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#### VALVOLE DI CONTROLLO E INTERCETTAZIONE, SISTEMI DI AZIONAMENTO, DISCHI DI ROTTURA E DISPOSITIVI DI SICUREZZA UTILIZZATI NELL'INDUSTRIA DI PROCESSO





Milano, 18 Aprile 2018 Auditorio TECNIMONT Valvole Di Sicurezza Per Servizi Criogenici Michele Giannini – Specialista Di Prodotto Emerson Automation Solution – Anderson Greenwood Crosby

## Natural Gas...

Highly flammable,Suffocating,"Green House" effect.

As liquid...
Cryogenic (-162°C),
High level of energy,
variable composition.

# 3 different applications :

- Thermal Expansion Relief Valves
  - Piping/pipeline protection
- Process Safety Valves
  - Vaporizers, heaters...
- Storage Tanks Relief Valves
  - Low pressure and vacuum

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#### Thermal Expansion Relief Valves





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# **Thermal Expansion RV**

- reduce freezing risks
  - -low simmer, pop action, high seat tightness
- reduce unnecessary product loss
   low simmer, short blowdown
- reduce line pressure to avoid fatigues
  - the valve must give a good pressure drop

#### The "Classic"



- Metal seated
- "Proportional"
- Fixed blowdown

#### The "Classic"



- Metal seated
- "Proportional"
- Fixed blowdown
- The small leakage creates important icing very rapidly
  - the valve may not be able to open anymore
  - Very dangerous 🕱 🕱 🕏 !!!

# Type 81: No Freezing



V-shaped PTFE soft seat

- resilience
  - bubble-tight
  - virtually no simmer
- repeatability
- inexpensive
- easy maintenance



# Type 81: No Freezing



- Powerful huddling chamber
  - Actual pop action: full opening at Set

# Type 81: No freezing



Type 81: TSV for Cryogenics

- Introduced in 1964
- Applications
  - NASA (LH2, LHE...)
  - LNG & LPG carriers
  - LNG plants: Brunei, Zeebruge, Ereglesi, Pyong Taek, Bonny, Oman ...
- Standardised at
  - Air Products, Praxair, Linde ...

# TYPE 81: TSV FOR CRYOGENICS



- Bubble-tight
- Pop action
- Externally adjustable blow-down
- Proven

#### - 11 -

### Process Safety Valves





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**Process Safety Valves** 

- reduce freezing risks
   low simmer, high seat tightness
- accurate and reliable at low temperature
   designed for temperature, pop action
- reduce unnecessary product loss
  - -low simmer, short blowdown, seat tightness
- ease of maintenance & settings
   particularly for the large valves

# **Conventional Spring Valve**



- Seat leakage
- Blowdown & pop linked
- Costly maintenance
- Sensitive to back-pressure

### **Balanced Spring Valve**



- Seat leakage
- Blowdown & pop linked
- Very costly maintenance
- Not reliable on low temperatures !!!! 🕱 🕱 🕱

Ice, Freezing!!!

### **Balanced Spring Valve**



#### API Std 520 latest edition :

It is important to remember that the bonnet of a balanced PRV shall be vented to atmosphere at all times. The user should be cautioned of the potential for freezing of atmospheric moisture inside the bonnet in cold service due to auto-refrigeration or cold ambient temperatures. (clause 4.2.1.3.9)

# Type 249/259 for Cryogenics



- Down to –253°C
- Pilot operated
- Soft seated
- Designed to avoid icing
- Ease of maintenance

# Closed: bubble-tight



 Seating force directly proportional to the pressure:

> Upwards =  $P x A_N$ Downwards =  $P x A_D$ Result  $\mathbf{F} = \mathbf{P} \mathbf{x} \left( \mathbf{A}_{\mathrm{D}} - \mathbf{A}_{\mathrm{N}} \right)$

The higher the Pressure The tighter the Valve

#### Seat Tightness vs Pressure



# Fully Open at Set



# **Comparing Cycles**



# Type 249/259: Pilot Operated

- No simmer
- Tightness increases with pressure – bubble-tight up to more than 95% of set
- Real pop action with non-flowing pilot
- Accuracy even on large valves
- Field test capabilities

Type 249/259: Pilot Operated











#### Field Test



# Type 249: Pilot Operated

- Adjustable blowdown
  - external; no influence on opening
- Not affected by back-pressure
- Top entry
- Sacrificial parts on piston:
  - seat, piston seal

#### **In-Line Maintenance**

![](_page_28_Picture_1.jpeg)

#### **In-Line Maintenance**

![](_page_29_Figure_1.jpeg)

#### Spare Parts?

![](_page_30_Picture_1.jpeg)

# Soft Goods Kits = No Lapping

![](_page_31_Picture_1.jpeg)

# Pilot Op. Vs Spring Loaded?

![](_page_32_Picture_1.jpeg)

### Higher Set Pressures

Size	Area (cm²)	Spring Valve	AGCO POPRV
8x10+10	285	N/A	102 +
8 T 10	167.7	20	102 +
6 R 8	103.2	20	102 +
4 P 6	41.16	69	255 +
3 K 4	11.86	153	255 +

### **Higher Set Pressures**

Size	Orifice	Direct Spring	AGC Pilot Operated
8 T 10	167 cm²	20.7	102.0 +
6 R 8	103 cm²	20.7	102.0 +
4 P 6	41cm <sup>2</sup>	69.0	255.5 +

Example: need 100 cm2 at 60 barg set spring valve: 3 valves 4P6 AGC Pilot Op. Valves: only 1 valve 6R8

### Type 249: for Cryogenics

![](_page_35_Figure_1.jpeg)




- Flexible V-shape seat
- Spring energised PTFE piston seal
- Bracket up



- Flexible V-shape seat
- Spring energised PTFE piston seal
- Bracket up
- Insulation pilot/bracket



- Flexible V-shape seat
- Spring energised PTFE piston seal
- Bracket up
- Insulation pilot/bracket
- Vaporiser

# Type 249 on Liquid N2



# Type 200 in Cryogenics

- Applications
  - -NASA
  - -LNG, LEG (ethylene) and LPG
  - Standardised at most air separation plants
- LNG plants: more than 65 projects
  - Bonny, Oman, Revithoussa, Ereglesi, Qatargas, Rasgas...

# **TYPE 249: PSV FOR CRYOGENICS**



Pilot operated
Bubble-tight
Pop action
Designed for -253°C
Field test
Applications

LNG plants
LNG ships

□ Air separation plants

Pop Action: Opens fully every time Waste of product Stress, reaction force... Pilot Not Balanced against backpressure Pilot exhausts to atmosphere

# Modulating Action for Cryogenics

- Type 400:
  - Fully and truly proportional
  - No emission to atmosphere



# Type 449: Modulating for Cryogenics



- Pilot operated
- Bubble-tight
- Fully Proportional
- Designed for –196°C
- Field test
- No emission to atmosphere
- Proven since 1996

# Approaching Set Point



# Pilot Begins to Vent



# **Pilot at Null Position**



# Main Valve Begins to Open



# **Pilot at Null Position**



# Series 400 Modulating Action



# Series 400 Modulating Action



# -III-Storage Tanks Relief Valves





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#### Tank Relief Valves

- reduce freezing risks
  - -low simmer, high seat tightness
- accurate and reliable
  - small tolerance on set, small overpressure
- balanced against back-pressure
  - discharge to flare system
- ease of maintenance & settings
   essential on large valves

#### The "Breather" Valve



- High simmer
- High overpressure
- Tolerances?
- Affected by back-pressure
- Acceptable on vacuum protection

# Type 9300 for Tank Safety



- Pilot operated
- All "Teflon" main valve
- Pressurised soft seat
- Isolated diaphragm
- High capacity verified
- Down to -196°C

#### **Bubble-Tight Seat**

- Pressurised seat design
  - increase film resilience
  - bubble-tight up to 98% of set



# Type 9300 on Pressure



- True pilot operated
  - fully open at <10% overpressure
  - +/- 3% tolerance
  - field test capability
  - not affected by back-pressure
  - pop or modulating

#### Overpressure



#### **Back-Flow Preventer**



If Back-Press > Inlet Press the valve will open and a back-flow will occur

#### **Back-Flow Preventer**



The Back-Flow Preventer insures that the dome is always at the highest pressure

The valve remains tight

Type 9300: Flow-Tested

- Introduced in 1986
- Applications
  - LNG & LPG carriers
  - LNG storage tanks: Inchon, Bontang, North West Shelf, RasGas, Bonny, Oman, Fujian, Dalian, Jiangsu, Guangdong, Shanghai...
- Standardised at most air separation plants
- Actually flow-tested at an ASME accepted facility

# TYPE 9300 FOR LNG STORAGE



- Bubble-Tight
- High capacities verified
- Low overpressure
- Accepts back-pressure
- Field test capability
- Proven

# Type 96A for Vacuum Relief



- Acceptable weight-loaded design
- Special features for real safety
  - -double soft-seat: o-ring seat and sponge seat
  - high capacity, all sizes actually flow-tested

Type 96A: Flow-Tested

- Introduced in 1973
- Applications
  - -LIN, LOX, LAR... storage tanks
  - LNG storage tanks: Inchon, Bontang, North West Shelf, Bonny, RasGas, Oman, Fujian, Dalian, Jiangsu, Guangdong, Shanghai...
- Standardised at most air separation plants
- Actually flow-tested at an ASME accepted facility

# TYPE 96A VACUUM BREAKER FOR LNG STORAGE



- Premium tightness
- High capacities verified
- Proven

#### **Pressure Protection**



# Large LNG Tanks



# Reserve Capacity Relief Valve (RCRV)

- LNG or LPG low pressure onshore tanks (Brunei, Bonny Island, ...)
- To relieve very large quantities of vapour generated by unusual conditions like:
  - Overfill
  - Inner wall failure
  - Rollover

#### **Roll-Over**

- LNG composition, density & temp will change during boil-off of gas
- If not mixed, a high density liquid will settle below the lower density liquid
- During heat leakage & evaporation, density of upper level of liquid can become higher than lower level and sudden rollover with mixing of liquids may occur giving sudden evaporation & pressure build-up



# **Reserve Capacity Relief Valve**

- Soft seated
  - O-ring seat that can be replaced tank under pressure
- Tension link
  - no leakage up to set; can be replaced with pressure in the tank
- Full open at pop
  - (if desired) no over-pressure to full lift


#### **Reserve Capacity Relief Valve**



# Furthermore.....



## **Cryogenic Test**



- Also "Boil-Off" test
- Actuate the valve to get test temperature
- Pop the valve 5 times at temperature
- No seat leakage at 90% of set after 20 min
- Re-check the set at ambient temperature
- EN 13648-1 "Safety Valves for Cryogenic Service"

### Summary

Thermal Relief Serie 81

□ Soft Seated, Pop Action, with Adjustable Blowdown

Process Valves Series 200 & 400 Pilot Operated, with special design for Cryogenic Liquid

Pilot Operated, with Enhanced Tank Valves Seat Tightness Series 9300 & 96A

Extensive Experience

□ >120 LNG plant with AGC valves

>350,000 AGC Pilot Operated SV around the world since 1962

# Grazie dell'attenzione

