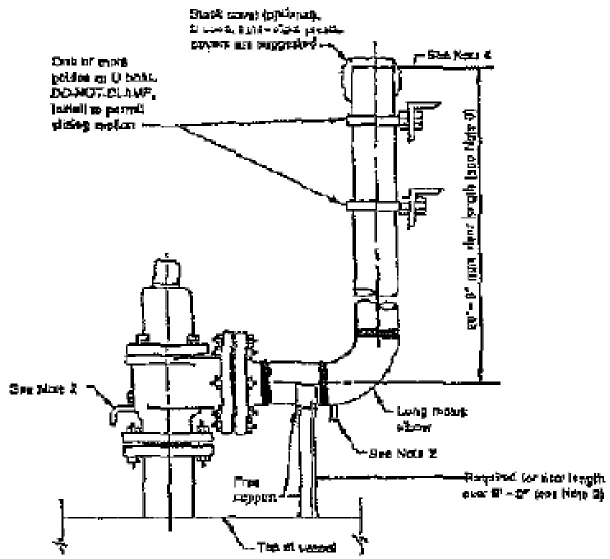
Typically, open discharge is employed to relieve the following fluids:

- Air
- Steam
- Water
- Nitrogen

Example of Open Discharge of Liquid (Cooling Water):



Example of Open Discharge of Vapor (Air):



Closed Discharge

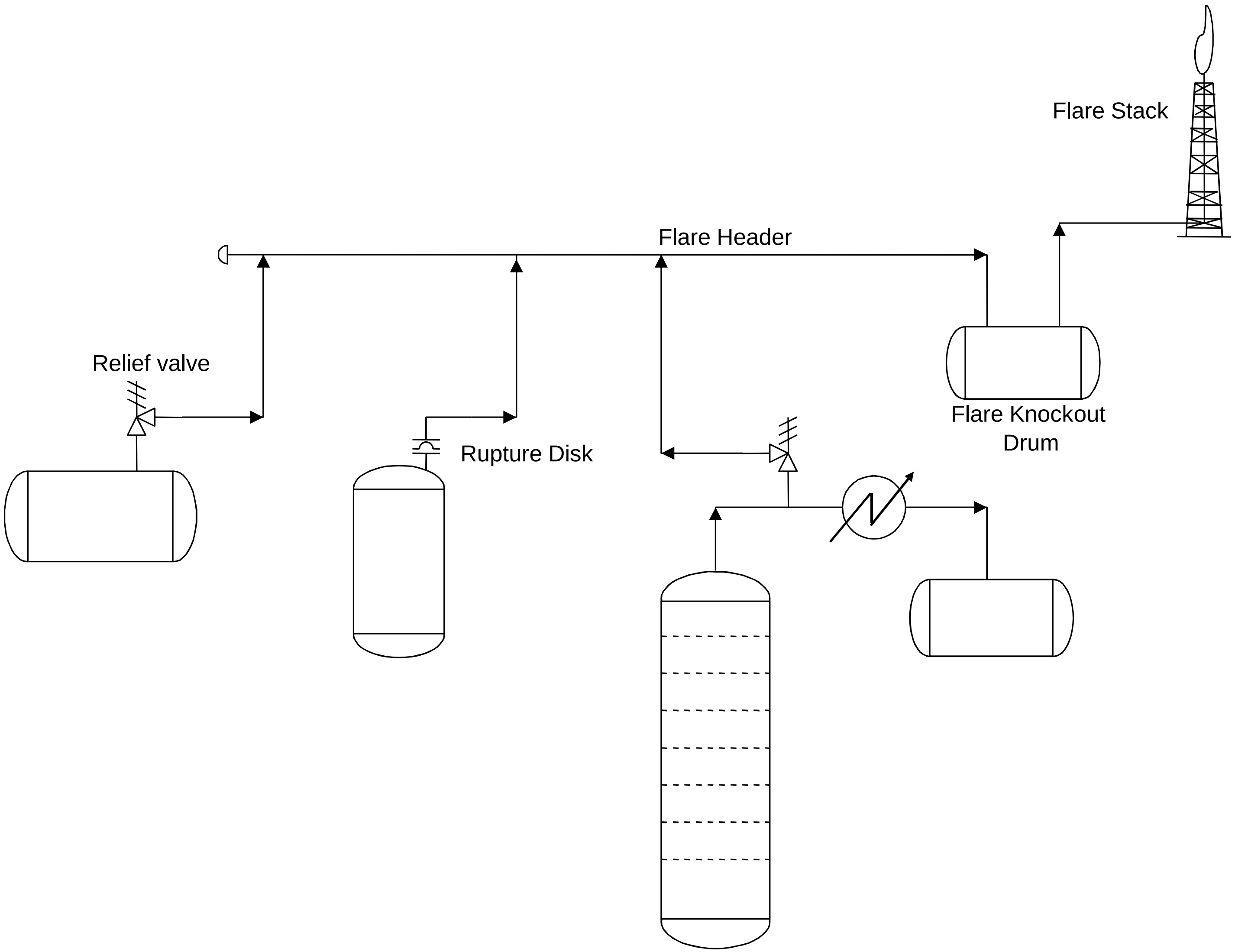
Closed Discharge refers to a relief path into a flare header system, an operating process system, a closed drain system, or any other system that is not open to the atmosphere. This type of discharge is recommended for the relief of hazardous fluids.

Hazards that would make closed discharge the most appropriate relief method include, but are not limited to, the following:

- Flammability
- Toxicity
- Reactivity
- Special Hazards (i.e. corrosive, oxidizer, carcinogen, etc.)

Refer to the figure on the next slide for a schematic example of a closed discharge system, in this case a flare header system.

Simplified Flare Header Schematic



Applicable Codes, Standards and References

- **OSHA**
  - **- 1910.119 (Process safety management of highly hazardous chemicals)**
  - **- 1910.106 (Flammable and combustible liquids)**

- **ASME**
  - Boiler and Pressure Vessel Code Section I
  - Boiler and Pressure Vessel Code Section VIII
  - Power Piping B31.1
  - Chemical Plant/Petroleum Refinery Piping B31.3

- **NFPA 30 (Flammable and combustible liquids code)**

- **Client specifications**

API

- RP 520 Part I & II (Recommended practices for the design & installation of PRV's)
- RP 521 (Guide for pressure relief & depressuring systems)
- STD 526 (Flanged steel safety relief valves for petroleum refineries)
- STD 527 (Commercial seat tightness of safety relief valves w/ metal-to-metal seats)
- STD 2000 (Venting atmospheric & low pressure storage tanks)
- STD 620 (Design and construction of large, welded, low pressure storage tanks)
- STD 650 (Welded Steel Tanks for Oil Storage; i.e., "Atmospheric Tanks")

Work Process for Relief System Design

Work Process for Relief System Design

Relief system design is a multi-step process.

1. **Evaluation of sources of overpressure**
2. **Calculation of relieving flow**
3. **Calculation of required relief device size**
4. **Specification of relief device**
5. **Piping considerations**

- **Inlet/outlet piping pressure drop**
- **Dispersion of vapor**
- **Environmental concerns**
- **Reaction forces/stress analysis/pipe support**
- **Noise**

Work Process for Relief System Design

Required data:

- Heat and Material Balances
- Process Flow Diagrams (PFD's)
- Piping and Instrumentation Drawings (P&ID's)
- Equipment Data (Vessel drawings, pump curves, etc.)
- Instrument Data (Control valve detail, RO sizes, etc.)
- Chemical Physical Properties
- Inlet/Outlet Piping Isometrics

RELIEF DEVICE TERMINOLOGY

Relief Device Terminology

- **Set Pressure - Pressure at which the PRV is set to begin opening.**

- **Burst Pressure – Pressure at which a rupture disk is designed to fail.**

- **Overpressure - Pressure increase over set pressure of the PRV at which the PRV is fully open, expressed as % of set pressure.**

- **Accumulation - Pressure increase over MAWP of vessel during relief, expressed as % of MAWP or in psi.**

Relief Device Terminology

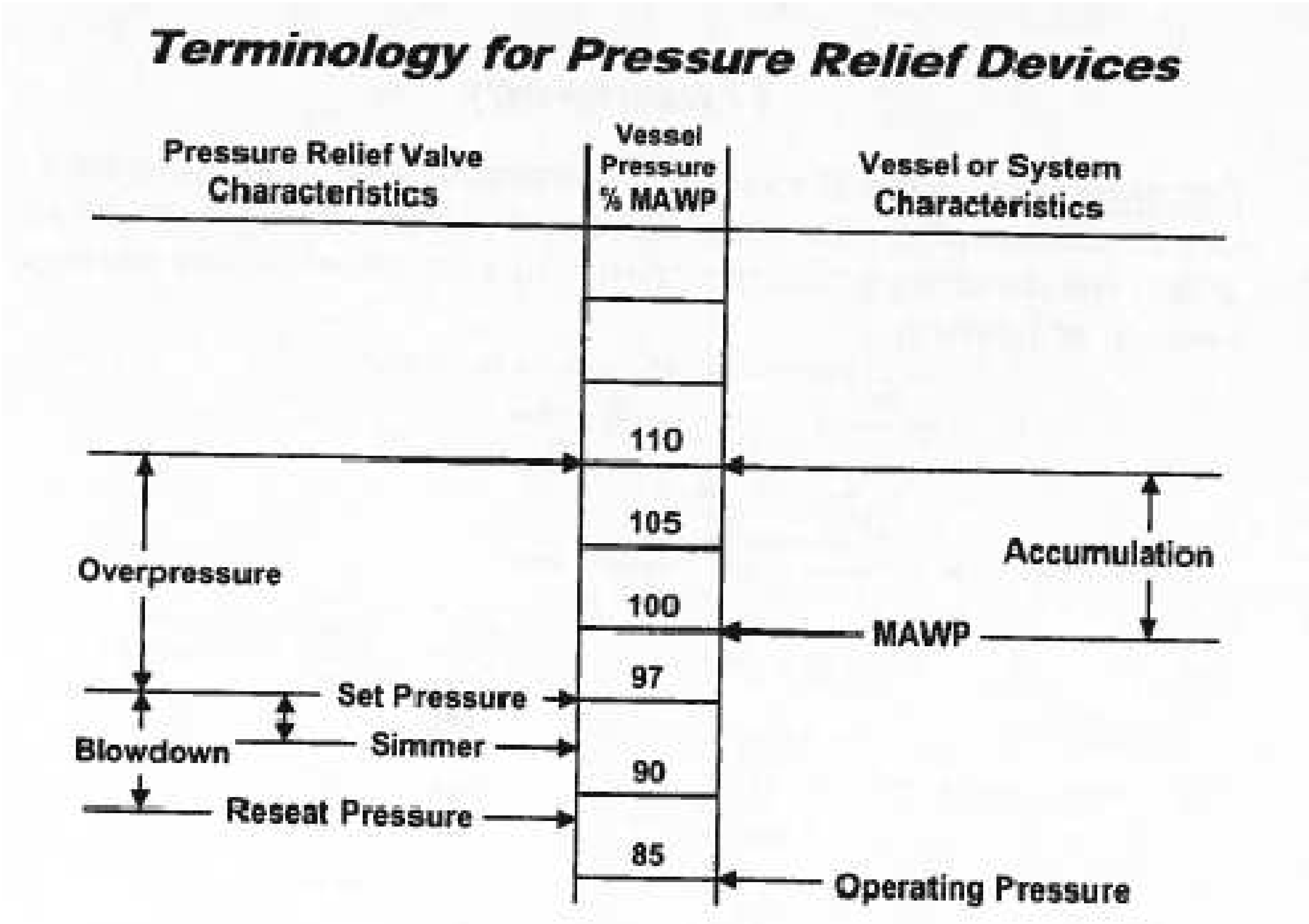
- **Simmer - The audible or visual release of fluid across the PRV just prior to opening at set pressure. Excessive simmering is detrimental to valve seating surfaces.**

- **Chattering - Rapid opening and closing of a PRV in quick succession. Chattering is also detrimental to the PRV seating surfaces, often causing the PRV to leak in normal operation.**

Chattering can be caused by:

- Oversized PRV
- Inlet losses exceeds 3% of set pressure
- Excessive back pressure
- Broken or leaking balanced bellows

Relief Device Terminology



Relief Device Terminology

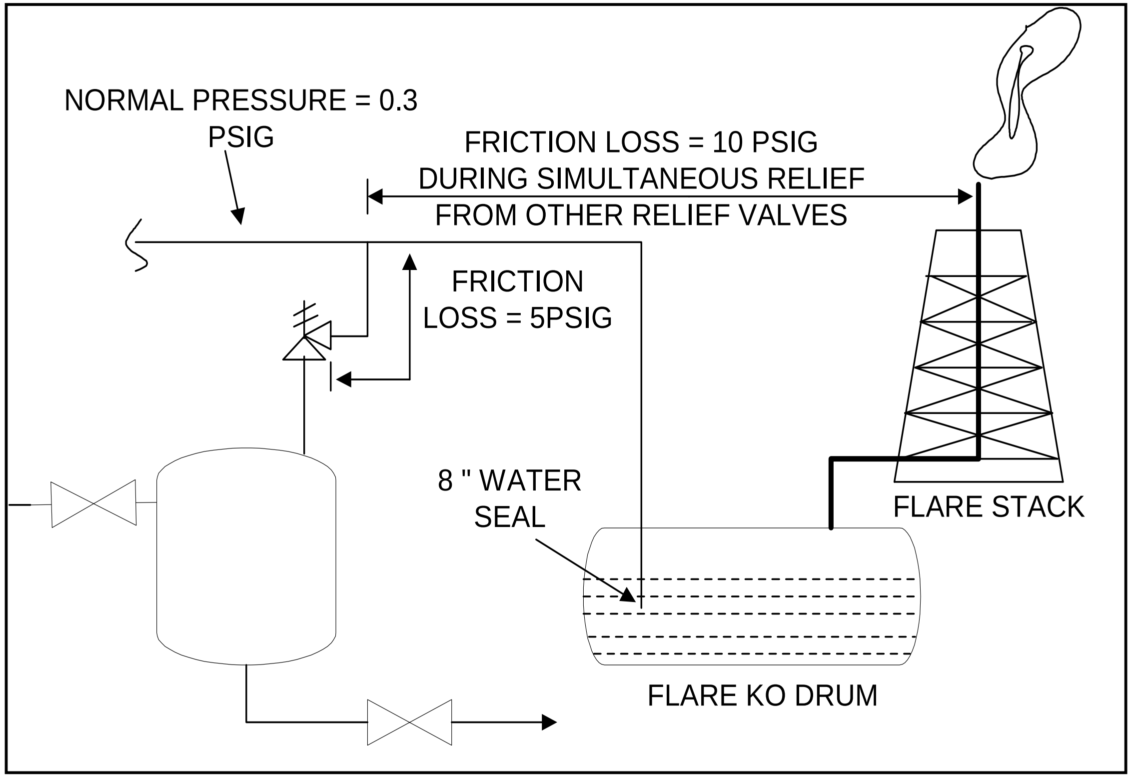
- **Back pressure - The pressure at the outlet of the PRV.**
- **Superimposed back pressure - The pressure at the PRV outlet before the PRV opens, resulting from pressure in the discharge system.**

  - Constant superimposed back pressure does not change appreciably under any condition of operation whether the PRV is open or closed.

  - Variable superimposed back pressure is pressure in discharge system that may fluctuate.

- **Built-up back pressure - The pressure that develops (builds up) in the discharge header when the relief valve opens.**
- **Total back pressure = Superimposed + Built-up back-pressures**

Back Pressure - Example



Superimposed Back Pressure = 8/(2.31*12) = 0.3 psig constant

Total Built-up Back Pressure = 15 psig

Total Back Pressure = 15.3 psig

CAUSES OF OVERPRESSURE & DETERMINATION OF RELIEF LOADS

Causes of Overpressure

- Blocked Outlet – Feed Continues
- Closed Outlet – Heat Source On
- Thermal Expansion of Liquids
- Cooling or Reflux Failure
- Utility Failure (Electricity, Steam, etc.)
- Instrument Failure (Instrument Air, DCS)
- Automatic Control Valve Failure
- Heat from External Fire

Causes of Overpressure (Continued)

- Entrance of a More Volatile Fluid
- Chemical Reaction or Decomposition
- Abnormal Fluid Input
- Backflow from Downstream Equipment
- Failure of Internal Pressure Boundary
- Heat Exchanger Tube Rupture
- Fractionation Tower Failure
- Start-Up/Shutdown Conditions

Causes of Overpressure/Underpressure

For vessels designed for < 15 psig

(Atmospheric tank protection)

- **Inbreathing from Maximum Emptying Rate**
- **Inbreathing from Ambient Temperature Decrease**
- **Outbreathing from Maximum Filling Rate**
- **Outbreathing from Ambient Temperature Increase**

Inbreathing from Liquid Movement

In-breathing from Maximum Emptying Rate is the larger value of A) or B)

A) Maximum emptying rate from pumping

Refer to "API 2000", 6th edition, Nov. 2009, Table A.2 for formula

For all liquids, regardless of flash point and boiling point,

Q (SCFH AIR) = 5.6 * Q (Barrels/hr) (42 gallons/barrel)

B) Emptying Rate from broken outlet nozzle

Mean Velocity of Outflow

V (ft/s) = (2 * G * H)^0.5

Q (SCFH AIR) = A * V * 3600 s/hr, where A = Area of broken nozzle (ft)

Inbreathing from Thermal Effects

In-breathing from Ambient Temperature Decrease

Q (SCFH AIR) = 0.0238 * V (gallons)   where V = tank volume

(Per Table A.4 of API 2000, 6th edition, November 2009 for tank capacities of 630,000 or less)

Per API 2000, 6th edition, November 2009:

A.3.1.1 "Normal venting" requirements shall be at least the sum of the venting requirements for liquid movement and for thermal effects.

Outbreathing from Liquid Movement

Outbreathing from Maximum Filling Rate is dependent on fluid flash point (volatility of fluid)

Add the maximum filling rate from all sources

- **Maximum pumping rates**
- **Maximum flowrate if line pressure and control valve Cv are known**

Flash Pt	Boiling Pt	Outbreathing Rate
≥ 100 ºF	≥ 300 ºF	6 ft3/hr for each 1 barrel/hr liquid in
< 100 ºF	< 300 ºF	12 ft3/hr for each 1 barrel/hr liquid in

Outbreathing from Thermal Effects

Out-breathing from Ambient Temperature Increase

Flash Pt	Boiling Pt	Outbreathing Rate
≥ 100 ºF	≥ 300 ºF	0.014 ft3/hr for each 1 gal tank volume
< 100 ºF	< 300 ºF	0.024 ft3/hr for each 1 gal tank volume

(Per Table A.4 of API 2000, 6th edition, November 2009 for tank capacities of 630,000 or less)

Per API 2000, 6th edition, November 2009:

A.3.1.1 "Normal venting" requirements shall be at least the sum of the venting requirements for liquid movement and for thermal effects.

Inbreathing/Outbreathing

Inbreathing results are in SCFH air

Outbreathing results are in ACFH vapor

Outbreathing results are considered to be equal to SCFH air if the tank is operating at ambient conditions. If tank contents are heated and/or pressurized greater than 1 psi, results must be converted to SCFH.

Blocked Outlet – Feed Continues

▶ Can be caused by:

- Downstream control valve fails closed
- Isolation valve inadvertently closed by operator
- Chemical reactions create a flow blockage

▶ Source pressure exceeds downstream equipment design pressure. Sources are:

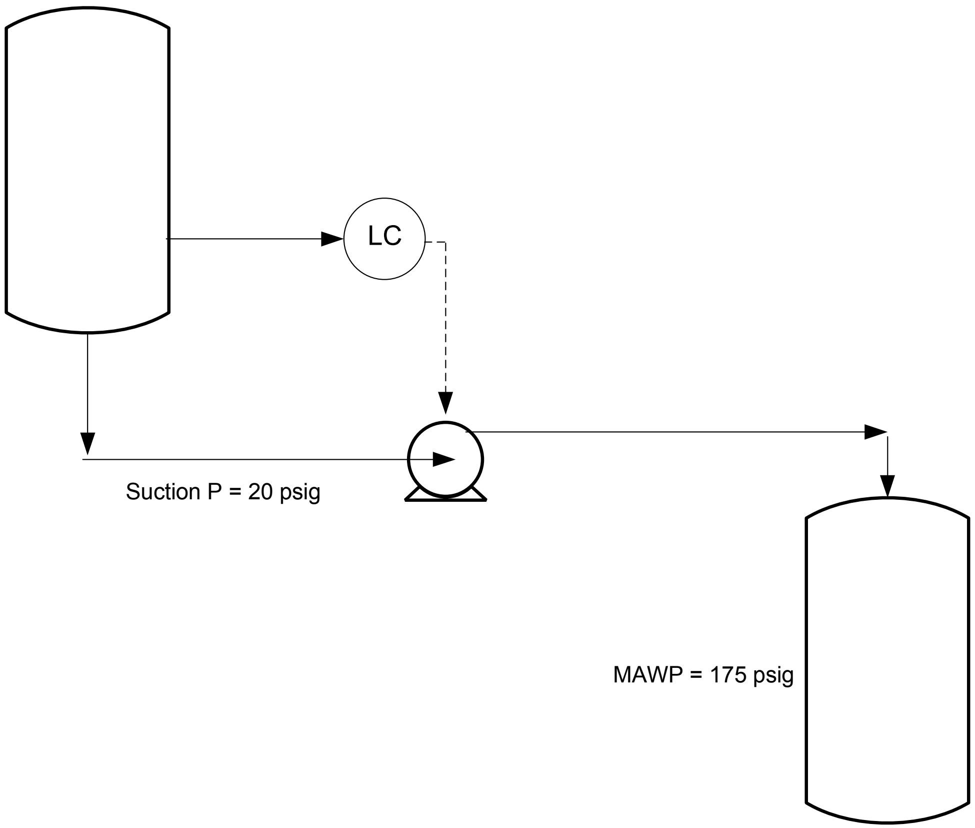
- Pumps
- Compressors
- High pressure utilities
- High pressure upstream fluids

Blocked Outlet – Centrifugal Pumps

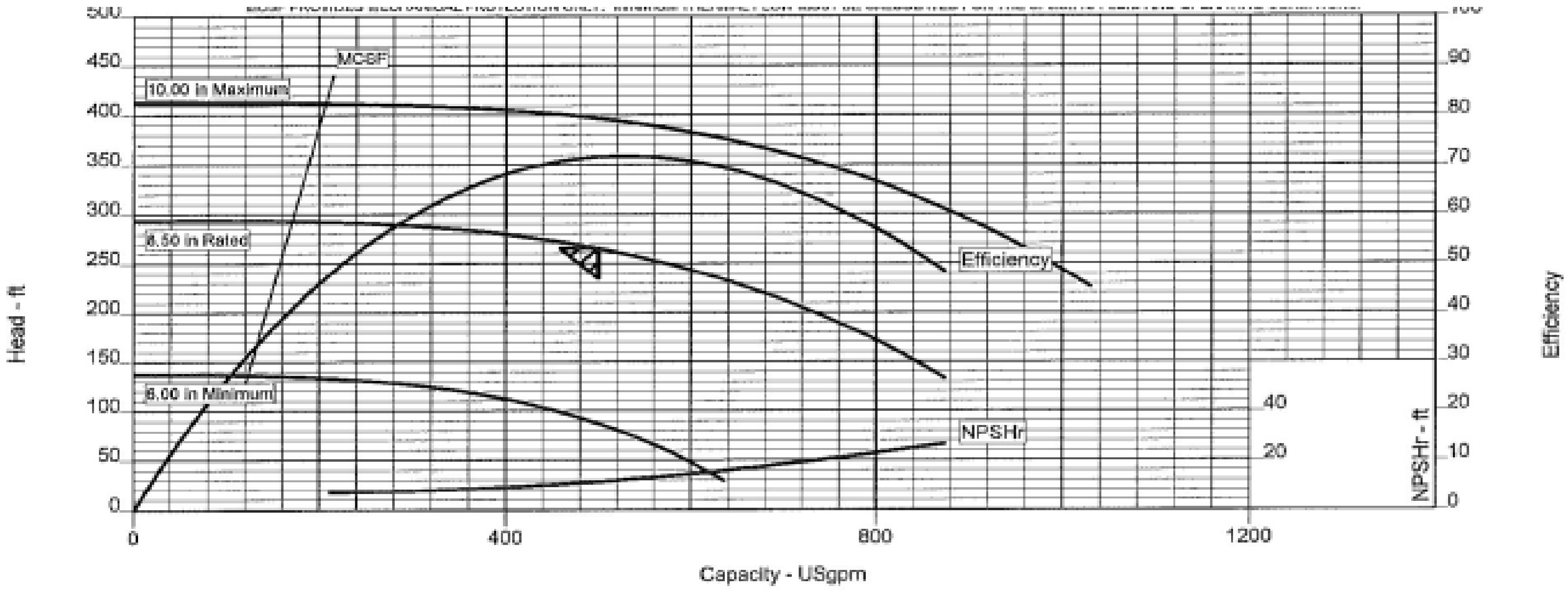
- **A pump's maximum discharge pressure is the sum of the shutoff pressure and the maximum suction pressure**
- **For common pumps, such as ANSI, many sites spare only the largest impeller for each casing size.**
- **Assume the pump contains the maximum (not trim) impeller unless:**
  - The pump type makes it difficult to install the incorrect impeller
  - The site has sufficient administrative controls for management of change
  - Motor limitations prevent operation with the largest impeller

Blocked Outlet – Centrifugal Pumps

- **Example**



Blocked Outlet – Centrifugal Pumps



- **8.5" impeller**
  - shutoff P = 293.6 ft/2.31 = 127 psig, add 20 psig suction P
- **10" impeller**
  - shutoff P = 410 ft/2.31 = 177 psig, add 20 psig suction P

155 psig*2.31 = 358 ft head

Flowrate at this TDH is approx 700 gpm = RV flowrate

Blocked Outlet – Positive Displacement Pump

- A positive displacement pump delivers fluid at a rate proportional to pump speed and independent of pressure differential across the pump.

- For rotary type pumps (gear, screw, and lobe vane):

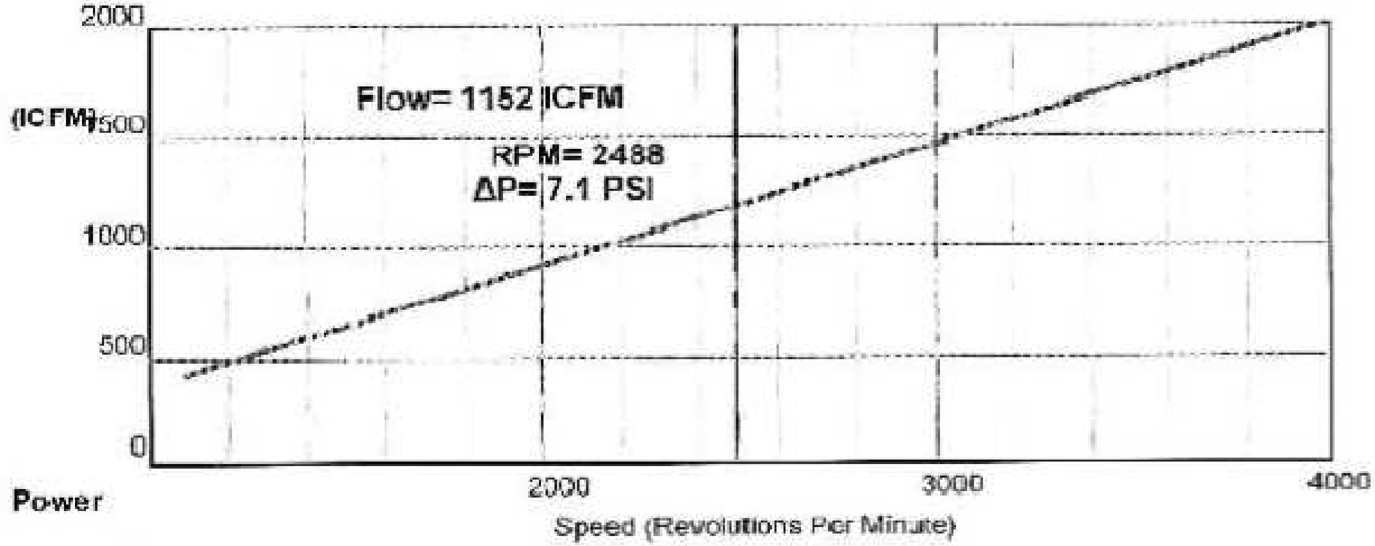
$$Flow_{max} = Flow_{rated}$$

- For reciprocating type pumps (piston or diaphragm):

$$Flow_{max} = 3.14\ Flow_{rated}$$

Blocked Outlet – Compressor

- **Positive Displacement Blower**



Liquid Thermal Expansion

- **Closed Outlet – Heat Source Continues**
- **Required for liquid-filled equipment and piping that can be blocked in and subsequently heated by:**
  - Solar radiation
  - Hot side of a heat exchanger
  - Heat tracing
  - External Fire (high bubble point liquid)
- **Generally provided for long sections of OSBL (outside battery limits) piping exposed to solar radiation. This is required by code for certain types of service.**
- **CSO or LO valves can eliminate the need for thermal relief valves. The client must agree that the valves are under administrative control.**

Liquid Thermal Expansion

Required relief rate in GPM = $$\frac{\beta * H}{500 * S_G * C_P}$$

β = coefficient of thermal expansion

H = heat flux (Btu/hr)

Exchangers use max heat duty in BTU/hr

Electric heat, 3415 BTU/hr per kW

Solar radiation = 300 BTU/hr/ft^2

S_G = specific gravity

C_P = specific heat capacity of liquid, BTU/lb-°F

For hydraulic expansion protection, engineers sometimes provide 3/4" x 1" PRV's and calculations are not performed.

External Fire

- External fire must be considered anytime there is the possibility of the formation of a liquid hydrocarbon pool under process equipment (even if the vessel contents are not flammable) and ignition sources are present.

- Radiant heat causes liquid contents of a vessel to boil or vapor contents of a vessel to expand, thus increasing vessel pressure.

- Either the equipment or the system is considered fully blocked in and isolated when the external fire occurs.

External Fire

- All ASME stamped equipment must be protected for external fire unless fire can be specifically ruled out or the equipment/system cannot be blocked in.

- Individual piping and piping components are not generally considered to require relief protection for an external fire. However, interconnecting piping between equipment will be included in the calculation for fire relief requirements for multiple equipment systems.

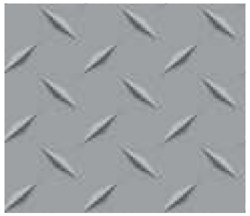
- All equipment surfaces contained in a **70' (21 m)** diameter and a **25' (8 m)** high envelope are considered to be engulfed in a single fire. **(3,850 ft^2 {358 m^2} Fire Circle, 96,200 ft^3 {2,724 m^3} Fire Cylinder)** *Note: 25' (8 m) height defined based on nearest surface capable of sustaining a pool fire.*

Which Surfaces Can Sustain a Pool Fire?

Surfaces That Can Sustain a Pool Fire:

Concrete

Asphalt



Solid Metal Decks
(Diamond Board Shown)

Natural Ground Surface
(Dirt Shown)

Surfaces That Cannot Sustain a Pool Fire:

Grated Metal Decks

Relief Load - External Fire Scenario

▶ **Liquid Vaporization:**

Heat Absorbed, BTU/hr (Q)

NOTE: API 521 Equations Shown.
(Could also use NFPA 30 equations.)

$Q = 21000FA^{0.82}$ **(in most cases with "adequate drainage and firefighting")**

$Q = 34500A^{0.82}$ **(for remote, unmanned areas and areas with poor firefighting facilities or poor drainage)**

A = Fire wetted surface area, ft^2
F = Environmental factor
= 1.0 by default (no fireproofing)
= 0.3 for fireproof insulation

The following do not qualify for fireproofing:
- aluminum covering over insulation
- polyurethane foam insulation
- partial covering by SST bands

Relief Load - External Fire Scenario

- **Relief rate, lb/h (W)**

  W = Q/L

  L = Latent heat of fluid, Btu/lb

- **Vapor expansion:**

  Relief Area $A = FA_{surface}/P_1^{0.5}$

- **ASME allows 21% overpressure of equipment exposed to an external fire.**

Fire Case Sizing Example

Fire wetted area $A = \pi d L + 1.084\ d^2$

$= \pi * 5 * 5 + 1.084 * 5^2$

$= 105.5\ ft^2$

Heat absorbed $Q = 21000\ F\ A^{0.82}$

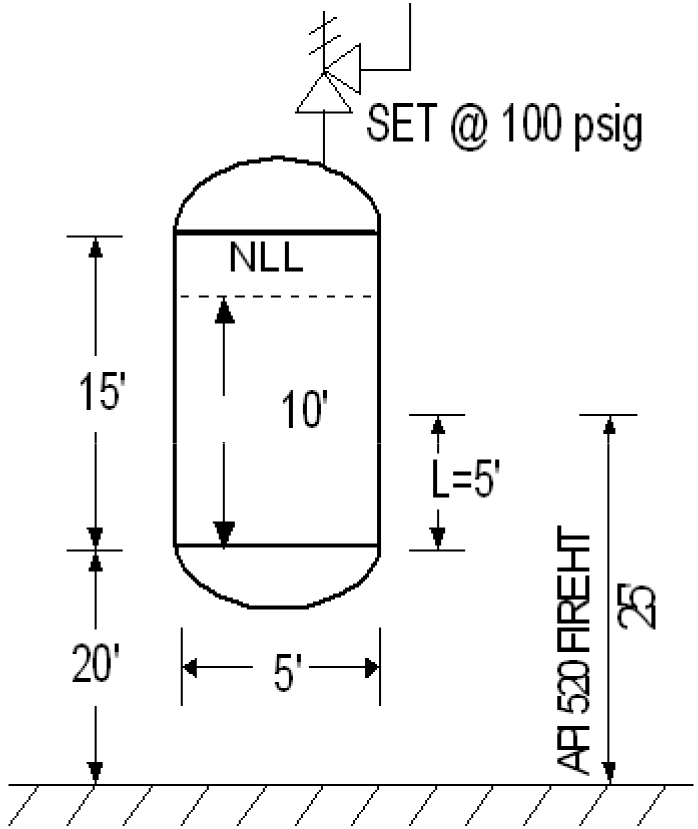
$= 21000 * 1 * (105.5)^{0.82}$

$= 957825$ BTU/hr

Relief rate $W = Q / \lambda$

$= 957825 / 560$

= 1710.40 #/hr



Automatic Control Failure

- **An automatic controller or control valve can fail due to:**
  - Instrument air failure, local or global
  - Loss of signal (wiring failure)
  - Mechanical malfunction of control valve
  - DCS hardware/software failure
  - Improper manual operation by console operator
  - Hand wheel left engaged on control valve
  - Plugging

Automatic Control Failure

- **For local control valve failure, consider both fully open and fully closed positions regardless of the actuator failure mode.**
- **Credit can be taken for flow paths which are normally open and are not affected by this failure, and no "double jeopardy" scenarios should be considered.**
- **For global instrument air failure scenarios, a system is evaluated considering all control valves in the system going to their failure modes.**
- **Client specific guidelines may require consideration of a fully or partially open manual bypass valve around the control valve.**

Automatic Control Failure

- If the control valve is immediately downstream of a pump, the flow capacity will be limited by the pump performance curve.
- If a restriction exists in the flow path, such as an orifice plate, the flow coefficient across the restriction can be considered in combination with the flow coefficient of the control valve…if the site has administrative controls to prevent removal of the restricting orifice.
- For the most conservative relief device size, use the largest trim size available for the valve body when evaluating a failed open valve.

Automatic Control Failure

- **Liquid Control Valves**

  Q (gpm) = Cv SQRT(dP / SG)

- **Vapor Control Valves**
  - Determine if critical or non-critical flow
  - Non-critical flow

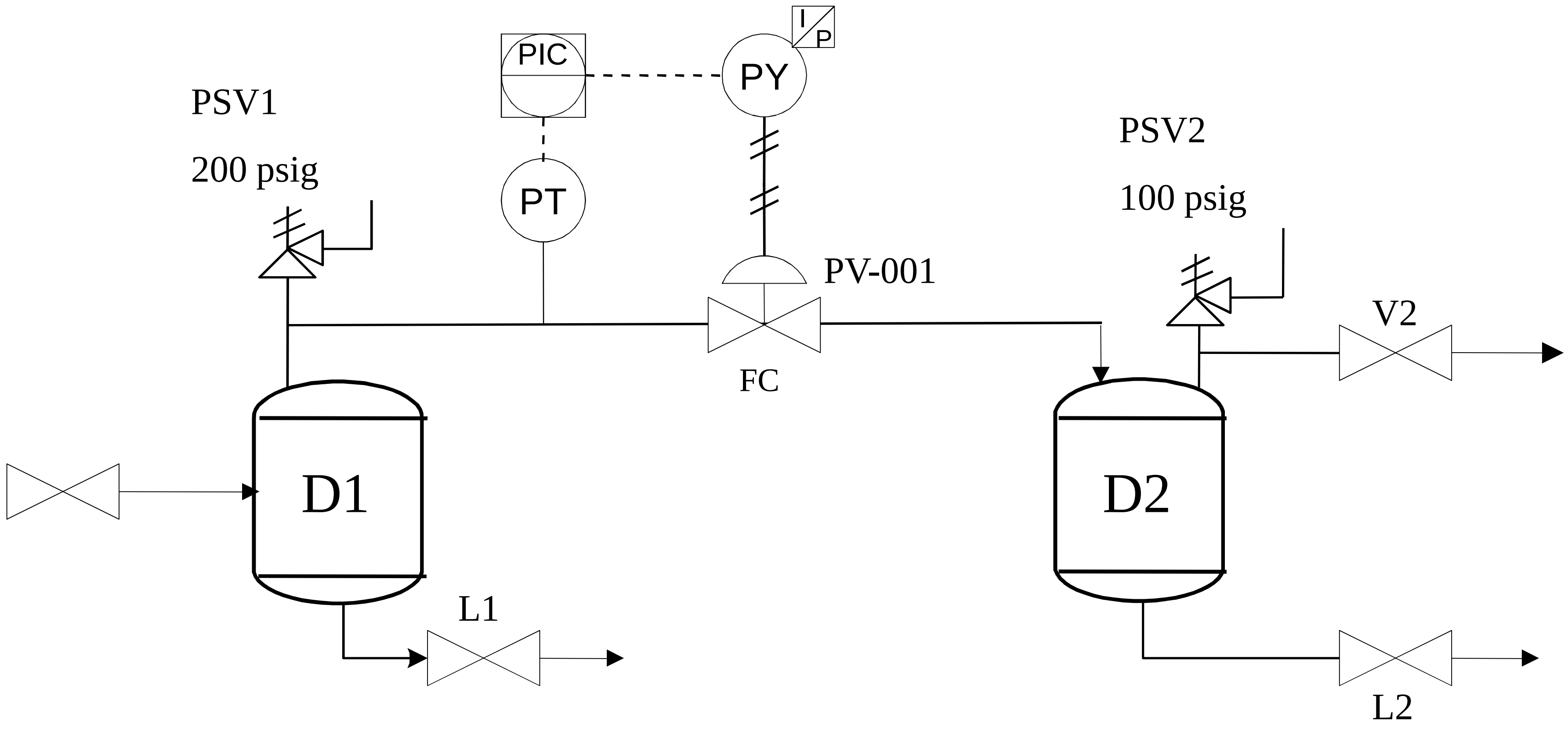
$$Q\ (SCFH) = \frac{963 \times Cv \times (\ P \times (P_1 + P_2))^{0.5})}{(G \times T)^{0.5}}$$

  - Critical Flow

$$W\ (scfh) = C_1 \times Cv \times (P+14.7) \times SQRT(520/(SG \times T°R))$$

Where C_1 = 16 to 37 (get from valve manufacturer)

Automatic Control Failure – Vapor



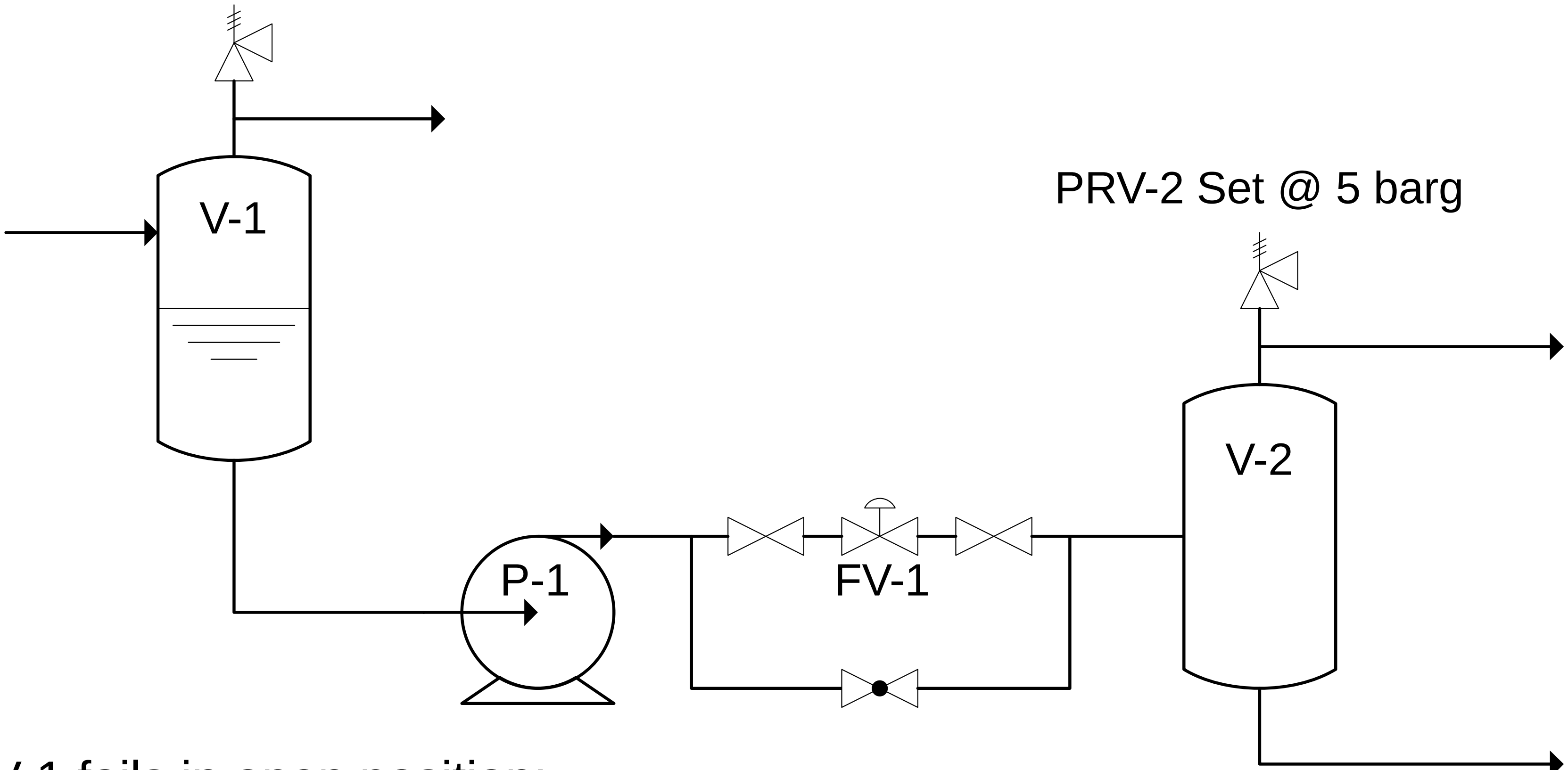
PV-001 fails in open position:

Relief rate = max flow through PV-001 - normal V2 flow

PV-001 fails in closed position, evaluate blocked outlet for PSV1

Automatic Control Failure – Liquid

PRV-1 Set @ 10 barg



FV-1 fails in open position:

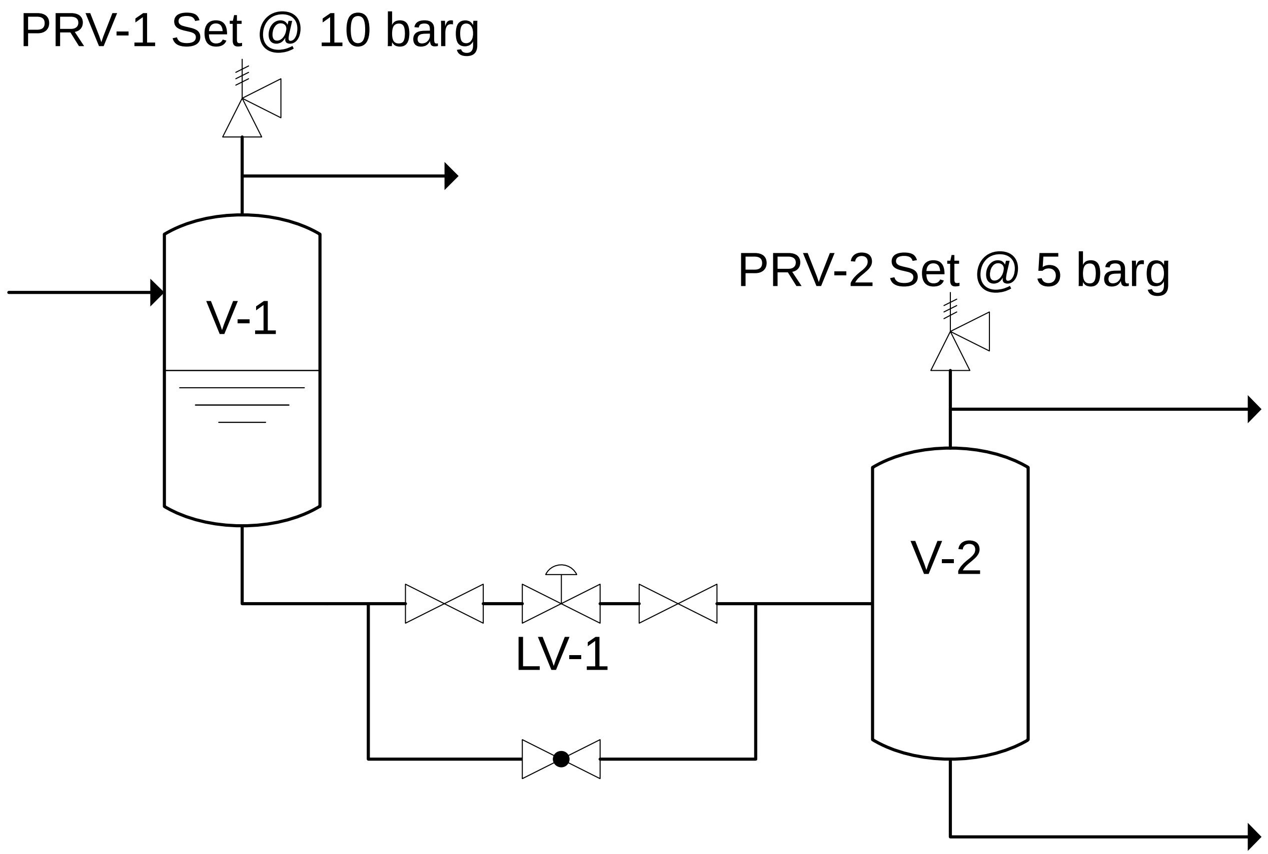
Relief rate = P-1 Capacity at Relief Pressure

FV-1 fails in closed position, evaluate liquid overfilling for PRV-1

Automatic Control Failure

- **Cases in which liquid level in a vessel is lost and subsequently high pressure vapor flows through a failed open level control valve should be considered. In addition, consideration should be given to the relative liquid volumes of the two vessels to determine if a liquid release may occur in the downstream vessel. Such cases are often described as "gas blow-through", "vapor blow-through", or "gas blow-by" cases.**

Automatic Control Failure – Vapor Blow-Through



LV-1 fails in open position, Liquid Inventory Drains Into V-2

Relief rate = Flow Capacity of LV-1 for V-1 Vapor (Provided V-1 Liquid Inventory Cannot Overfill V-2)

LV-1 fails in closed position, evaluate liquid overfilling for PRV-1

Exchanger Tube Rupture

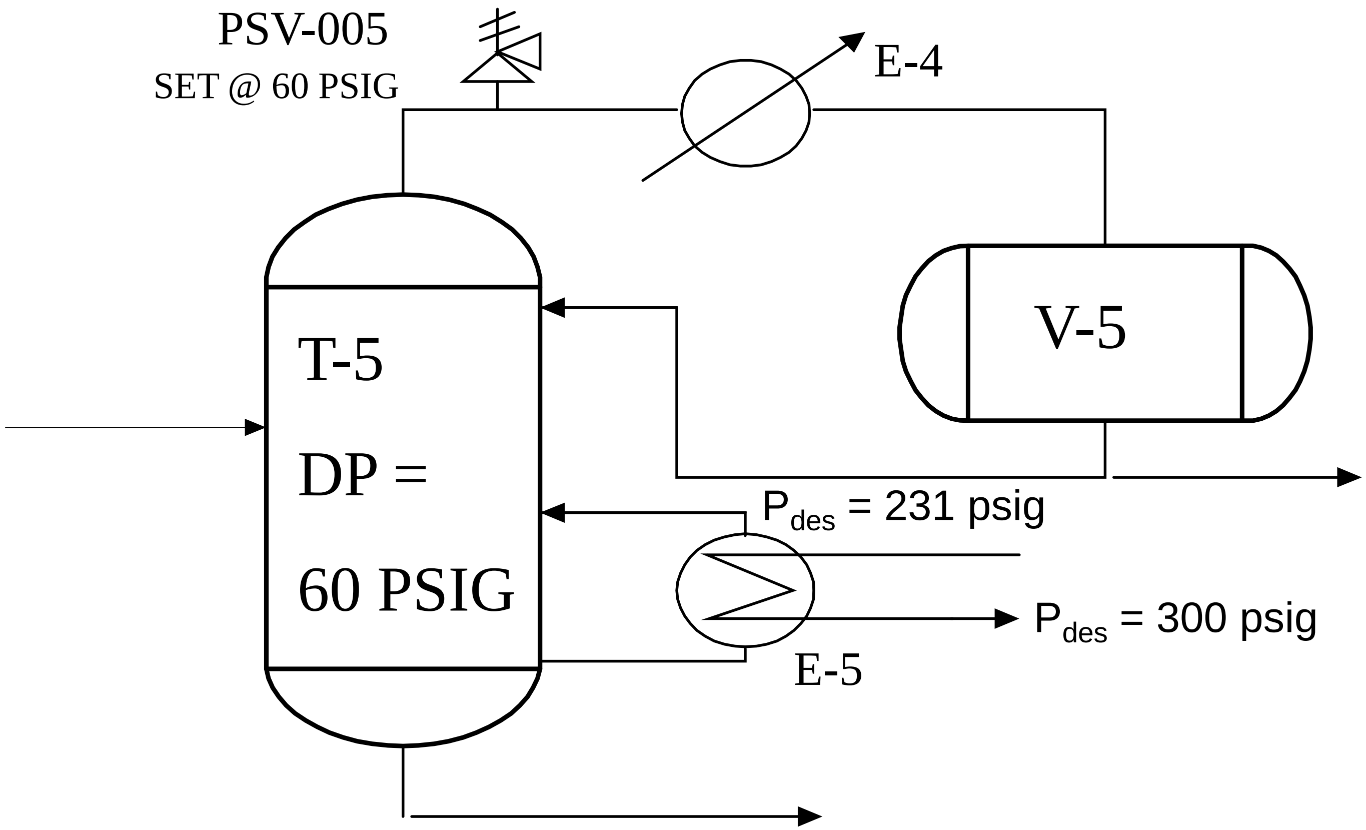
- **Tubes of shell and tube heat exchangers may fail due to thermal shock, mechanical vibration, corrosion, maintenance error.**

- **10/13 rule: Relief protection is not required if the low pressure side design pressure is 0.77 of the high pressure side design pressure per some industry standards.**

- **Designing to the '0.77 rule' does not mean that tubes can no longer rupture.**
  - Must evaluate possible overpressure of connected equipment and/or possibility of chemical reaction.

- **Credit is taken for normally open paths (i.e. low pressure side outlet line is not considered blocked)**

Exchanger Tube Rupture - Example



E-5 tube side design pressure = 300 psig

E-5 shell side design pressure = 231 psig

PSV-005 must be evaluated for tube rupture even though E-5 is designed per the 0.77 rule

Exchanger Tube Rupture

- **A Pinhole leak can be calculated as flow across an orifice.**

- **A complete tube failure calculation is more complex.**
  - **liquid-liquid exchangers**
  - **vapor-liquid exchangers**

- **Consider the impact of heat transfer when a tube ruptures.**
  - **Vaporization of liquids**

Human Error

- **Inadvertent opening or closing of block valves.**
- **Panic response results in incorrect action.**
- **Incorrect interpretation of multiple simultaneous alarms.**
- **No Double Jeopardy**
- **A Note of Caution:**

"Saying that accidents are due to human error is like saying that falls are due to gravity."

\- Dr. Trevor Kletz

Author, <u>What Went Wrong</u>

Chemical Reactions

- **Exothermic reactions can 'runaway'**
  - Relief rate determination is complex; and therefore done in conjunction with the client, the catalyst manufacturer, the process licensor, or other experts
- **Inadvertent mixing of two reactive streams**
- **Decomposition or polymerization due to abnormal heat input or loss of cooling**

Utility Failures

Local or Global

- Electric power failure
- Steam Failure
- Cooling Water Failure
- Refrigerant Failure
- Instrument air failure
- Boiler Feedwater failure

Cascading Failures

- One failure leads to another
- Steam turbines: steam failure leads to power failure.
- IA compressor is power driven; therefore, power failure leads to IA failure.
- CW pumps are power driven; therefore, power failure leads to CW failure.

“Token” Valves

- **What if a thorough analysis reveals there are no credible sources of overpressure?**
- **Common industry practice is to install a “token” valve**
- **If fact, ASME code *required* a relief device, until…**

UG-140: Overpressure Protection by System Design

B & PV Code Section VIII Division 1

General Requirements

UG-140 Overpressure Protection by System Design

UG-140(a) A pressure vessel does not require a pressure relief device if the pressure is self-limiting (e.g., the maximum discharge pressure of a pump or compressor), and this pressure is less than or equal to the MAWP of the vessel at the coincident temperature and the following conditions are met:

UG-140(a)(1) The decision to limit the pressure by system design is the responsibility of the user. The user shall request that the Manufacturer's data report state that over-pressure protection is provided by system design per UG-140(a).

UG-140: Overpressure Protection by System Design

- Great idea in theory, however in practice…
- If a vessel is ASME code stamped, on OSHA inspector on your site will be expecting a pressure relief device.
- If no device is present, they will want to see the U-1 form.
- The U-1 form must indicate "overpressure protection is provided by system design".

UG-140: Overpressure Protection by System Design

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by EATON FILTRATION. AV.CHAPULTEPEC, SN. LOTE 1, MANZANA 6 PARQUE COLONIAL , REYNOSA, TAMAULIPAS, 88780, MEXICO (Name and address of Manufacturer)

2. Manufactured for BUILT FOR STOCK (Name and address of Purchaser)

3. Location of installation BUILT FOR STOCK (Name and address)

4. Type: VERTICAL (Horizontal or vertical, tank) F-8068 (Manufacturer's serial number) N/A (CRN) WAA1788 REV.D (Drawing Number) 510 (National Board Number) 2008 (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 Edition 2007 (Year) to W/O AD (Addenda (Date)) N/A (Code Case Numbers) N/A (Special Service per UG-120 (d))

6. Shell: SA-53 Gr B (Material, (Spec.Number Grade)) 0.3750 in (Nom. Thickness) 0.0 in (Corr.Allow) OD 24.0 in (Inner diameter) 49.37 in (Length overall)

7. Seams: Welded (Long. (Welded, Dbl.,Sngl., Lap, Butt)) None (R.T. (Spot or Full)) 85 (Eff., %) None (H.T. Temp.) None (Time, hr) Sngl. Butt Type 1 (Girth (Welded, Dbl., Sngl., Lap, Butt)) None (R.T. (Spot, or Full)) 70 (Eff., %) 01 (No. of Courses)

8. Heads: (a) Matl. SA – 516 Gr 70 (Spec. No., Grade) (b) Matl. SA – 516 Gr 70 (Spec. No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	Bottom	0.4375 in	0.0	N/A	N/A	2:1	N/A	N/A	N/A	CONCAVE
(b)	Top	0.3125 in	0.0	N/A	N/A	2:1	N/A	N/A	N/A	CONCAVE

If removable, bolts used (describe other fastenings) SEE PARTIAL DATA REPORT FOR TB CLOSURE (Material Spec. Number, Grade, Size, Number)

9. MAWP 150 PSI (Internal) NONE (External) at max. temp. 365 F (Internal) NONE (External)

UG-140: Overpressure Protection by System Design

In reality…

- **Vessel fabrication is typically a long-lead item. The vessel fabrication and the U-1 form are finished long before an engineer is tasked with performing pressure relief analysis.**
- **Manufacturers may be reluctant to indicate "overpressure protection is provided by system design" on the U-1 form because they are providing the vessel, not the entire system.**

UG-140: Overpressure Protection by System Design

B & PV Code Section VIII Division 1

General Requirements

UG-140(a)(2) The user shall conduct a detailed analysis to identify and examine all potential overpressure scenarios. The "Causes of Overpressure" described in ANSI/API Standard 521, Pressure-Relieving and Depressuring Systems, shall be considered. Other standards or recommended practices that are more appropriate to the specific application may also be considered. A multidisciplinary team experienced in methods such as hazards and operability analysis (HazOp); failure modes, effects, and criticality analysis (FMECA); "what-if' analysis; or other equivalent methodology shall establish that there are no sources of pressure that can exceed the MAWP at the coincident temperature.

UG-140: Overpressure Protection by System Design

B & PV Code Section VIII Division 1

General Requirements

UG-140(a)(3) The results of the analysis shall be documented and signed by the individual in responsible charge of the management of the operation of the vessel. This documen-tation shall include as a minimum the following:

- *(a) detailed process and instrument flow diagrams (P&IDs), showing all pertinent elements of the system associated with the vessel*
- *(b) a description of all operating and upset scenar-ios, including scenarios involving fire and those that result from operator error, and equipment and/or instrumentation malfunctions*
- *(c) an analysis showing the maximum coincident pressure and temperature that can result from each of the scenarios listed in item UG-140(a)(3)(b) above does not exceed the MAWP at that temperature*

Course Content for Another Day

- More complicated sources of overpressure
- Relief device selection
- Relief device sizing
- Piping considerations
  - Inlet/outlet piping pressure drop
  - Dispersion of vapor
  - Environmental concerns
  - Reaction forces/stress analysis/pipe support
  - Noise

Questions?

Thank you and have a great evening.