Overpressure Protection

Safety by Design

Overpressure Protection

Overpressure protection is used to protect people and facilities by preventing components & equipment (e.g. tubing, pipes, reactors, etc) from being overpressurized

The lack of overpressure protection can result in serious or fatal accidents

Ruptured liquid nitrogen tank.
(Pressure relief device had been removed)

http://ucih.ucdavis.edu/docs/chemistry_301a.pdf

MAWP Ratings

MAWP stands for ***Maximum Allowable Working Pressure*** (aka Working Pressure)

Components and equipment you will use need to have a MAWP rating adequate for the pressure to which it will be subjected

MAWP ratings are determined & provided by manufacturers - contact the manufacturer of your product if you need the MAWP rating

Overpressure Protection

Some causes of overpressurization:

- High pressure gas traveling from a cylinder (or other source) into downstream components or equipment
- A thermal runaway reaction
- Warming a liquid that is normally a gas at NTP too quickly in a container

Note: high pressure gas regulators can fail allowing cylinder pressure into the downstream system

Some More Causes

Additional causes of overpressurization include, but aren't limited to:

- Operator error
  (e.g. not working within operational prameters)
- Utility failure
- Fire

-Example Incident 1-

Dec 3, 2009

High Pressure Air Tanks

High pressure air from tanks pressurized to roughly 1200 psig passed through a regulated valve into downstream pvc piping

The air pressure exceeded the working pressure rating of the PVC pipe resulting in its rupture. Shards of PVC pipe were blown toward pathways and the building

This shard was about a foot long, sharp, & embedded in grass roughly 100 feet away

(See next slide for images related to this incident)

Images

Images

Images

Images

Luckily no one was in the trajectory of the pipe shards

-Example Incident 2-

Synthron LLC Jan 31, 2006

Thermal Runaway Reaction

http://www.csb.gov/assets/1/19/synthron_final_report1.pdf

Thermal Runaway Reaction

Synthron LLC
January 31, 2006

1 Fatality
14 Others Injured
(2 seriously)

http://www.csb.gov/assets/1/19/synthron_final_report1.pdf

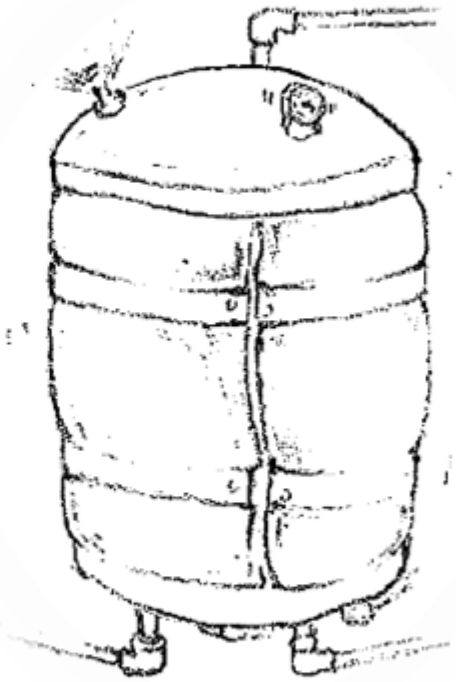
Thermal Runaway Reactions

Exothermic reactions need to be controlled by cooling them

If cooling fails then a runaway reaction can occur

Increased heat increases the rate of the reaction which leads to gas build-up & overpressurization

The containment can catastrophically fail when a runaway reaction occurs

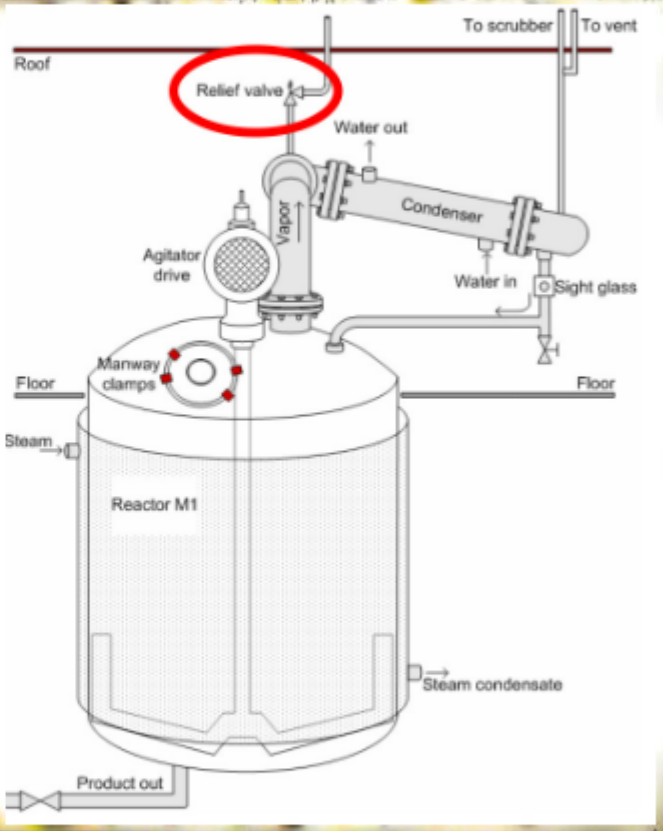


A reactor at Synthron catastrophically failed when a thermal runaway reaction occurred

Thermal Runaway Reaction

Synthron LLC had a pressure relief valve in place, but it didn't provide adequate protection because Synthron strayed outside operating parameters

You must stay within operating parameters for pressure relief devices to work properly (e.g. temp, pressure, quantity of reactants...)



http://www.csb.gov/assets/1/19/synthron_final_report1.pdf

-Example Incident(s) 3-

Berkeley, & BYU

Warming Liquid

A student at Berkeley was seriously injured when a glass container ruptured, throwing shards of glass in all directions

The container ruptured as a liquid (normally a gas at NTP) was warmed

The best solution for this problem is to make sure containers are rated to withstand the pressures to which they may be subjected

The discoloration on the safety glasses is blood

https://ehs.berkeley.edu/lessons-learned/lesson-learned-glass-reactor-over-pressurization-causes-serious-injury-grad-student

Warming Liquid

A similar incident occurred at BYU a few years ago

A researcher collected liquid oxygen in a beaker as it condensed from his process

The beaker was placed on a cart and as the researcher was wheeling the cart through a corridor the oxygen rapidly expanded & overpressurized the beaker

The researcher almost lost an eye

https://ehs.berkeley.edu/lessons-learned/lesson-learned-glass-reactor-over-pressurization-causes-serious-injury-grad-student

-Protective Measures-

Methods of Protection

Solutions that can be used to protect against overpressurizaton:

Avoidance Strategies

- Design the system to withstand the maximum pressure that could develop
- Use redundant cooling systems
- Develop and use safe operating procedures and train operators properly

Pressure Relief Devices

- Spring loaded pressure relief valves
- Rupture discs
- Buckling pin relief valves
- Rupture pin relief valves

…& other options

Pressure relief devices must be utilized unless the entire system is designed to withstand the maximum pressure that could develop

-Pressure Relief Devices-

Relief Device Selection

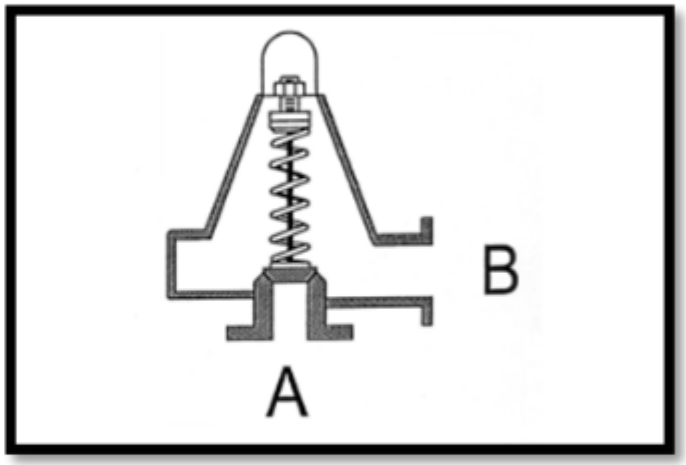
Steps for selecting pressure relief devices:

- ⇨ Select the type of relief device you would like to use based upon their characteristics (see following slides)
- ⇨ Create a schematic of your setup, identifying the maximum safe operating pressure for each component of your system
- ⇨ Contact a manufacturer of the relief device you wish to use and have them help you with proper selection

Spring Loaded Pressure Relief Valves

Spring loaded pressure relief valves open at a specified set pressure and reseat after blow-down (2 to 20% below set-pressure)

Outlet gases need to be channeled to an appropriate location



(diagram from Clarkson University)

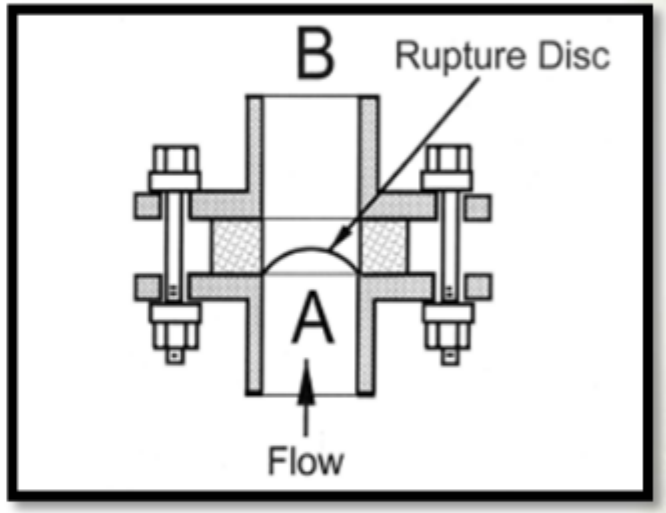
These valves can release gas (simmer) at 95% capacity.
And they require annual inspection and bench top testing

Rupture Discs

Rupture discs contain a one time use membrane that ruptures near a specified set pressure

Rupture discs fatigue over time and need to be replaced in accordance with manufacturer recommendations

Outlet gases need to be channeled to an appropriate location

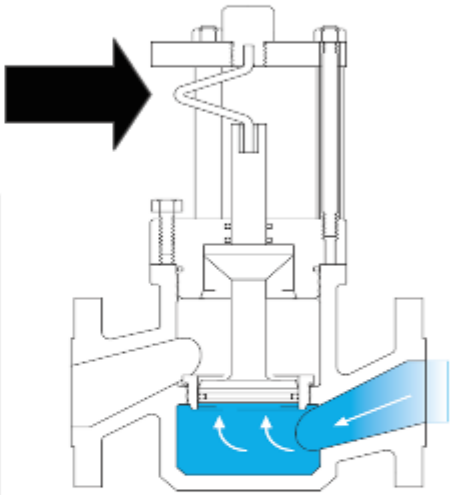


(diagram from Clarkson University)

A rupture disc's stress at the burst point is much greater than the yeild stress. Disc's need to be replaced once they are used

Buckling & Rupture Pin Valves

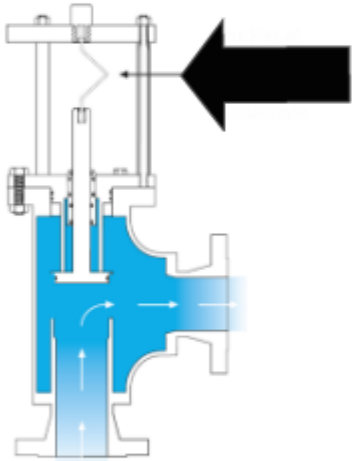
Buckling pins buckle at a precise set pressure allowing the valve to isolate upstream gas & pressure



CLOSED - Pressure at set point

(bucklingpin.com)

Rupture pins buckle at a precise set pressure allowing the valve to relieve the pressure. The vented gases need to be channeled to an appropriate location



FULL OPEN - Pressure at set point *(rupturepin.com)*

Expensive but there are no size or pressure limitations for the design of the valve. Plus the pins can be replaced while the valves are in service. And, they open/close within milliseconds

-Summary-

Protect Against Overpressure

1. Identify any overpressure hazards before you begin your work
2. Develop effective operating procedures and training
3. Carfully manage any changes to existing processes

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4. Use overpressure protection when equipment could be pressurized above its Maximum Allowable Working Pressure (MAWP) rating

   Overpressure protection can be achieved by using:

   - ⇨ Avoidance Strategies

     (such as designing the system to withstand the maximum pressure that could develop)

   - ⇨ Pressure Relief Devices

Testing & Maintenance

After installing overpressure protection, don't forget to test and maintain it according to manufacturer recommendations

Install ➡ Test ➡ Maintain

Pressure relief devices can fail if not properly installed and maintained

-End-