Relief Systems

Relief Scenarios

- A single relief event requires a particulate vent area and valve size
- Relief scenarios are determined based on a PHA
- For each scenario, a vent area is calculated
- The worst-case scenario requires the largest vent area.
- Ex. Relief scenarios: Ex. 8-2, p. 363, Tab 8-2, p. 365

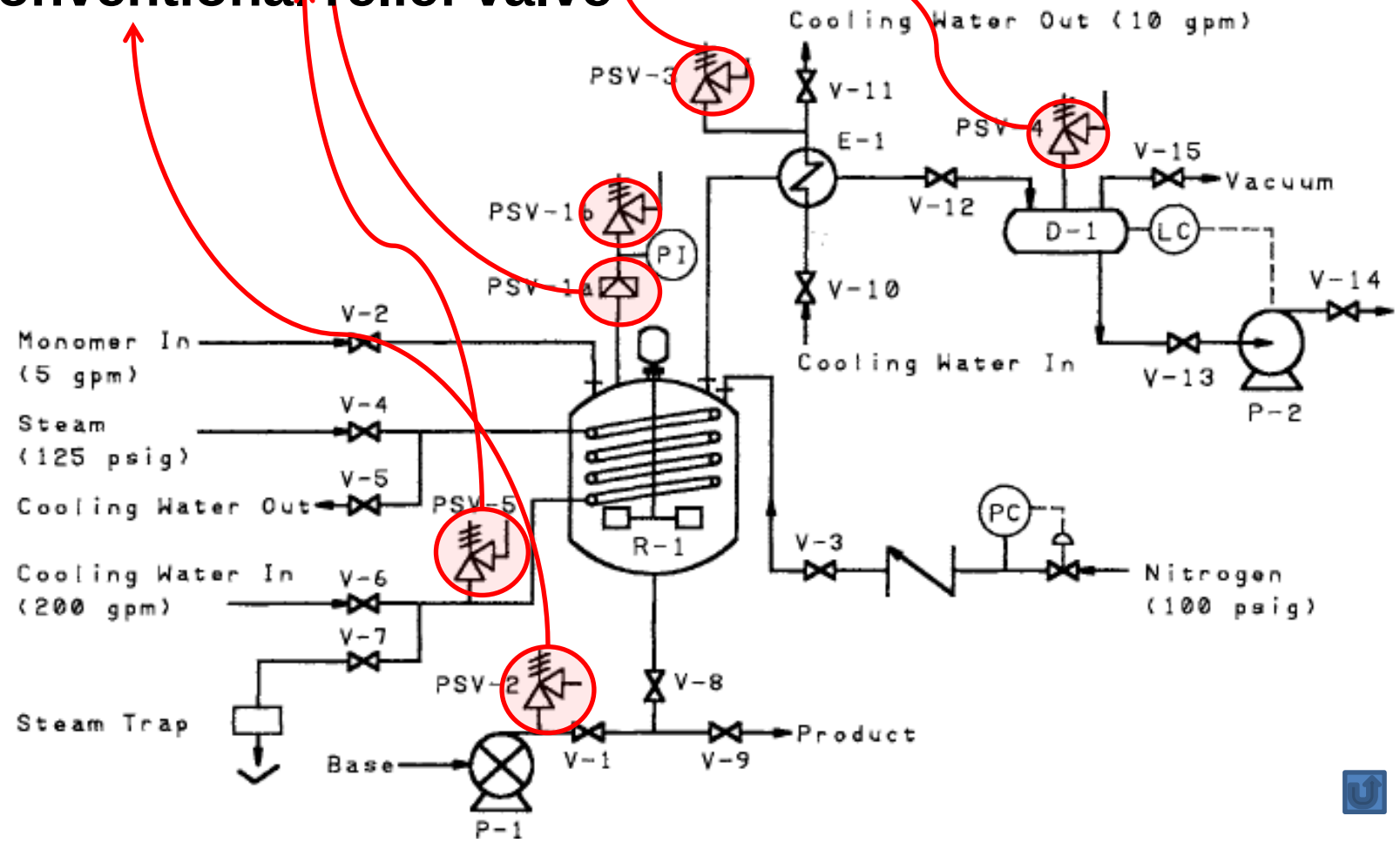
A rupture disc to protect PSV-1b from the reactive monomers (plugging from polymerization

conventional relief valve

balanced bellows

a relief valve for liquid service only

conventional relief valve



Ex 8-2 Relief Scenarios

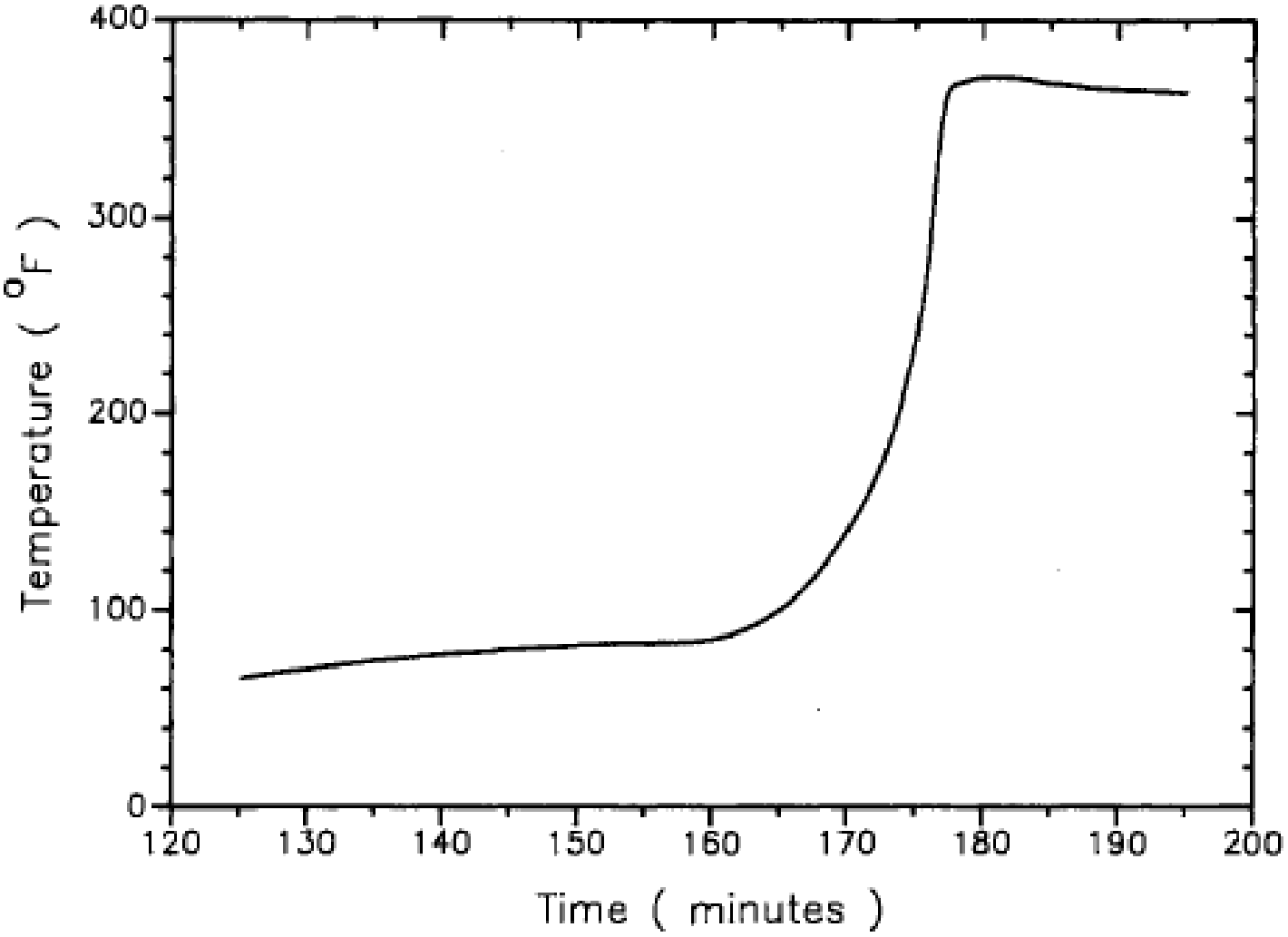
Relief Identifications	Scenarios
PSV-1a & PSV-1b	Vessel full of *l* and P-1 is accidentally actuated
	Cooling coil is broken and water enters at 200gpm and 50 psig
	N_2 regulator fails, giving critical flow in 1” line
	Runaway rxn (Loss of cooling)
PSV-2	V1 is accidentally closed; systems need relief for 100 gpm at 50 psig
PSV-3	Confined water line is heated with 125-psig steam
PSV-4	N_2 regulator fails, giving critical flow in 1/2” line
	The other R-1 scenario will be relieved via PSV-1
PSV-5	Water blocked inside coil, and heat of rxn causes thermal expansion

Data for Relief Sizing

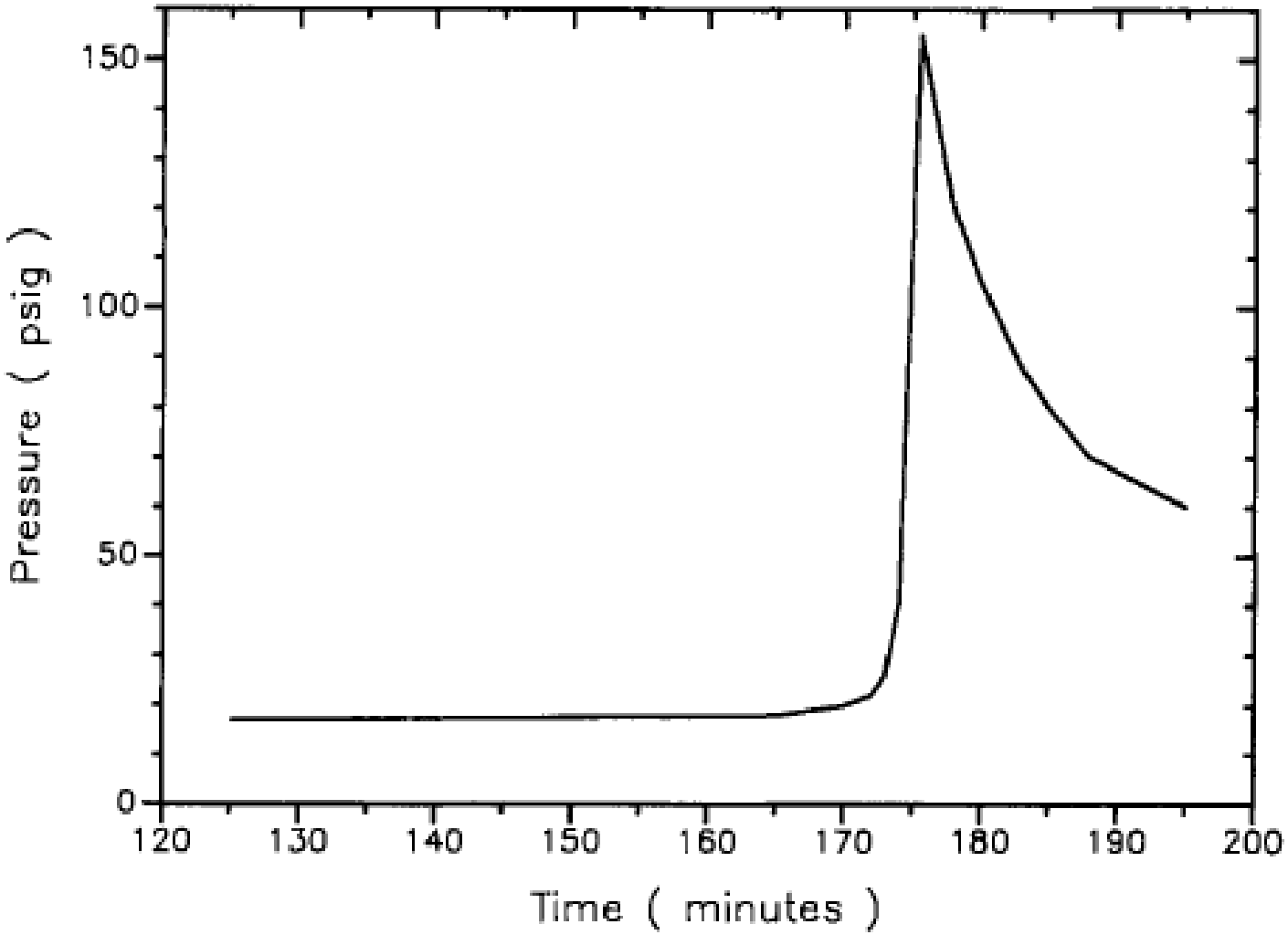
- **Physical property data**
- **Chemical reaction rate behavior**
- **Single phase releases: vapor, liquid, solid**
- **Multiple phase releases**
- **Runaway reaction relief: liquid & vapor**
- **Gas or dust explosions from combustion apparatus**
- **These data are part of the process safety information needed for a PHA**

Reaction Behavior Measurement

- **For accurate relief vent area determinations, experimental data are most important**
- **Calorimeters are used to characterize behavior during normal reaction or runaway.**
- **Sample is progressively heated to search for an exothermic reaction**
- **Raw data includes T, P, time, amount of non condensable gas formed, onset temperature, maximum heat rate, maximum pressure rate**

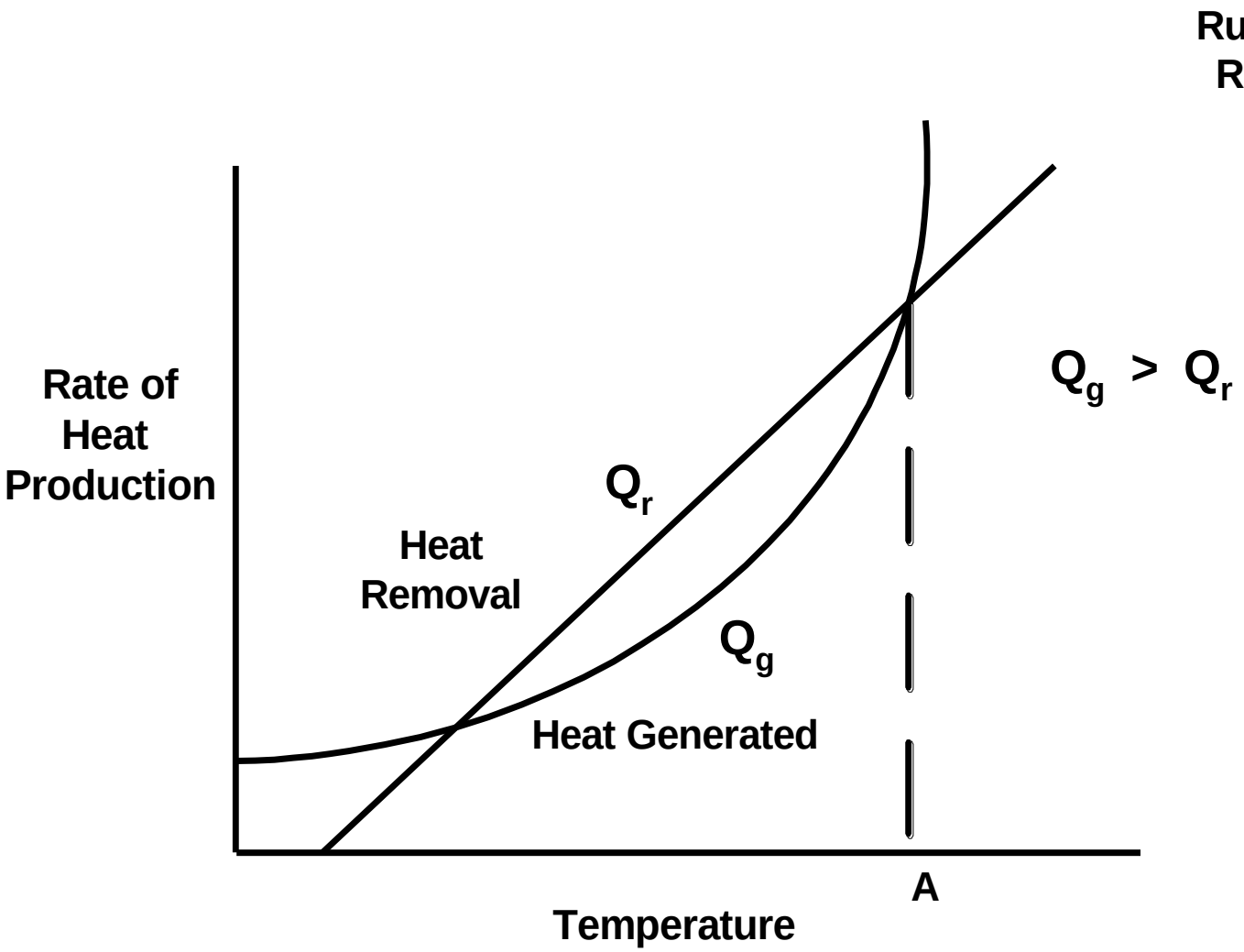


Runaway reaction temperature data acquired using the vent sizing package (VSP)



Runaway reaction pressure data acquired using the vent sizing package

Runaway Reaction Behavior



Preventing a Runaway Reaction

- **Measures to prevent a polymerization reaction runaway due to loss of coolant:**
- **Coolant flow gauge with low-flow alarm**
- **Stirrer rpm gauge with alarm**
- **Stirrer and coolant interlock for monomer addition (inherent safety principle)**
- **Monomer addition stopped if coolant control valve near 100 % open.**
- **Temperature sensors along length of reactor to check for normal profile and upset indication**

Relief Installation Guidelines

- **Industrial standards published by the American Society of Mechanical Engineers (ASME) and by the American Petroleum Institute (API)**

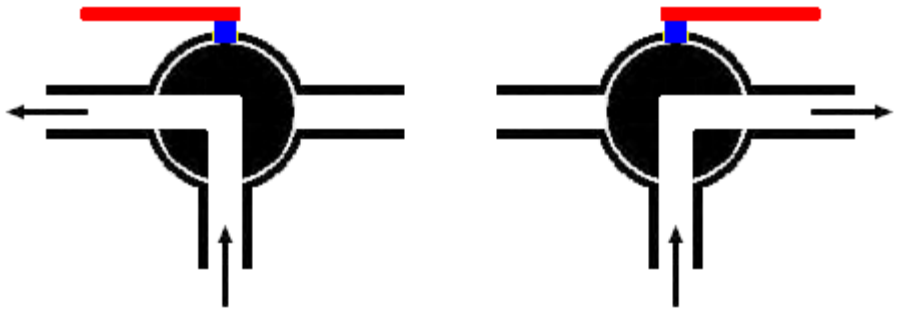
- Stress analysis and reaction forces for material flow through relief systems: API standards

- Relief system weight

- Static pressure, pressure changes

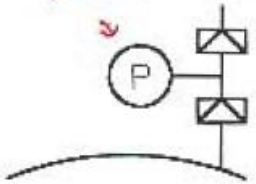
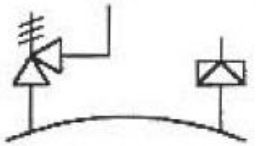
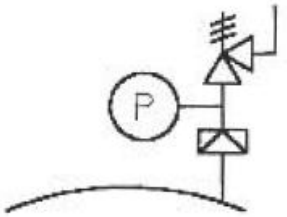
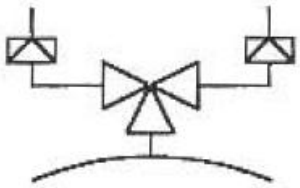
Relief Installation Examples

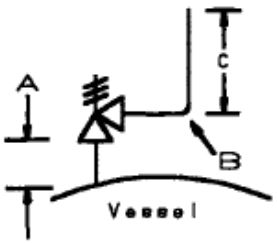
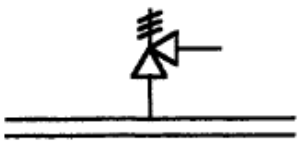
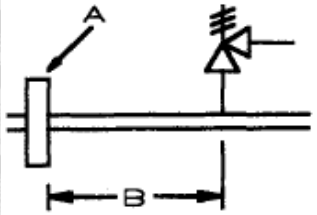
- Two rupture disks with pressure gauge between to detect for leakage: toxic materials
- Two rupture disks connected with 3-way valve to allow maintenance on one disk
- Backup rupture disk in parallel with a smaller relief valve set at a lower pressure.
- Rupture disk to protect more expensive relief valve with a pressure gauge between them

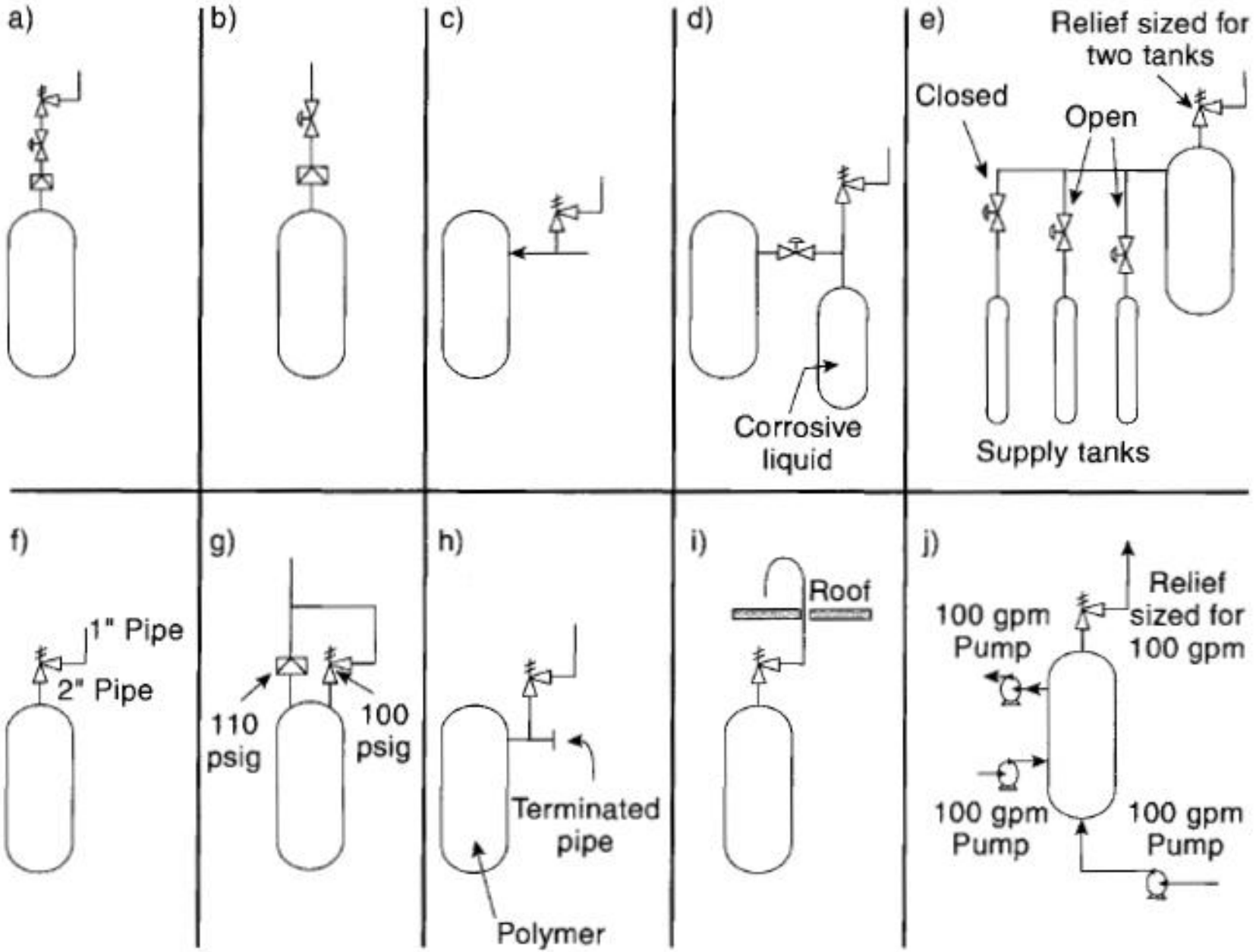


Location Guidelines

- Relief valves on all vessels
- Pressure or vacuum protection for vessels
- Steam jackets
- Pipes between valves
- Pumps, compressors, turbines on discharge
- High pressure connected to low pressure
- Safety/cost balance: relief device vs design for highest pressure

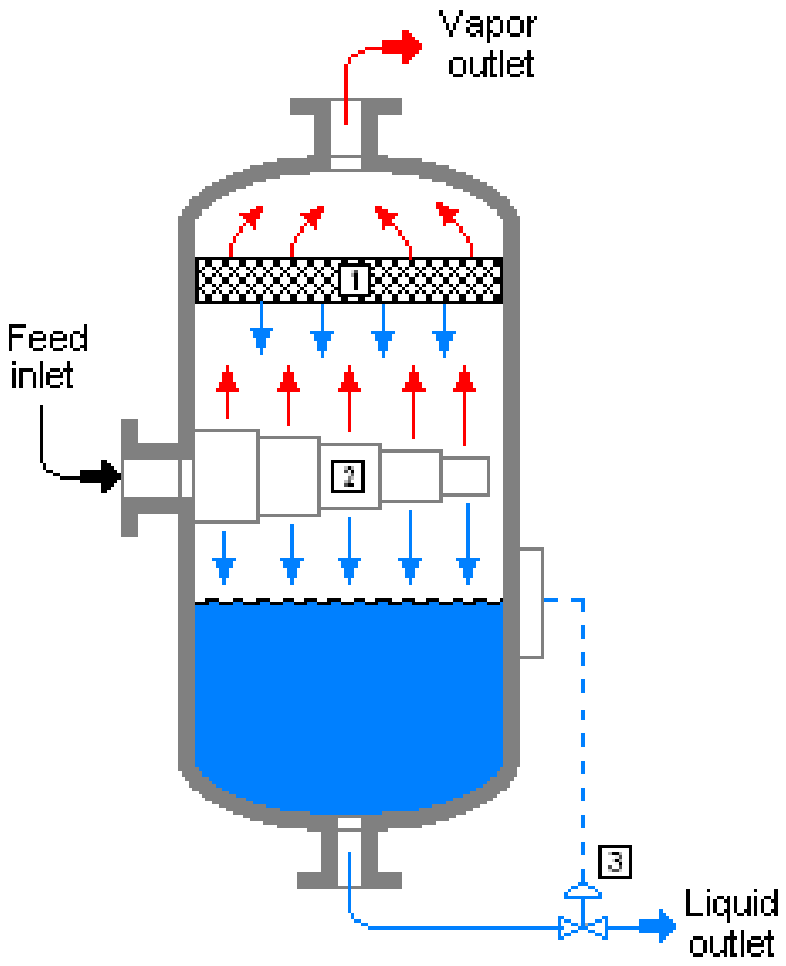
System	Recommendations
	● Rupture Disc in Corrosive Service. ● Or for Highly Toxic Materials where Spring Loaded Valve May Weep.
tell-tale pressure gauge 	● Two Rupture Discs in Extremely Corrosive Service. The 1st May Periodically Need to be Replaced.
	● Rupture Disc and Spring Loaded Relief. Normal Relief May Go Through Spring Loaded Device, and Rupture Disc Is Back-up for Larger Reliefs.
	● Two Reliefs in Series. The Rupture Disc Protects Against Toxicity or Corrosion. The Spring Loaded Relief Closes and Minimizes Losses.
	● Two Rupture Discs with Special Valve Which Keeps One Valve Always Directly Connected to Vessel. This Type Design Is Good for Polymerization Reactors Where Periodic Cleaning Is Necessary.

Syetem	Recommendatione
	A. Pressure Drop Not More Than 3% of Set Pressure B. Long Radius Elbow C. If Distance is Greater Than 10 Feet, Weight and Reaction Forces Should be Supported Below the Long Radius Elbow.
	● Orifice Area of a Single Safety Relief in Vapor Service, Should Not Exceed 2% of the Cross Sectional Area of the Protected Line. ● Multiple Valves with Staggered Settings May be Required.
	A. Process Lines Should Not be Connected to Safety Valve Inlet Piping.
	A. Turbulence Causing Device B. Dimension (B) shown below: Device Causing Turbulence — Minimum Number of Straight Pipe Diameters Regulator or Valve: 25 2 Ells or Bends Not in Same Plane: 20 2 Ells or Bends in Same Plane: 15 1 Ell or Bend: 10 Pulsation Damper: 10

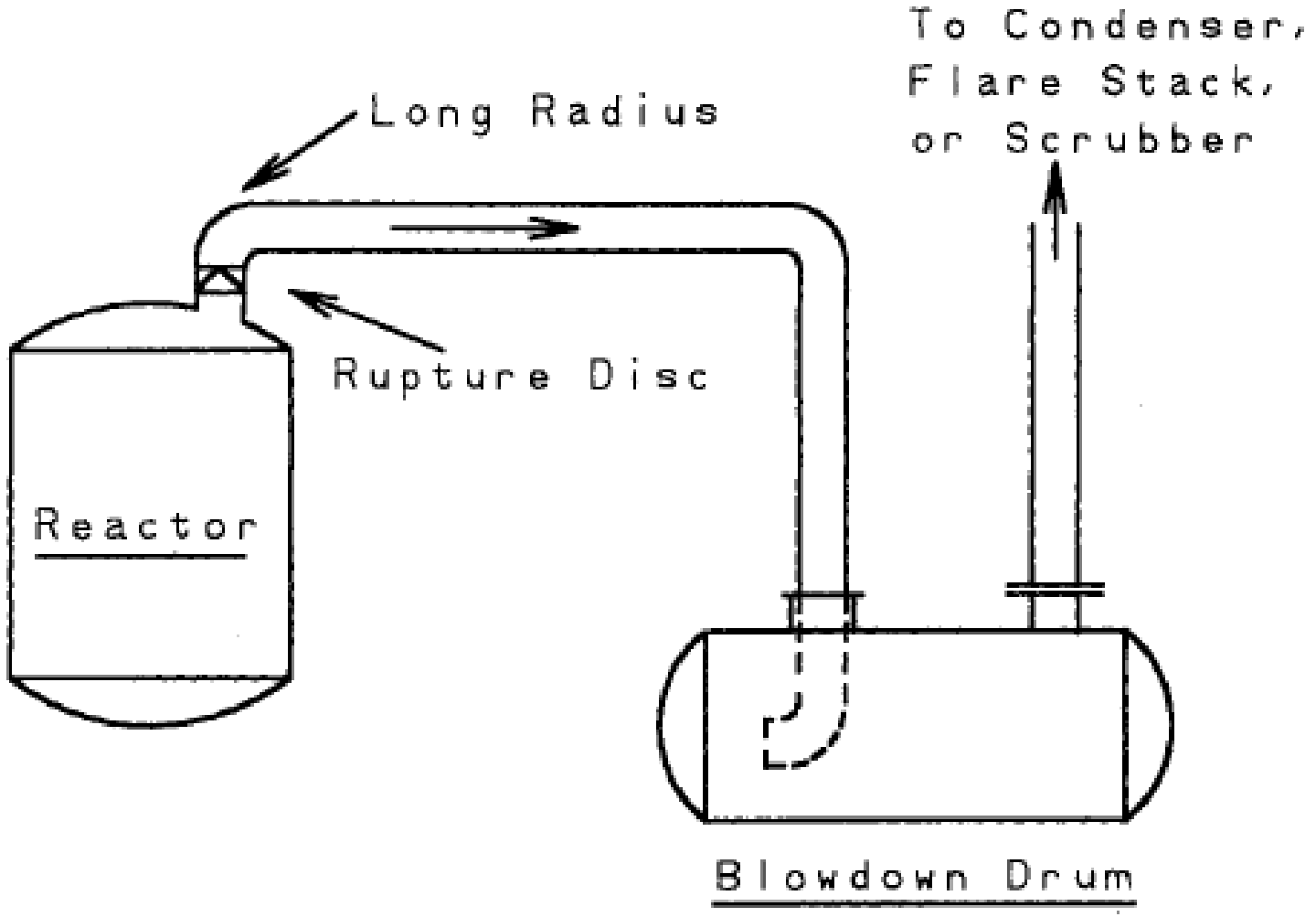

a)
b)
c)
d)
e)
Relief sized for two tanks
Closed
Open
Corrosive liquid
Supply tanks
f)
1" Pipe
2" Pipe
g)
110 psig
100 psig
h)
Terminated pipe
Polymer
i)
Roof
j)
Relief sized for 100 gpm
100 gpm Pump
100 gpm Pump
100 gpm Pump

Total Containment Systems

- Relief materials are mostly vented to total containment and treatment systems
- Knockout: separation of liquid from vapor; coolant for high boiling material (Ex 8-3, p. 374)
- Liquid collected, transferred, incinerated
- Vapor transferred to treatment, e.g., condenser (high boiling), scrubber (toxic), incinerator, flare (combustible, toxic), combination



1 De-entrainment mesh pad
2 Inlet diffuser (distributor)
3 Liquid level control valve



Relief containment system with blowdown drum. The blowdown drum separates the vapor from the liquid

Material Treatment

- **Flares: flammable or toxic materials converted to less hazardous combustion products**

  - Flare design: for a stable flame and a non-hazardous radiation (Ex 8-4, p. 375)

- **Scrubbers: columns for surface contact; convert to less hazardous or more manageable materials**

  - Scrubber examples: caustic bath (H_2S), water (NO_2)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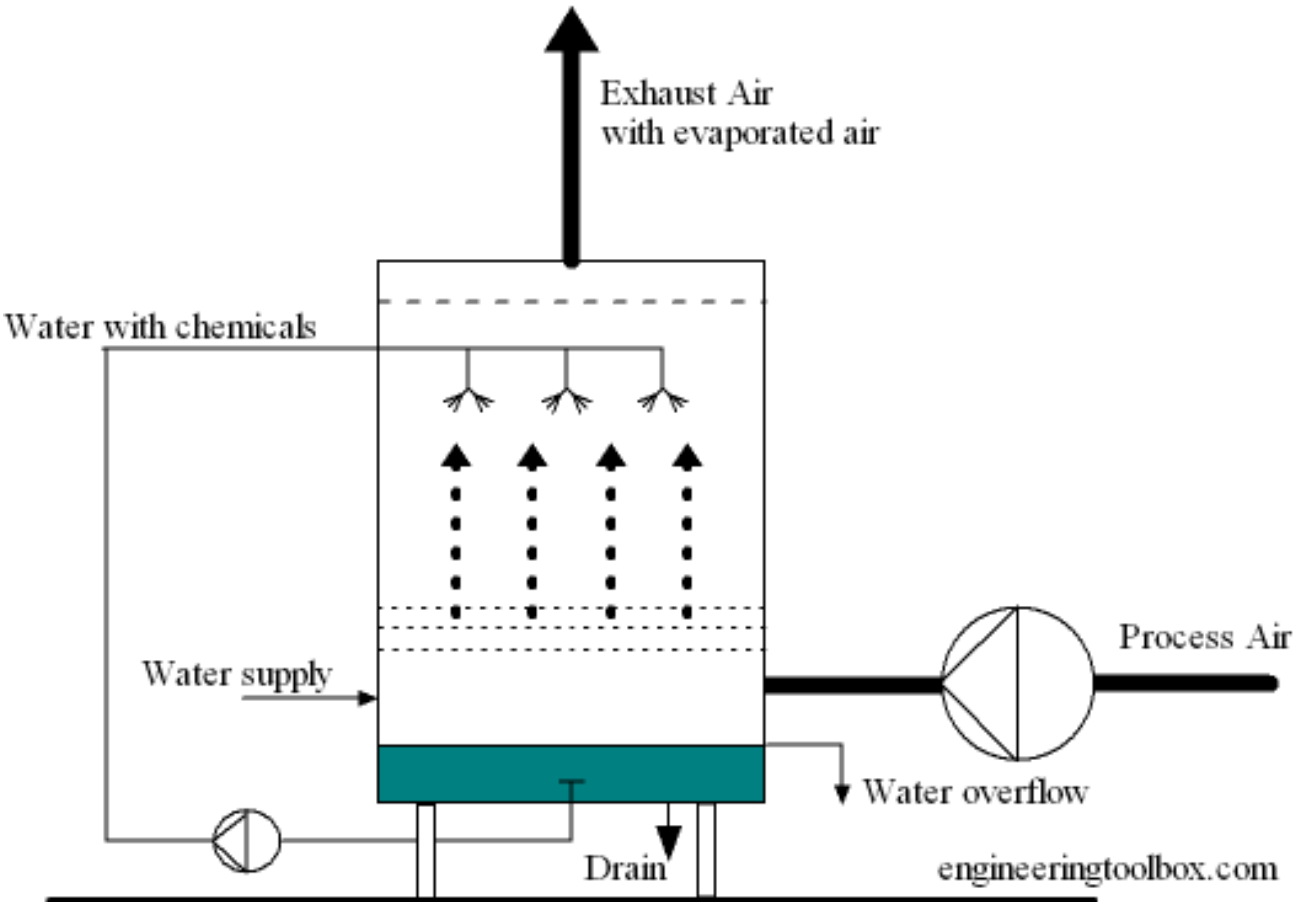
Exhaust Air
with evaporated air
Water with chemicals
Water supply
Process Air
Water overflow
Drain
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