AIChE
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
Netherlands / Belgium Section

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Pressure Relief – Thinking Ahead for a Safe Start-Up

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Disclaimer

The information contained in this presentation represents the current view of the authors at the time of publication.

Process safety management is complex and this document cannot embody all possible scenarios or solutions related to compliance.

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Experience

My background:

37 years research, design, start-up, process improvement with

29 years specialization in relief system design

Investigations related to start-ups:

- Gauge blown out on positive displacement pump (1980)
- Runaway reactor (1981)
- Overfill of ammonia column – released 2000 lbs (1982)
- Trays ‘blown out” of column (1983)
- Incorrect metallurgy - failed in 3 days (1985)
- Failure of 8” line - 17,000 lbs vapor (1987)
- et. al.

Experience

Siemens Process Safety Group:

- Evaluated
  - > 100,000 Relief systems
  - > 600 Units
  - > 200 Flares

- Offices
  - Houston, TX (USA)
  - Belgium
  - Singapore
  - UAE
  - Bucharest, Romania
  - Rio, Brazil

Historical Perspective

Incidents that shaped industry

1976 – Seveso, Italy

Photo per www.dataforth.com

1984 – Bhopal, India

Photo per Daniel Berehulak/Getty Images

Historical Perspective

Incidents that shaped industry

1992 - La Mede, France (1992)

Photo per AFP

Historical Perspective

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Incidents that shaped industry

2005 - Texas City Isom Explosion

Photo per Houston Chronicle

Historical Perspective

It’s about more than just compliance…

- Injuries/deaths to friends, coworkers, community
- Litigation
- Damage to the facilities
- Damage to the company’s reputation

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➔ **It’s personal**

➔ **It profoundly affects the company**

- Union Carbide
- BP (Texas City, TX)
- Bayer (Charleston, WV)
- DuPont (Pasadena, TX)

Historical Perspective - USA

1910
From 1865 - 1910 ~10,000 steam boiler explosions

1911
ASME established Boiler and Pressure Vessel Committee

1955
API published first document on Pressure Relief Systems

1969
API published 1st ed API 521 separate from API 520

1976
AIChE formed DIERS (Design Institute for Emergency Relief Systems)

1993
OSHA 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals"

OSHA 29 CFR 1910.119 PSM

14 Elements

Employee participation	Process Hazards Analysis	Operating Procedures	Training
Contractors	Pre-Startup Safety Reviews	Mechanical Integrity	Hot Work Permits
Management of Change	Incident Investigations	Emergency Plan/Response	Compliance Audits
	Trade Secrets	Process Safety Information	

"Information … shall include: Relief system design and design basis"

OSHA 29 CFR 1910.119 PSM

Elements involved in start-up

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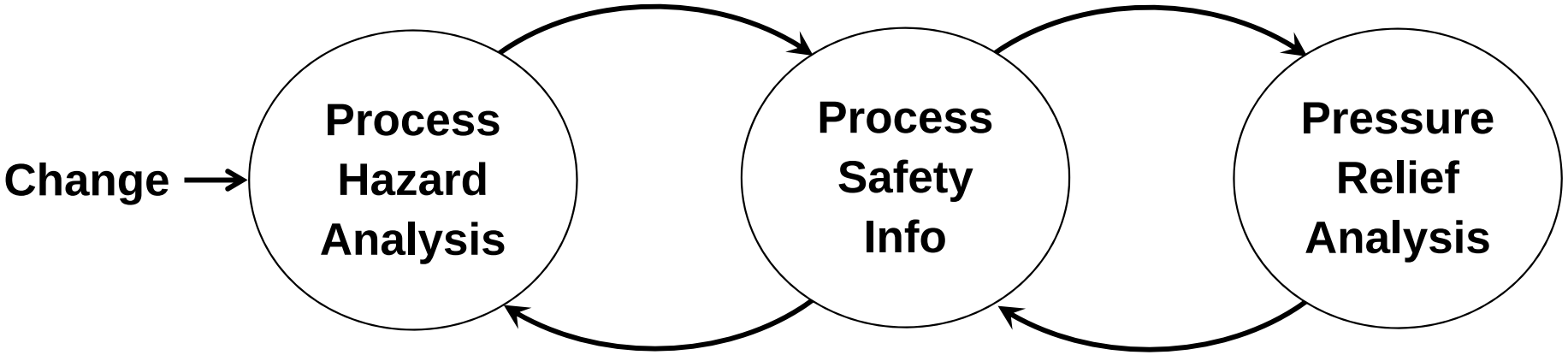
Safety Management System

Thinking ahead for a safe start-up



Changes that trigger an evaluation:

Process

- Changes in feed rate or composition
- New or different chemistry
- New feed, catalyst, or different sequence
- Changes in operating conditions

Procedures

- Changes in operating or maintenance
- Changes in set point
  (pressure, temperature, flow)
- Change in inventory
- Changes in car seal / lock list

Fixed Equipment

- Installation of a new vessel
- Replace vessel with different dimensions
- Modifications to vessels
- Rerating of vessels (temp or pressure)
- Change in metallurgy
- Change in heat transfer area
- Change in firing rate
- Changes to piping
- Changes in fire rated insulation

Rotating Equipment

- Changes in number / size of impellers
- Change in driver type, Hp, Speed

Instrumentation

- Changes to alarm points.
- Changes in control valve or bypass
- Change in control valve fail position
- Installation of Safety Instrumented Systems

Electrical

- Changes in electrical distribution
- Additional electrical circuits
- New electrical equipment

Relief System

- Changes in relief devices
  - Piping
  - Set pressure
  - Size
  - Type (conventional → bellows)
- Change in the disposal system
  - Piping
  - Knockout drums
  - Different flare tip

What is Pressure Relief Analysis?

- **Pressure Relief Analysis (PRA) - Design, document, and manage pressure relief systems**
  - Identify sources of overpressure
  - Quantify relieving loads
  - Ensure proper sizing, selection, and installation
  - Evaluate disposal system (flares, etc.)

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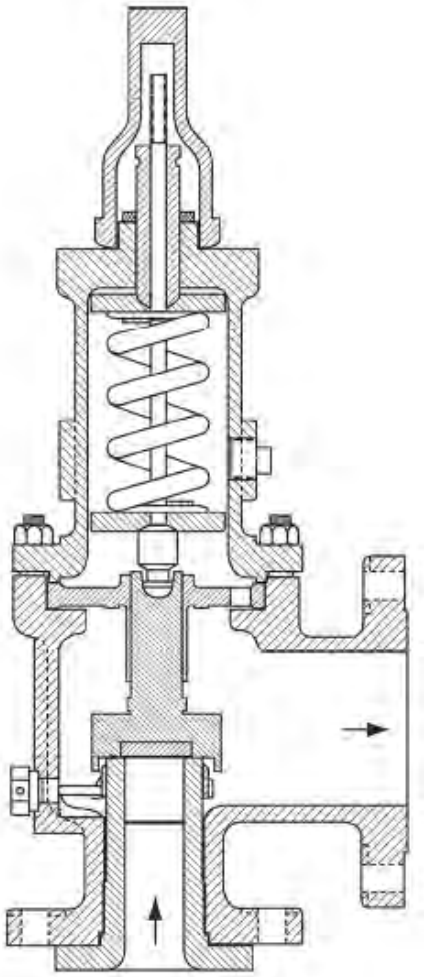
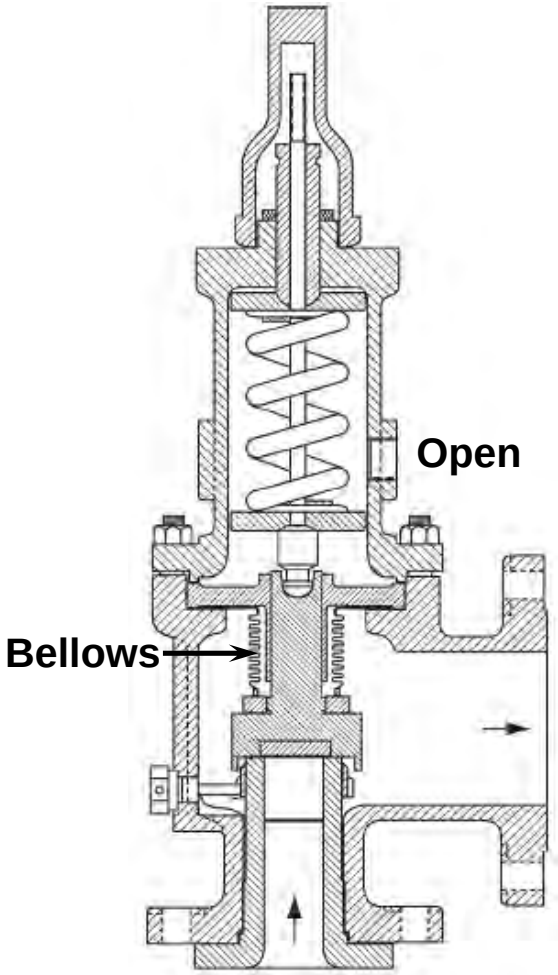
Specifically consider normal and non-normal operation including start-up and shutdown

Examples of Relief Valves

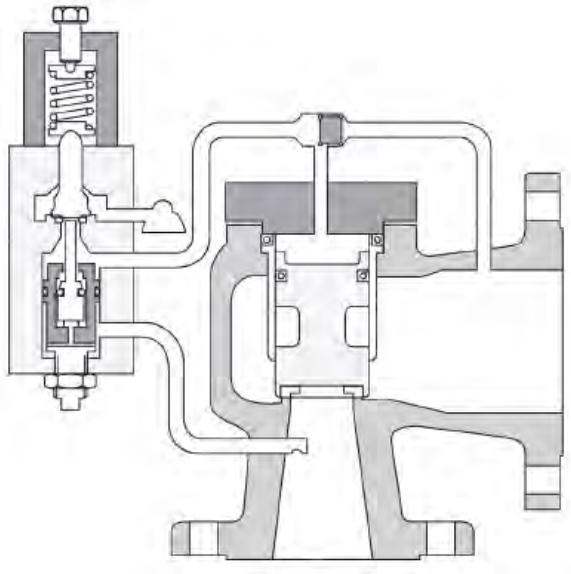
Drawings per API 520



Conventional



Bellows



Pilot Operated

Examples of Flares

Elevated Flares

Steam Assisted

Air Assisted

High Pressure (Sonic)

Examples of Flares

Multi-Stage Ground Flare

Pictures per John Zink (Texas City Flare 5)

Common Scenarios

1	Blocked outlets
2	Cooling water failure to condenser
3	Top tower reflux failure
4	Sidestream reflux failure
5	Lean oil failure to absorber
6	Accumulation of noncondensables
7	Entrance of highly volatile material
8	Overfilling
9	Failure of automatic controls

10	Abnormal heat or vapor input
11	Internal explosions / transient spikes
12	Chemical reaction
13	Hydraulic expansion
14	Fire
15	Heat transfer equipment failure
16	Power failure
17	Maintenance

The majority of these can occur on start-up!

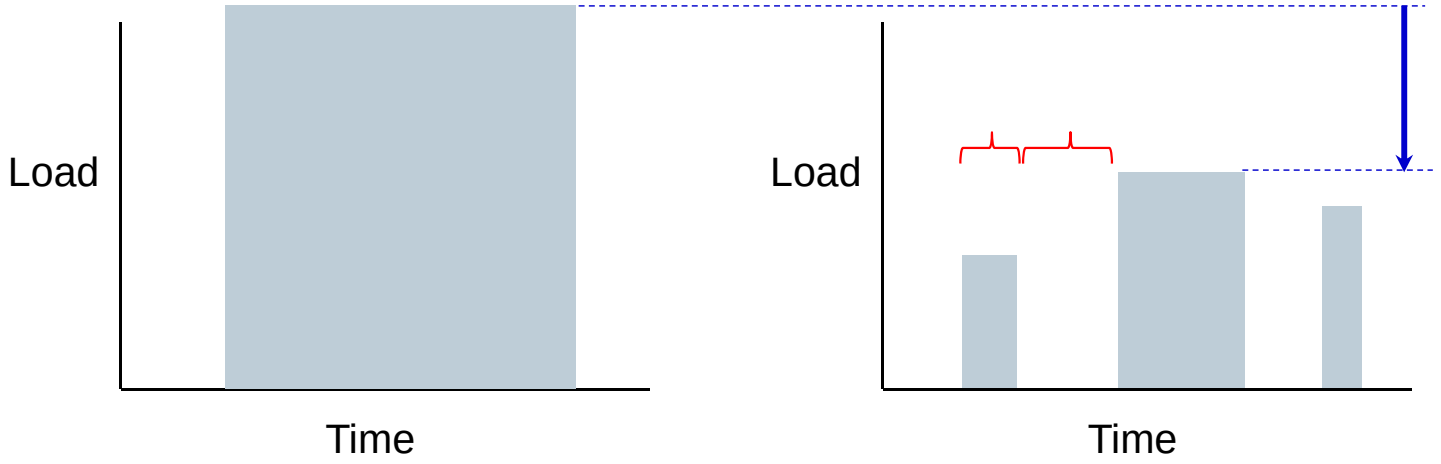
Additional Options

If the relief systems are inadequate, consider:

- Dynamic simulation
- Quantitative risk assessment

Dynamic Simulation

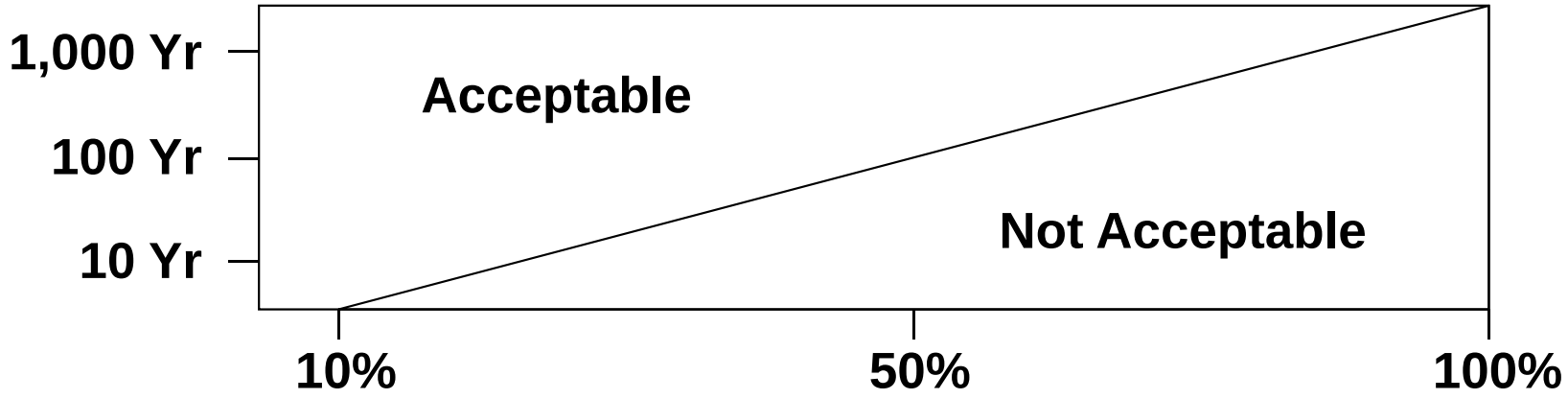
Take credit for duration of loads and when loads occur



Additional Options

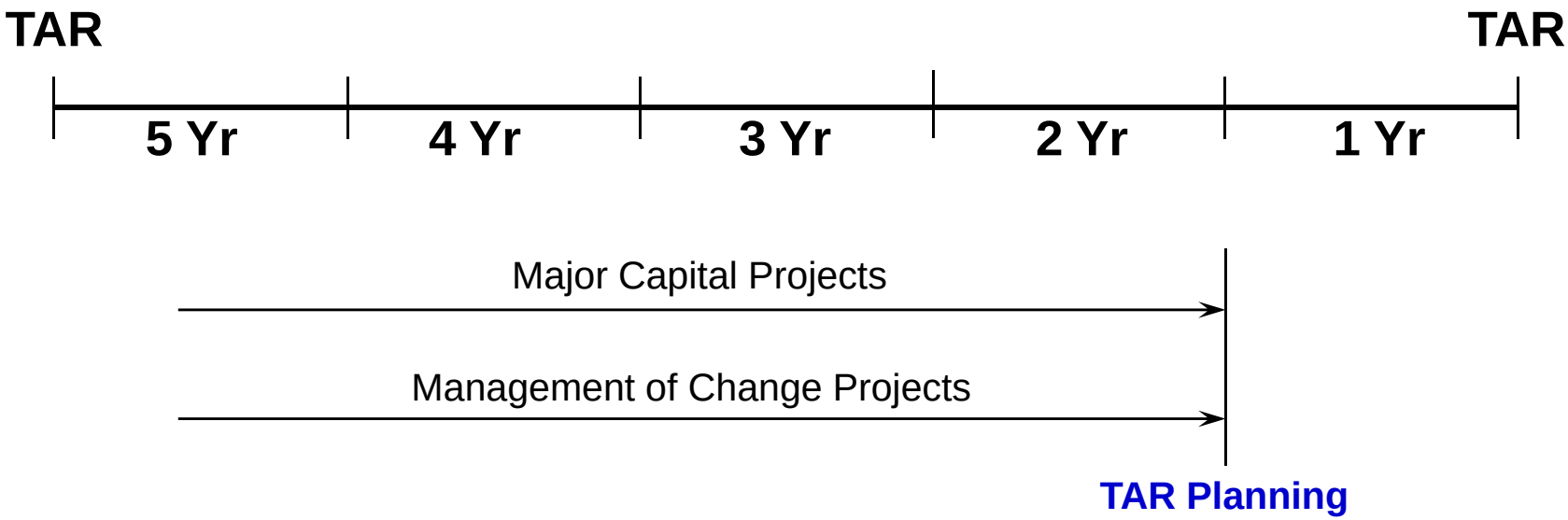
Quantitative Risk Assessment

- Statistical analysis
  - Rules for vessel overpressure based on backpressure
  - Safeguards with probability of failure on demand
- Agreed upon acceptance criteria



Timing

Turnaround Planning



➔ **Design must be finished ~ 1 year ahead of the TAR**

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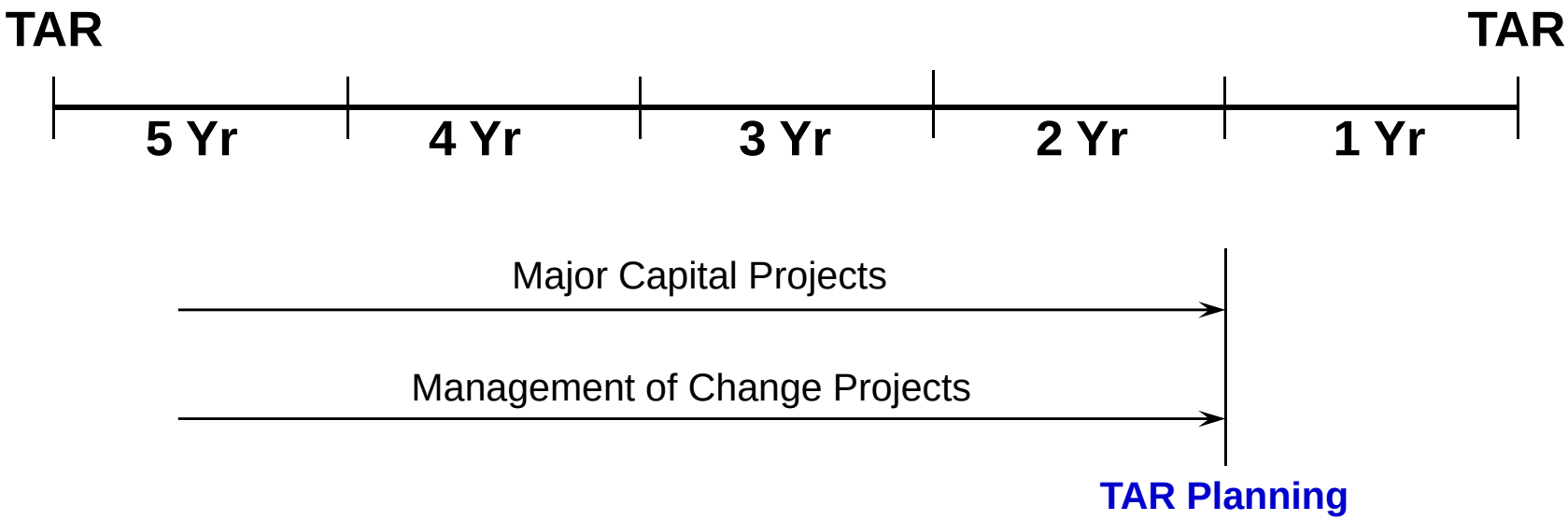

➔ **Design must be finished ~ 1 year ahead of the TAR**

➔ **You're already behind**

Conclusions

1) **The pressure relief system is the last line of defense.**
2) **It's a fundamental part of the plant design.**
3) **It takes an in-depth understanding of the equipment, process, and modes of operation including start-up and shutdown.**
4) **The effect of changes on the design basis must be considered well in advance of a turnaround.**
5) **Solutions should be creative / innovation to minimize cost.**

Questions?

Contact us for more information!

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