Liquefied Gas Carriers
Tank Safety Valves
Isolation & Piping Considerations

Jean-Paul Boyer
PRV Process Director, Europe | Emerson
jeanpaul.boyer@emerson.com

Emerson - Tank Safety Valves

Anderson Greenwood

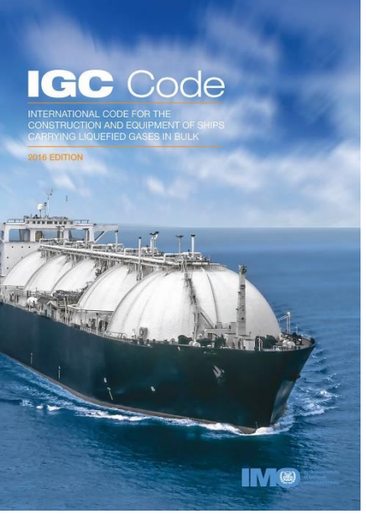
- Since 1964 on LNG & LPG carriers and on-shore terminals
  - Also **Luceat** (obsolete)
  - 3rd generation for cargo tank safety valves, low and high pressures
- 4 safety valves global factories
  - Stafford, Tx, USA (full marine certifications)
  - Manchester, UK
  - Cluj-Napoca, Romania
  - Qingpu, China (full marine certifications)
- Assembly / Service Centres around the world
  - UK, Spain, Netherlands, UAE, Singapore, Australia…

Jean-Paul Boyer

Former merchant navy officer (France, DESMM 1987)

30+ years safety valves experience

The views expressed in this presentation do not necessarily reflect the views of Emerson, and are solely those of the presenter.



IGC 2016: Important changes for Cargo Safety Valves

from Chapter 8

- 2 safety valves minimum for all cargo tanks, no size limit (~~>20m³~~)
- Allowed to "stagger" the set pressures of the PRV, up to 5% above MARVS
  - To help minimizing release of vapour
- Clearer and more detailed testing requirements
  - References to ISO 21013-1 and ISO 4126-1… scope issues: would need revising
    - ISO 21013-1: up to DN150 / 6", onshore, cryogenic type-testing
    - ISO 4126-1: spring loaded PRV only

Interesting also for On-Shore Tanks…

1. New details on pressure losses, important for PRV sizing and stability
   - Upstream and downstream piping systems
   - *Very important for any tank*
2. Emergency isolation means mandatory for cargo tank PRV
   - Only mandatory for cargo tank valves, not for insulation spaces or other PRV
   - Not required to maintain 100% relieving capacity
   - No details on the "means" (IGC is 'goal-based', not prescriptive) which could lead to some issues
   - *On-shore, isolation is common, with one 'spare valve'*

PRV: Pressure Relief Valve, Safety Valve…

IGC Ch. 8 – … Needs clarifications

- 8.4.2 to 8.4.5: new text on pressure losses, can be confusing and would benefit from some modifications.

  For example:

  "Pilot-operated PRVs shall be unaffected by inlet pipe pressure losses…"

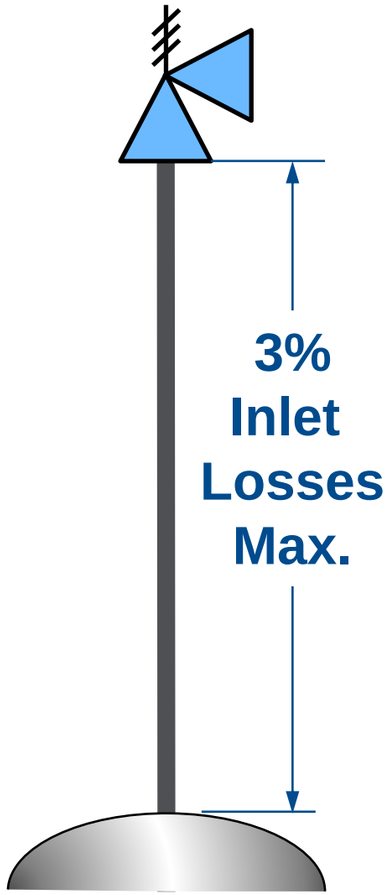
  → they are affected: the flow capacity through the valve is reduced; configuration of the pilot remote sensing line…

  - Could be in a separate paragraph: "8.5 Vent pipe system"

- 8.2.9: **mandatory** isolation for cargo tank PRV
  - Could cause more bad than good
    - 8.4.3 (Upstream pressure losses) must be complied with
    - Potential for turbulences or vortexes?
    - Reliance on "procedures"…
  - This is unique: no other code or standard imposes isolation means on PRV

Pressure Losses

Inlet Piping: the Famous 3%



- Pressure losses between protected system and the safety valve **≤ 3% of Set** pressure
  - API 520-II, ISO EN 4126-9, ASME VIII M-6, AD.A2…
    and now IGC 8.4.3.1: *"pressure drop in the vent line from the tank to the PRV inlet shall not exceed 3% of the valve set pressure at the calculated flow rate"*

- Recommendation to limit risks of Chatter

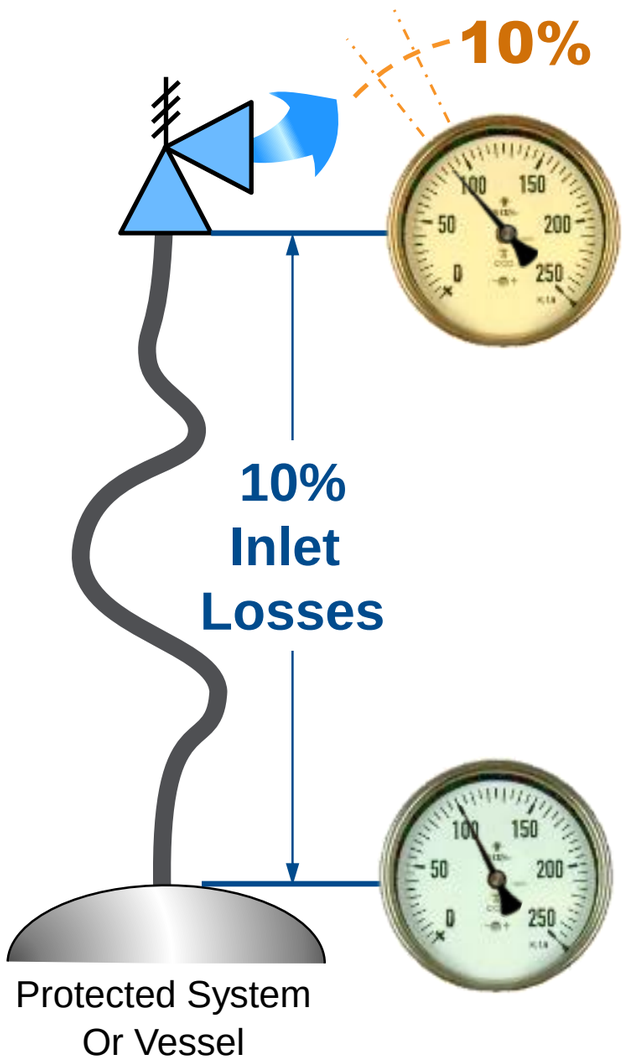
  Does NOT guarantee stability of the valve

  Does not eliminate turbulences, vortexes…

  - Possible exception:
    - Thermal relief (pipeline protection), very small flow
    - Engineering analysis of installation… (→ not in IGC)
    - Pilot operated safety valve with remote sense

  IGC 8.4.3.2: *"Pilot-operated PRVs shall be unaffected by inlet pipe pressure losses when the pilot senses directly from the tank dome"*… confusing…

Chatter due to Upstream pressure losses

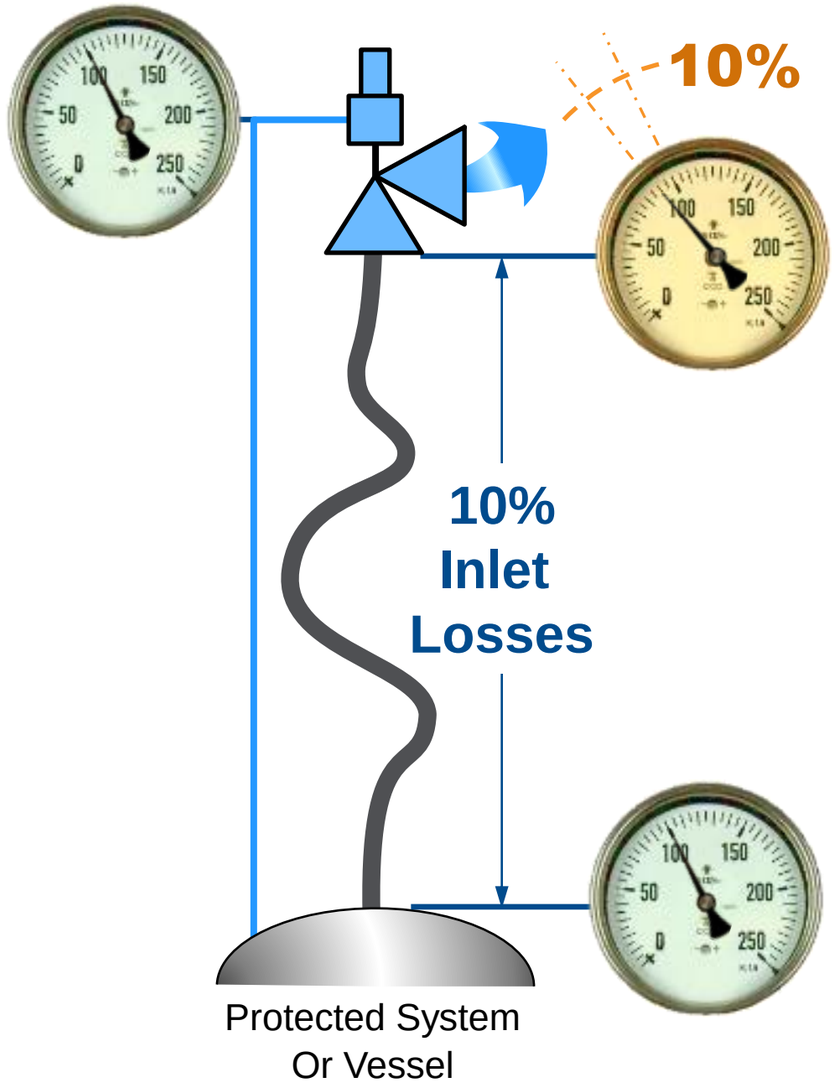


- Instability due to high Inlet Losses

  If Inlet Losses > PRV Blowdown

- Example
  - Set = 100 mbarg
  - Blowdown = 7% → Reseat = 100 – 7% = 93 mbarg
  - ➢ Inlet Losses = 10% …
    Valve closes when Inlet P. = 93 > 100 – 10%
  - ➢ PRV closes immediately after opening, then
    re-open… re-close… re-open… re-close… re-open… re-close… re-open…

Eliminate Chatter with Remote Sense



- Pilot valve with remote sensing =
  Pilot always senses System pressure → Stable

  - Some limitations on total length of sensing line, etc.
    even on non-flowing pilots

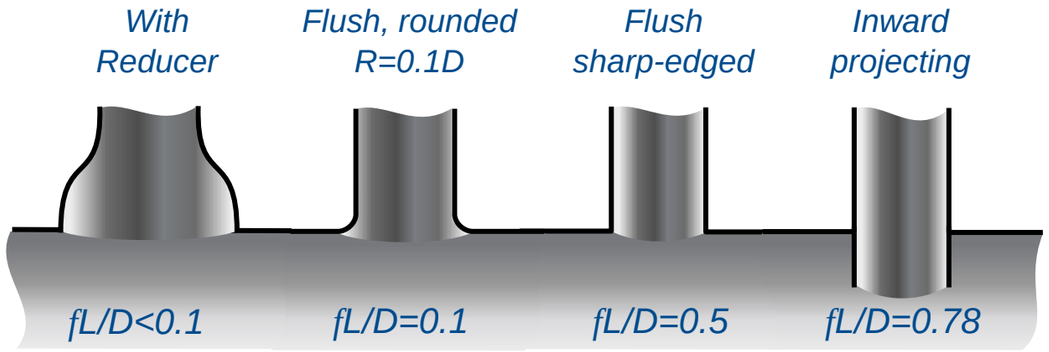
    → Needs confirmation from manufacturer

  - The remote sensing does not prevent from turbulences or vortexes

Inlet losses must be included in sizing,
they reduce total capable mass flow through the PRV

Upstream pressure losses (illustration only)

- **Entrance design**, pipe on dome
  - 90º sharp edge = 5 x more losses



Examples PRV Inlet Loss	3L4	3FB4	10x12
Entrance with Reducer	<0.4%	<1.7%	<1.6%
Rounded	0.4%	1.7%	1.6%
Sharp-Edged	2.0%	8.7%	7.8%
Projecting	3.1%	13.5%	12.2%

- **Any 'accident'** between tank and PRV, e.g. isolation valve

fL/D	General	3"	10"
Ball Valve (F.B)	3 f_T	0.054	0.042
Gate Valve (F.B)	8 f_T	0.144	0.112
D.Offset Butterfly Valve		~1.8	0.480

Examples PRV Inlet Loss	3L4	3FB4	10x12
Ball Valve (F.B)	0.2%	0.9%	0.7%
Gate Valve (F.B)	0.6%	2.5%	1.8%
D.Offset Butterfly Valve	~6.7%	~28%	7.7%

PRV examples: Propane at 5.3 barg set, 20% OP, 10ºC: 3" L 4" (API orifice size) and 3"x4" 'Full Bore' (maximised flow)
Natural gas at -155ºC, 350 mbarg set, 20% OP: 10"x12" typical

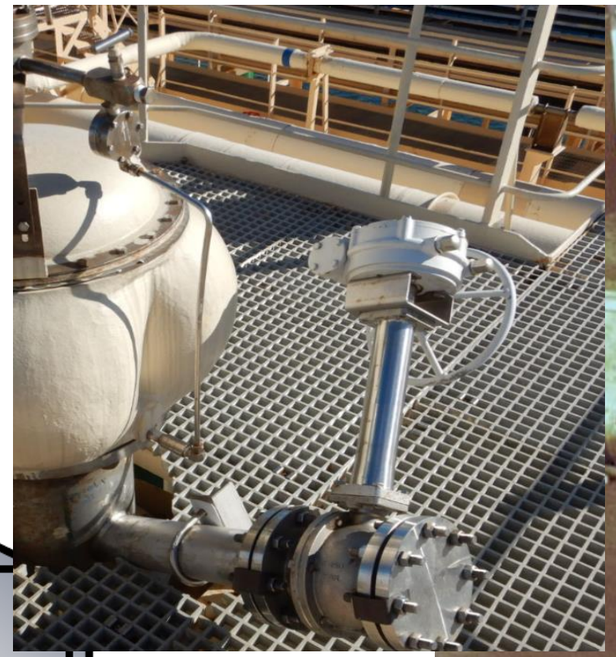
fL/D: from CRANE Publication 410M, 'Flow of fluids through Valves, Fittings, and Pipe'

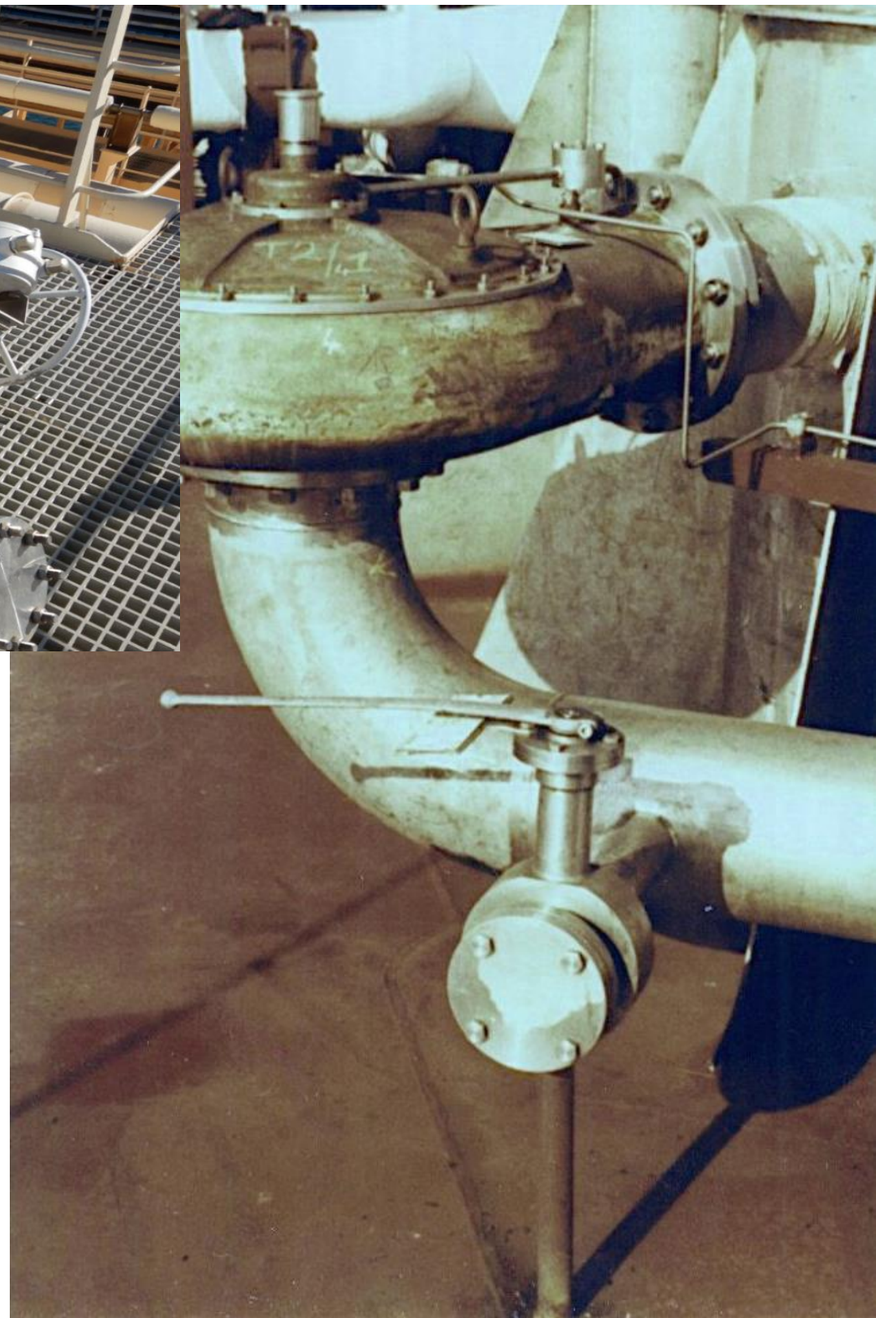
Emergency Isolation

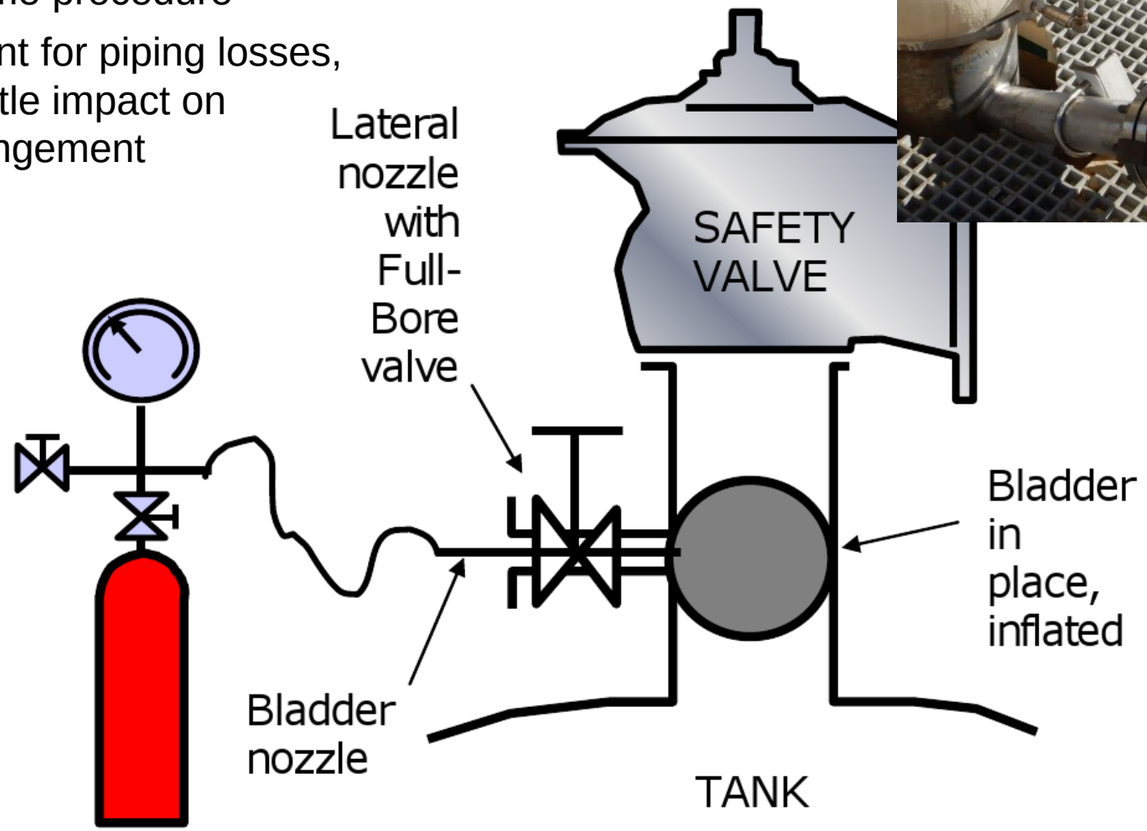
Isolation on some LNG and LPG

Bladder or Balloon: since mid 1970's

- Only for non-corrosive, not aggressive gases
- Class certification…
- Cumbersome procedure
- But excellent for piping losses, with very little impact on piping arrangement







Isolation Valve

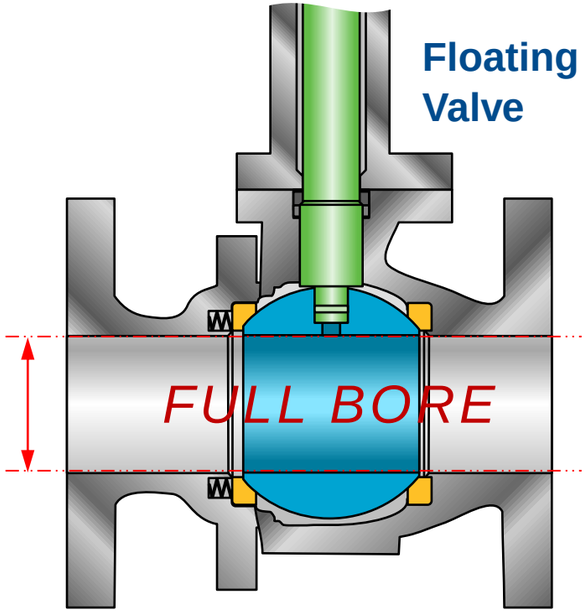
- Highly recommended use of **Full-Bore** valves

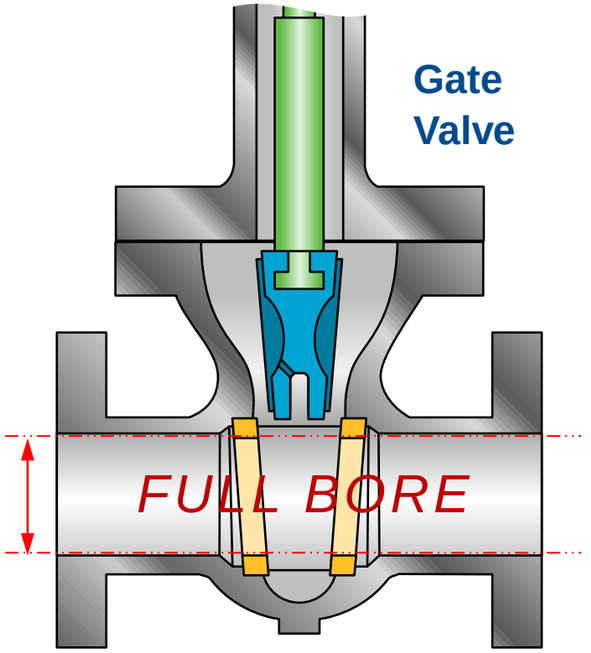
The opening through all pipe, fittings, … shall have at least the area of the pressure relief valve inlet ASME BPVC VIII-1

Full-area stop valves may be provided upstream and/or downstream of the pressure-relieving device… ASME BPVC XIII

Any isolation block valve (on the PV valve inlet) shall be full bore with its minimum flow area to be equal to or greater than the PV valve inlet area API Std 2000

Isolating valves and fittings in the inlet piping to a safety device should be of the full bore type. ISO EN 4126-9



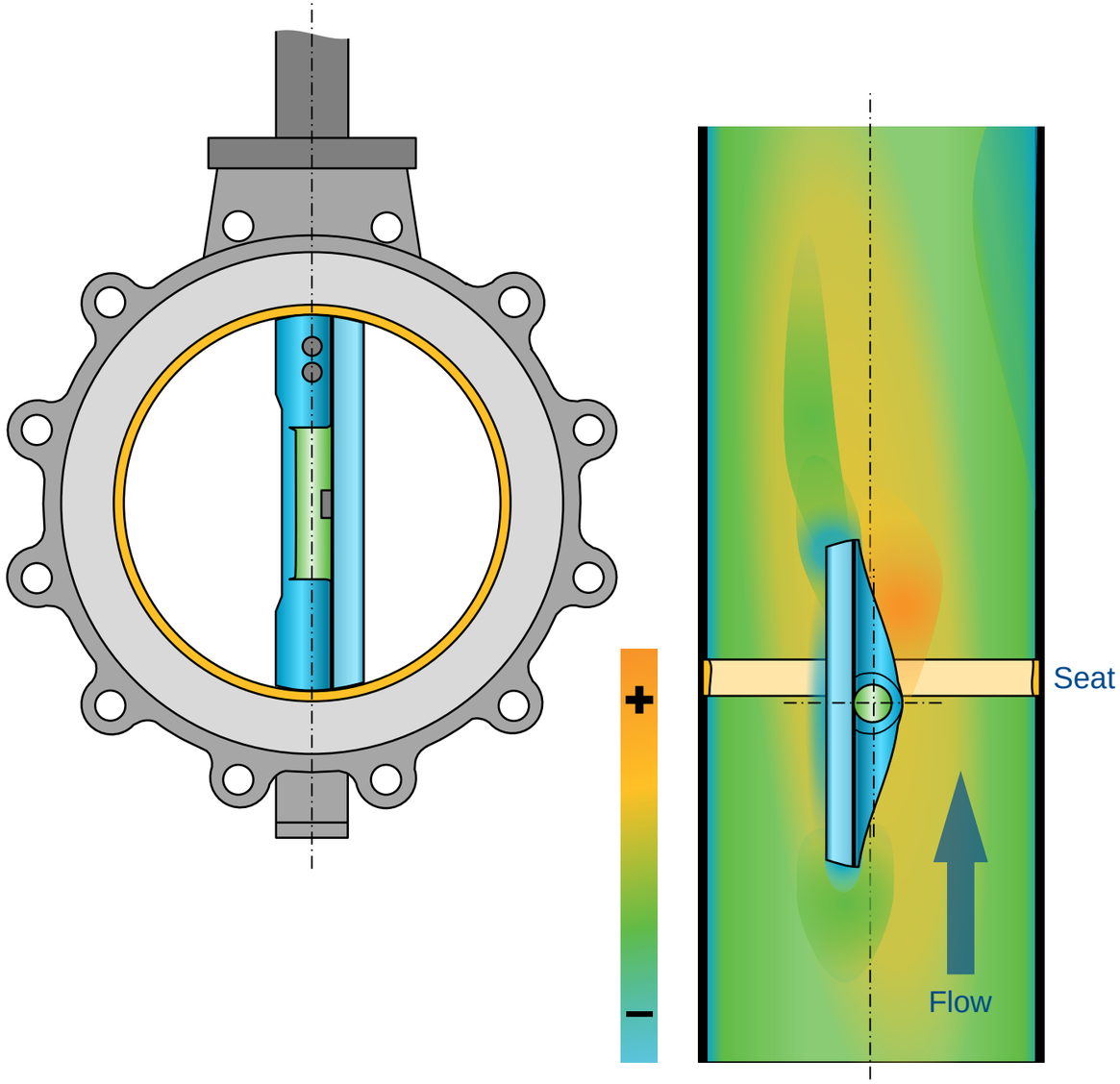


Isolation Valve

- Butterfly valves should not be used

  The opening through all pipe and fittings (including stop valves) … shall have at least the area of the PRV inlet connection… Butterfly valves and globe valves are not full area... In addition, there is the potential for internal failure of the butterfly valve, causing an obstruction in the PRD inlet line. For these reasons, butterfly valves and globe valves should not be used as PRD isolation valves.
  API Std 520 part 2

- Typical cryogenic butterfly valve, double offset
  - Thick disc and shaft in flow path (disc deported on one side)
    Tightness from torque means sturdy shaft
    - Important pressure losses
    - Important turbulences, ‘tail’
  - Requires long downstream pipe before stable flow



Velocity modelling (illustration only)
view from top

Isolation Mean: what to select?

- Bladder:
  - Not universal, limited sources, cumbersome procedure
- Isolation valve
  - Butterfly valve: dangerous, high pressure losses, turbulences… Never recommended
  - Ball valve: full-bore type only, up to 4”~6”
    - Above, very bulky, heavy…?
  - Gate valve: full bore type only
    - Cryogenic large sizes tend to be bulky, extended bonnet
    - Some very few low profile, lighter weight…

  - Pressure bleed facility?
    - Need to safely reduce pressure trapped between isolation valve and safety valve

Isolation Valve under PRV: Exception, not the rule

- IGC is unique – All other codes/standards: Never mandatory

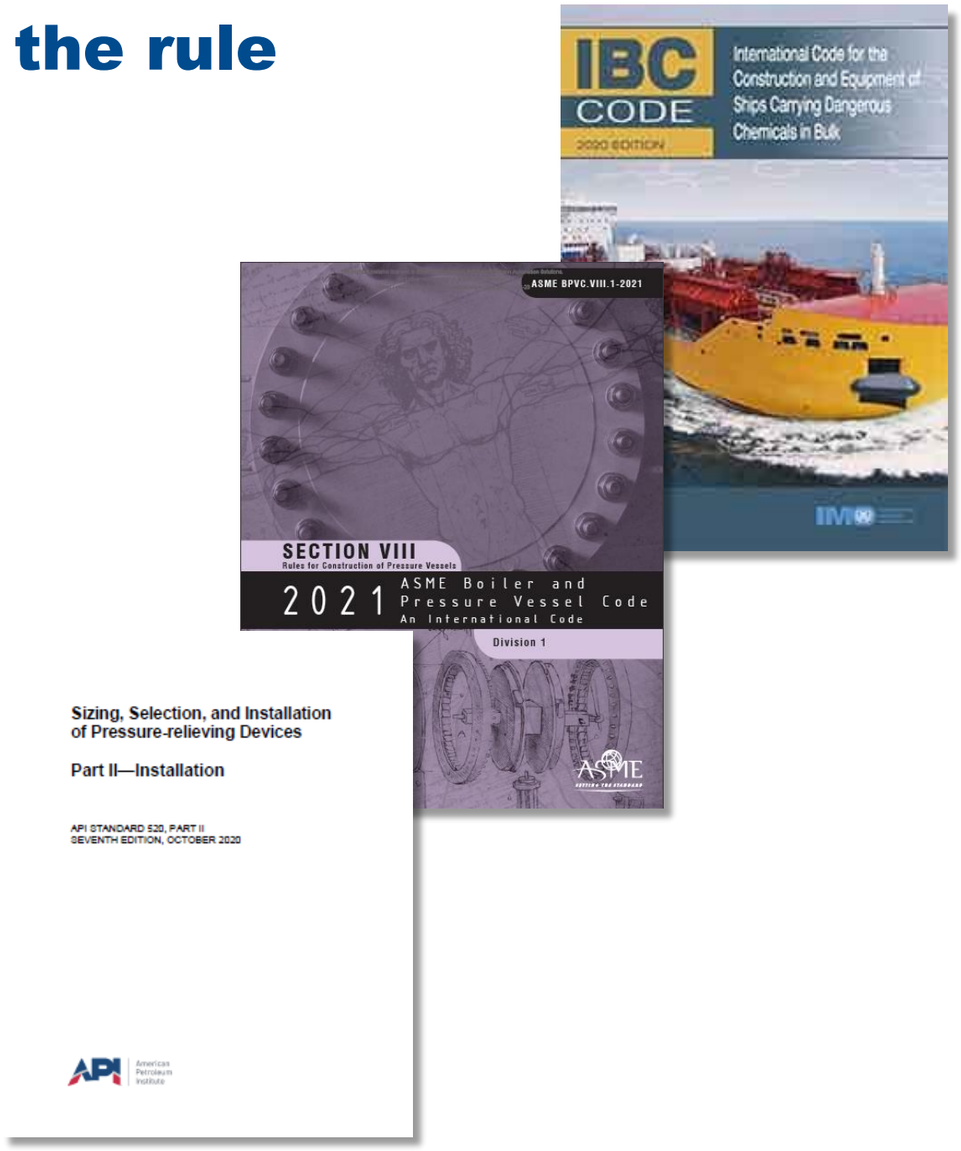
  In no case shall shut-off valves be fitted either above or below pressure- or vacuum-relief valves or pressure/vacuum valves. IBC code

  There shall be no intervening stop valves between the vessel and its pressure relief device or devices… except… ASME BPVC VIII-1

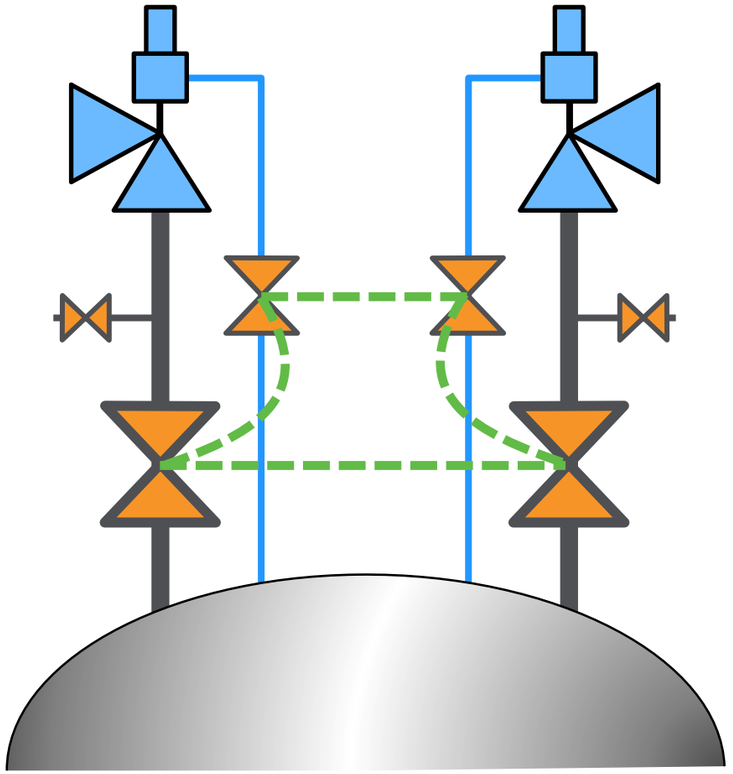
  Isolation block valves may be used for maintenance purposes to isolate a PRD from the equipment it protects… API Std 520 part 2

  There shall be no isolating valve in a pressure relief system except for the cases… ISO EN 4126-9

- IGC should make it optional again, and stress the importance of proper study of flow degradation upstream PRV in case of isolation valve



Safe Procedure for Isolation – To be developed



IGC 8.2.9: *…allow only one of the cargo tank installed PRVs to be isolated*

- Bladder system: fairly obvious
- Isolation valve:
  - Interlocking?
  - Remote indication in Control Room (position sensor)
  - Bleed port to safely release trapped pressure (depends on cargo, pressure…)
- Remote sense lines of the pilots?
- How to ensure correct and safe sequence of isolation:
  1. Isolate Main Valve. Confirm fully isolated, bleed pressure & check
  2. Then isolate the pilot of the isolated MV
  3. On re-start: open the pilot sensing line of the MV
  4. Then open on the MV
  - Open / Close always S-L-O-W-L-Y

Revise IGC Ch. 8

Clearer and using Existing, Proven Practices

Pressure Losses

- Big improvements from 93 ed
  - Needs more details, clarifications, better references
- Upstream and Downstream
  - Harmonised requirements
  - Would be clearer in same clauses
  - Should refer to internationally accepted standard

Isolation Means

- Should remain ‘optional’
- Make clear that main function is the PRV
  - Isolation mean shall not create any undue losses and/or turbulences
  - Shall be mechanically locked open (sealed)
  - Full-bore design, no obstruction
- Safety of the isolation procedure
  - Interlock? Procedure?
  - Bleed ports?

IGC is ‘goal-oriented’, not be prescriptive: keep focusing on basic points necessary for safety, and refer to standards (ISO, also API...) where appropriate

Jean- Paul Boyer
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