Relief Systems



Korean lizard protect itself by cutting off its tail when attacked 2010 Fall

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Accidental Flow

Safety Levels

Prevention

- Mechanical integrityPredictive/preventive
- maintenances. inspection, testing
- Operator trainingHuman factors
- Impact barriers

Control

- Automatic process ·Alarms control systems
- •Manual control
- On-line spares
- Backup Systems

Protection

- •Operator intervention
- Interlocks, traps
- Emergency shutdownLast-resort controls
- Emergency relief
- •Ignition source control

Mitigation

- •Emergency response •Sprinkler, deluge
- Dike. trench
- Blast wall, barricade
- Water curtain
- Personal protective equipment

Hazard

Cause

Deviation

Accidental **Event**

Impact

Material/energy Contained and controlled during normal operation

- Toxicity
- •Flammability
- Reactivity
- Elevated pressure etc.

- **Initiating event** of process upset; Start of accident event sequence
- **Excursion** Beyond design/ **Operating limits**
- Loss of containment of process material/energy
- Loss of containment of process material/energy

- Mechanical failureNo flow
- Procedural error
- External force
- Fouling etc.
- High temperature
- Low level
- Impurities
- Wrong material
- •Step omitted etc.

- •Fire
- Explosion
- Hazardous materialProperty damage release etc.
- Other energy releases
- •Illnesses/injuries/ Death
- Business
 - interruption
 - Environmental damage etc3

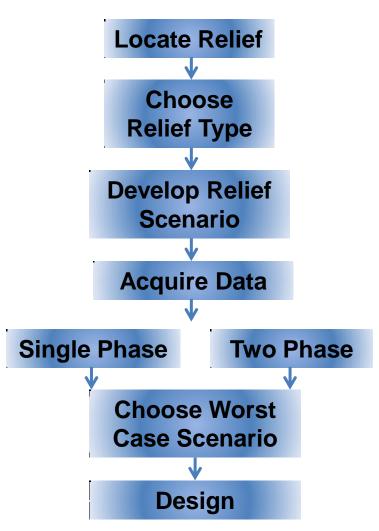
Relief System Protection

- o Tiered safety systems, Tab. 5-10, p. 214
 - Last layer of preventive protection
 - Prevent costly incident at price of lost material
 - Material released into containment system, a plantwide system within a process plant

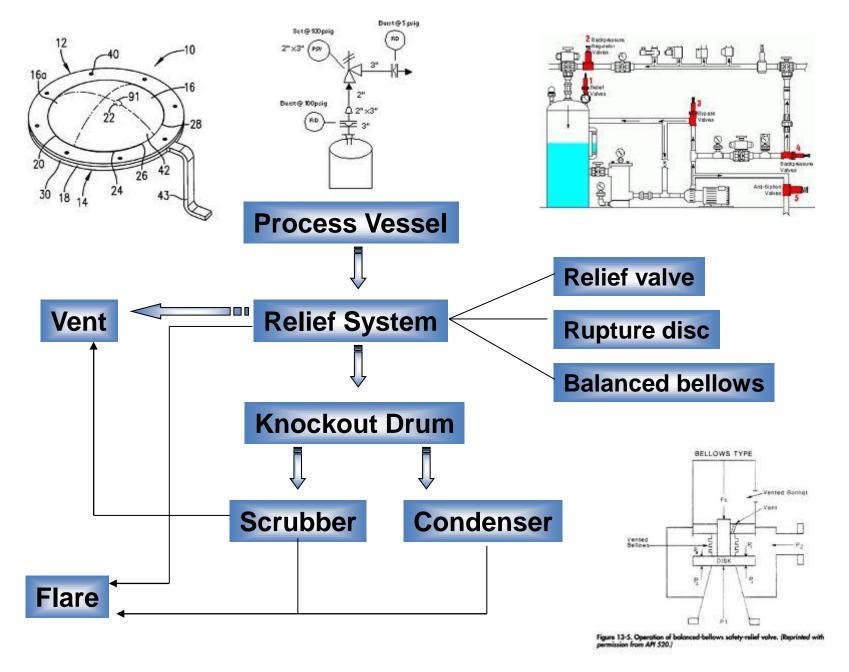
Major area	Examples	
Inherent safety		
Engineering design	Plant physical integrity, Process integrity, Process design features for emergency control: Emergency relief systems, Spill containment	
Management		
Early vapor detection and warning		
Countermeasures		
₁₁ ⊑m ergency response	2010 Fall 4	

Relief System Issues

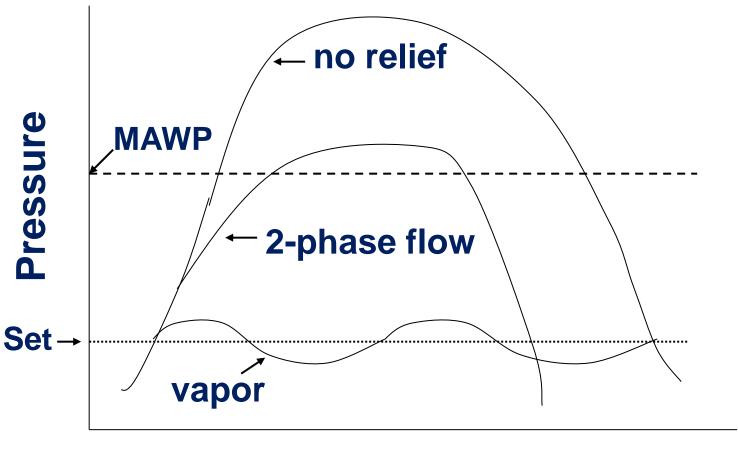
- Relief capacities: not too small or too large
- Properties of materials for treatment
- Containment system capacity, compatibility
- Locations and types of relief devices
- Relief method: Fig 8-1, p. 354
- Nomenclature, pp. 356, 357



- Relief Concepts
 - to protect personnel from the dangers of overpressurizing equipment,
 - to minimize chemical losses during pressure upsets,
 - to prevent damage to equipment
 - to prevent damage to adjoining property,
 - to reduce insurance premiums, and
 - to comply with governmental regulations.
- Relief system: The network of components around a relief device, including the pipe to the relief, the relief device, discharge pipelines, knockout drum, scrubber, flare, or other types of equipment that assist in the safe relief process.



Release Behavior



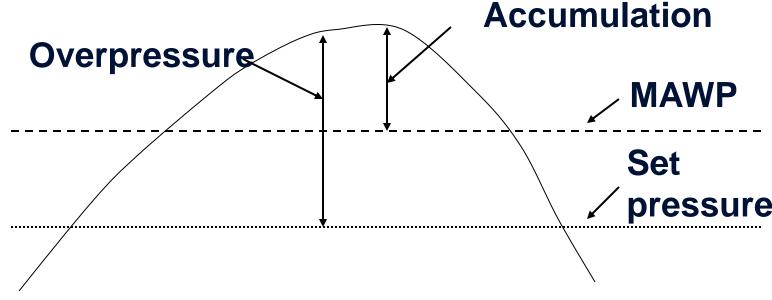
Time

- Set pressure: The pressure at which the relief device begins to activate.
- Maximum allowable working pressure (MAWP): The maximum gauge pressure permissible at the top of a vessel for a designated T resign pressure.
 - Operating T ↑, the MAWP ↓
 - the vessel metal loses its strength
 - Operating T↓, the MAWP ↓
 - metal embrittlement at lower T
 - Vessel failure typically occurs at 4 or 5 times the MAWP
 - Vessel deformation may occur at as low as twice the MAWP.

- Operating pressure: The gauge pressure during normal service, usually 10% below the MAWP.
- Accumulation: The pressure increase over the MAWP of a vessel during the relief process. <a>™ % of the MAWP
- Overpressure: The pressure increase in the vessel over the set pressure during the relieving process.
 - Equivalent to the accumulation when the set pressure is at the MAWP ☜ % of the set pressure
- Backpressure: The pressure at the outlet of the relief device during the relief process
- Maximum allowable accumulated pressure: The sum of the MAWP and the allowable accumulation.

Relief Device Locations

- Process unit operations
- Hazardous pressures: exceed allowable accumulation > MAWP
- Identify hazardous pressures (HAZOP)



Guideline for Relief Pressure

Pressure Vessel Requirement	Vessel Pressur e	Safety Relief Valves
Max Allowable Accumulated P	121	Max Relieving P for Fire
Max Allowable Accumulated P for Multiple-valve Installation	116	Max Relieving P for Process Overpressure (Max)
Fig. 8-4, p. 358	110	Max Allowable Set P for Supplemental Valves
Max Allowable Working P or Design P	105 ²	Overpressure (Typical) Max Allowable Set P for Single Valve Start to Open
Usual Max Normal Operating P	95	Standard Leak Test P

Causes of Increased Pressure

- Heating, loss of cooling, inadequate agitation
- Incorrect concentration, contaminants
- Catalysts, contaminants
- Operator error
- Enclosed liquids, thermal expansion
- Valve failure
- External fire

Relief Type Selection

- Select type and size
 - Material: gases, liquids, gases & liquids, solids
 - Properties, e.g., corrosive, flammable, inert
 - Process conditions
- Vent: atmosphere, treatment systems (scrubber, flare, condenser, incinerator)

Standard Relief Valve

- Operation: pressure drop across valve seat
- Flow rate proportional to pressure drop
- Set pressure: spring tension adjusted for 10 % above normal operating pressure
- Set pressure and flow rate through valve are dependent on downstream pressure or backpressure

Standard, Bellows, and Rupture Relief Devices

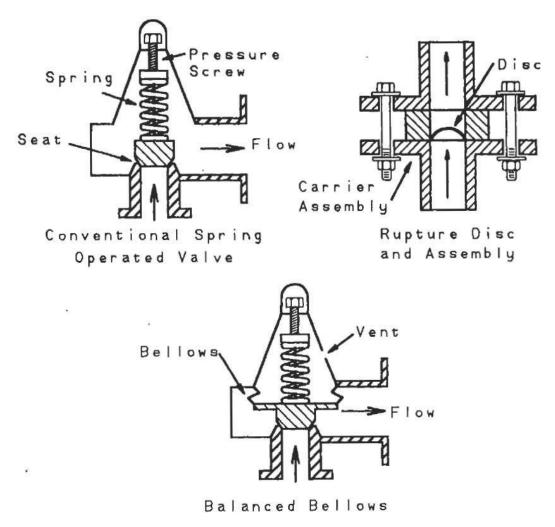


Figure 8-7 Major types of relief devices.

Balanced-Bellows Valve I

- Spring and back of valve seat is separated from fluid by a bellows
- Back of valve is vented to atmosphere
- Valve opens at the set pressure regardless of backpressure
- Flow rate through valve is dependent on backpressure

Balanced-Bellows Valve II

- Advantages: more accurate set pressure, better protected from fluids
- Disadvantage: expensive
- When to use: for a constant relief flow rate if large variations in back pressure can occur

Spring Relief Valve Types

- "Relief" valve for liquids
 - Begins to open at set pressure
 - Max flow at 25% overpressure
- "Safety" valve for gases
 - Pops open above set pressure
 - Flow keeps valve open
 - Reseats at 4 % below set pressure (blowdown)
- "Safety relief" valve for liquids and gases
 - Begins to open at set pressure
 - Max flow at 25% overpressure

Advantages of Rupture Disks

- Simple, inexpensive
- Single reliable sealing
- Available in wide range of sizes, including larger than standard valves
- Venting rates can be much larger than with spring-operated valves
- Often used in series with a standard relief valve

Disadvantages of Rupture Disks

- Does not close after opening
- Excessive material can be vented
- Air can leak in after opening
- Corrosion can result in disk holes and leaking
- Flexing of disk due to cycling can lead to failure at lower than nominal Pressure