AIGA 2005 Meeting

Cryogenic Vaporisation Systems

Prevention of brittle fracture of equipment and piping

by Eric Fortuit, Air Liquide

30 August 2005

Explosion in Italy: what happened

- The accident took place on April, 13th, 2003 morning, on an On-Site plant supplying nitrogen to the Customer PPG in Italy near Naples
- Our employee was called by the customer probably because something was not normal and the accident took place a few moments after he arrived at site
- A violent rupture of a nitrogen buffer capacity occurred
- The top part of the buffer capacity was found upside down near the bottom part and the water of the vaporization pool was found frozen
- One AL employee as well as three customer employees died during the accident

Picture

Explosion in Italy: explanation

- The accident happened on a 500 m3/h nitrogen plant equipped with a nitrogen vaporization system and a buffer capacity at 9 bar (130 psi) pressure
- The vaporization system consisted in a liquid nitrogen storage and a water bath type vaporizer with water supplied by the customer
- There has been an entrance of cold gaseous or liquid nitrogen into the buffer tank
- The buffer, made of carbon steel, did not withstand the cold and bursted

Pictures

AdHoc Group of EIGA: participants

José Ballester Ricart	Praxair Espana
Martin Dennehy	Air Products
Lennart Fredriksson	Linde
Grant Holland	BOC
Wolfgang Otte	Messer
Pierre Petit	Air Liquide

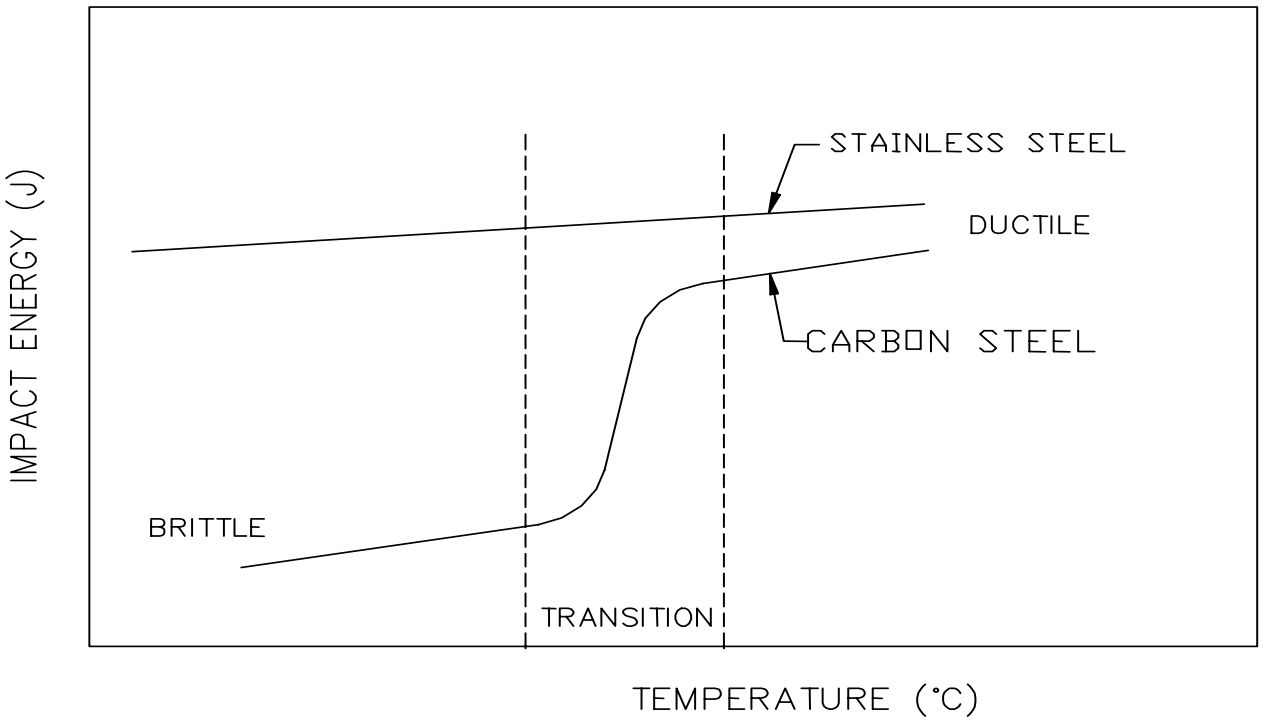
Main outlines of the document

- Causes and consequences of low temperature
- Types of vaporizers
- Design philosophy
- Ranking of hazards
- Safe design criteria
- Consideration for low temperature protection
- Solutions for low temperature protection
- Operation
- Periodic testing
- Training
- Customer awareness

Causes of low temperature examples

- Customer demand higher than design capacity during an extended period
- Flow control valve fully open by malfunction
- Vaporizer heavily iced
- Low water level in water bath type vaporizers
- Steam supply, electrical heating, fuel gas failure for these types of vaporizers
- Fan stop for forced fan ambiant vaporizers

Cryogenic Embrittlement of metals



- Impact energy and temperature for carbon and austenitic stainless steels
- Carbon steels become brittle at temperatures below –20°C-40°C

Types of vaporizers

- **Ambiant air** vaporizers
- **High thermal ballast** vaporizers
  - Water bath vaporizers with hot water circulation
  - Electrically heated metal block vaporizers
  - Forced draft, fan ambiant vaporizers
  - Ambient air vaporizers with trim heaters
  - Ambient air vaporizer with switchover system
- **Low thermal ballast** vaporizers
  - Have little or no stored energy at a time of a utility outage
  - Examples:
    - **Vaporizers with heating fluid pumped through**
    - **Direct steam jacketed vaporizers**

Risk assessment and PHLS factors

- **Severity of consequences** linked to PV of equipment which may be subject to cryogenic embrittlement
  - P3 (high severity): vaporizer with downstream buffer greater than 180 bar*liter
  - P2 (medium severity): pressure*outlet diameter>1000 bar*mm
  - P1 (low severity): pressure*outlet diameter<1000 bar*mm
- **Fluid hazards**
  - H3:toxic and flamable gases
  - H2: oxygen (for P3 and P2)
  - H1: inerts and oxygen (P1 only)
- **Likelihood of low temperature**
  - L2:High thermal ballast vaporizers
  - L1: ambient air vaporizers
- **Operating pattern**
  - S2: continuous supply or backup for peak shaving
  - S1: backup supply only

Solutions for Low temperature protection systems

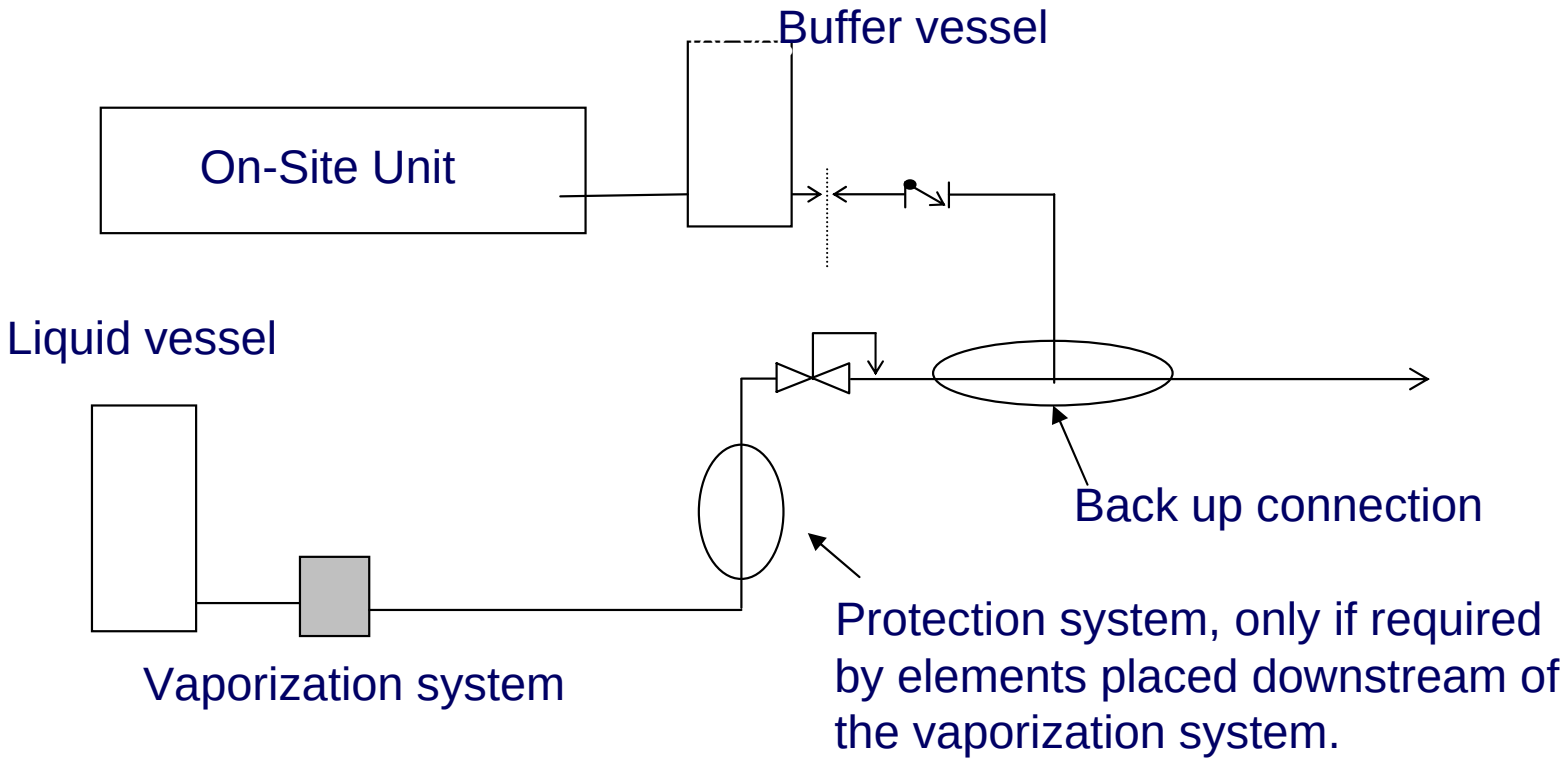
- Following the risk assesment and the PHLS factors, the EIGA document proposes to select a specific type of low temperature protection system

- These protection systems may include:
  - Low temperature detection device(s)
  - Logic solver
  - Shut-off device(s)
  -

- Shut-off devices may be
  - Vaporiser outlet valve shut-off
  - Vaporiser inlet valve shut-off
  - Pump motor shut down on pump feeding liquid to the vaporiser

- If several sensors or shut-off devices are selected, they must be independent

Safe Design criteria



- One example of safe design described in the EIGA document

Operation

- Consumption monitoring
  - Flow rate
  - Use pattern (continuous or not)
- Periodical inspection
  - Ice build up
  - Frosting of pipework
  - Leakage of process fluids or utilities
  - Addition of equipment by the customer (ex: buffer)
- Frequency of inspections

Personnel training and customer awareness

- Cryogenic embrittlement risks and design solutions must be known by process engineers, maintenance managers and technicians

- Customer contracts must take into account
  - Estimated flow rates and use patterns
  - Design performance of the vaporization system
  - Emergency response in case of non normal situation
  - The selected low temperature protection system
  - Customer training

PUBLICATION

IGC Document 133/05/E
Cryogenic Vaporisation Systems
Prevention of brittle fracture of Equipment and piping

has been published

can be viewed and downloaded free of charge at

www.eiga.be

and is candidate for global harmonization

A practical exercise

What do you do
if you see the following
when visiting a plant?


2005 3 7

Thank You for your attention