

Applying Safety Principles to CCS Transportation Installations

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Agenda

- What is National Grids interest
- What are the threats
- Competency
- Layers of protection
 - Process design
 - Process control systems
 - Prevention
 - Mitigation
 - Plant emergency response
 - Community emergency response

National Grid - Experts in Pipelines

High pressure National Transmission System – No major incidents



Over 7600 km pipeline system length

23 operating compressor stations

Electric and gas drive compressors

100% reliability

Experience of building and operating networks

Safety, Reliability and Efficiency

CCS Infrastructure: Yorkshire & Humber

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What is the big deal with CO₂?

- In free water reacts to form carbonic acid (internal corrosion)
- May form hydrates
- Is a very effective solvent
- Effects some lubricants and elastomers
- Poor lubricant
- Heavier than air
- Is an asphyxiant and has toxicological effects
- Complex phase behavior
 - p,v,t

What is the big deal with Anthropogenic CO₂?

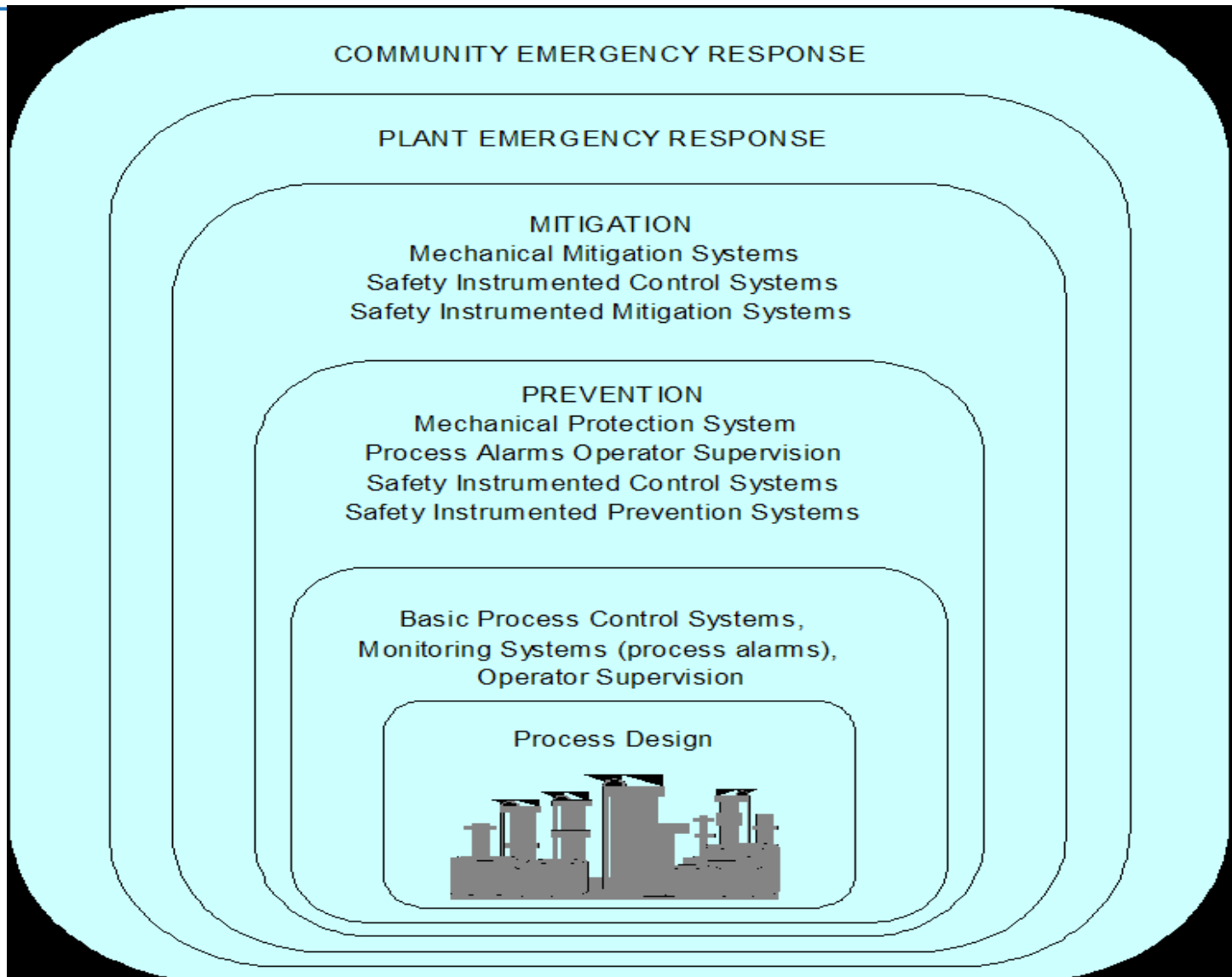
- Everything on the previous slide plus;
- Can have a mixture of other impurities
 - H₂, H₂S, N₂, O₂, Ar....
- Higher temperatures
- Subject to various capture techniques
 - Reliability
 - Rate changes

1st Management Challenge

- Find designers who are familiar with the product
- And/or re-educate them.

- Competency
 - Important to recognise different threats
 - Design them out
 - Plan to deal with the threats
 - Put Management systems in place

Typical Layers of Protection



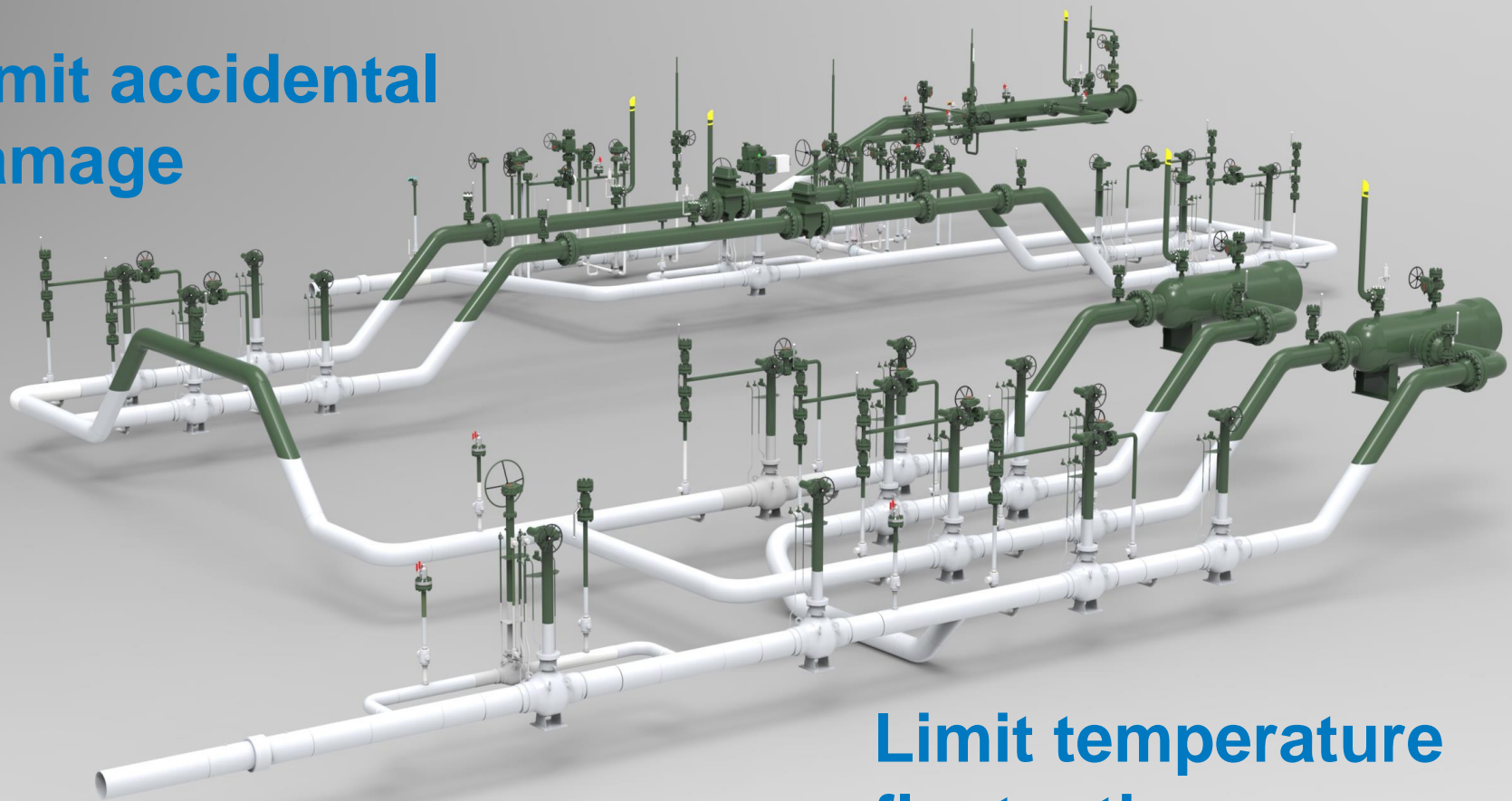
The Risk Target(s)

- General Public
- Employees

Process Design

Burying pipework

**Limit accidental
damage**



**Limit temperature
fluctuations**

Material Selection

- Low temperatures created by Joule Thompson effect during venting
- Materials selection for seals



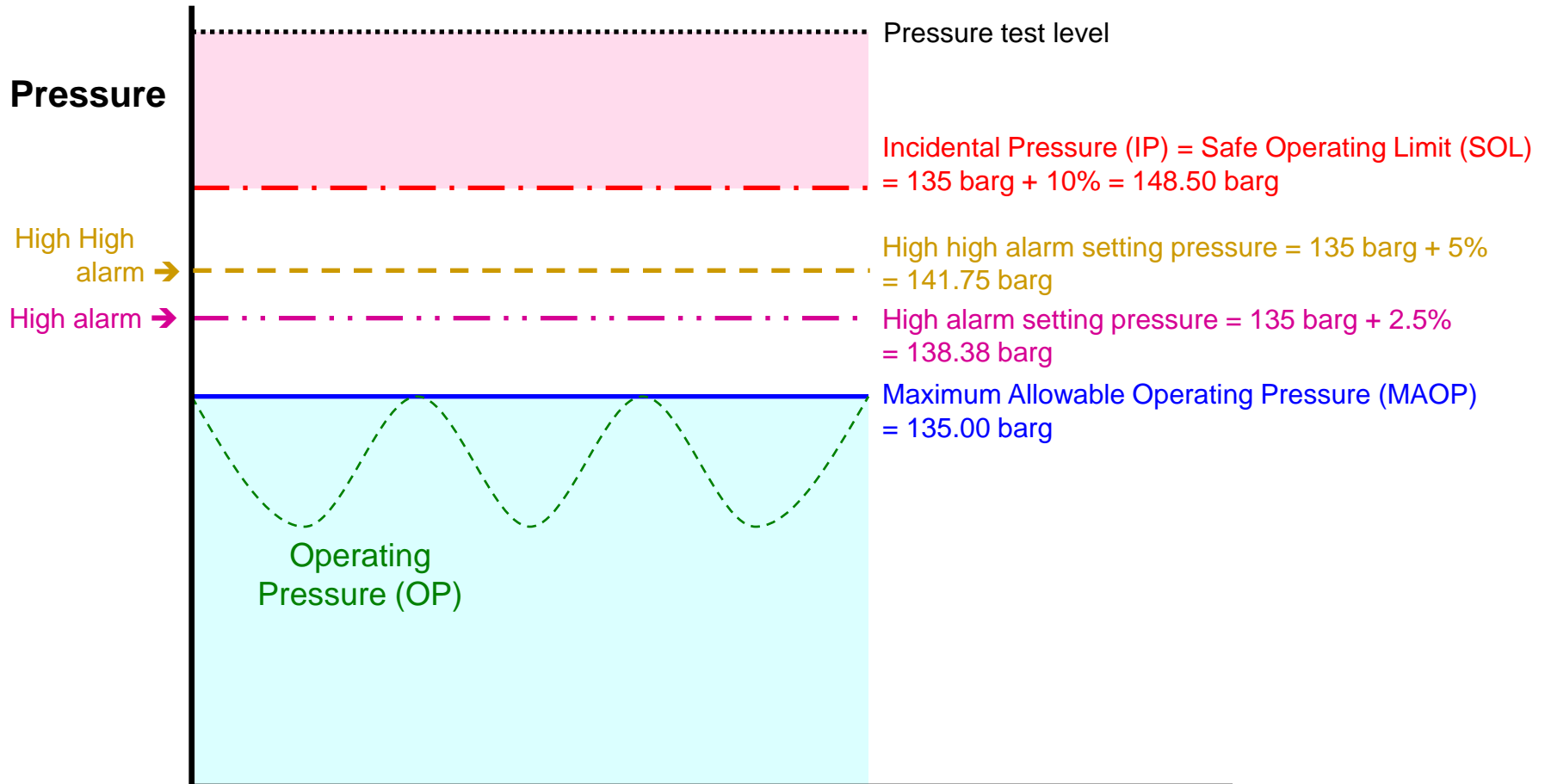
Corrosion control

Carbon Dioxide quality specification for transportation by pipeline	
Compound	Maximum Allowable Level % Vol (ppmv values quoted for minor components)
Carbon dioxide (CO ₂)	100
Water (H ₂ O)	0.005 (50 ppmv)
Hydrogen sulphide (H ₂ S)	0.002 (20 ppmv)
Oxygen (O ₂)	0.001 (10 ppmv)
Carbon monoxide (CO)	0.2 (2000 ppmv)
Oxides of nitrogen (NO _x)	0.01 (100 ppmv)
Oxides of sulphur (SO _x)	0.01 (100 ppmv)
Hydrogen (H ₂), Nitrogen (N ₂), Oxygen (O ₂), argon (Ar), methane (CH ₄)	Total for all non-condensable gases and hydrocarbons is limited by the upper limit on the saturation pressure of 80 barg in the dens phase or to 4 mol. % total, whichever is the lower.
NOTES <ul style="list-style-type: none"> i. The minimum allowable level of Carbon Dioxide is 96% volume. ii. The hydrogen (H₂) content will be limited to 2 mol% total. 	

Process Control

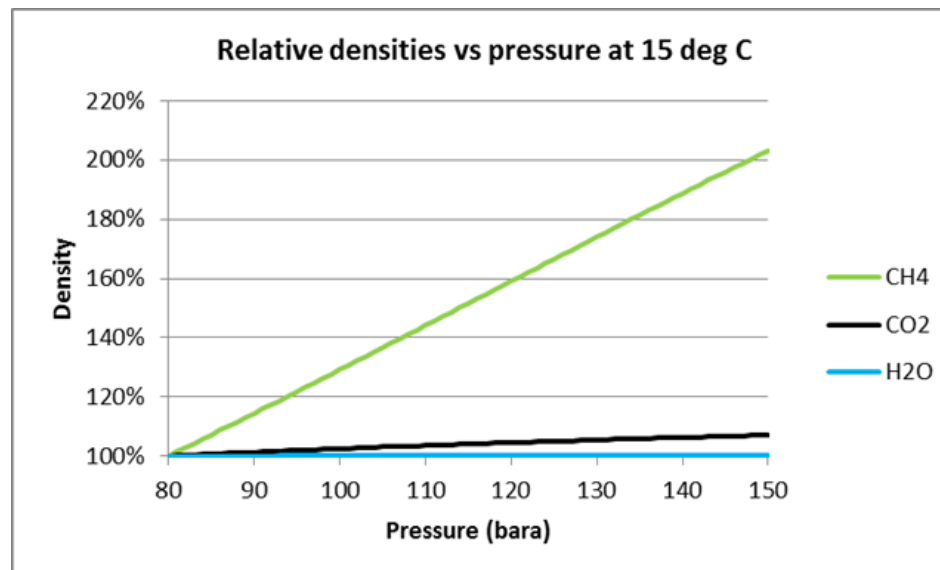
- **Monitoring systems (process alarms)**
- **Operator Supervision**

Pipeline pressure levels during normal operation



Quality & Flow

- Monitor quality at the Power Plant
 - Before entry into the transportation system
 - Share readings with the Storage Operator
- Monitor flow rates into and out of the transportation system



On site

- Monitor CO2
 - Build up within Buildings
 - Near moving parts
 - Key risk areas
 - Personnel monitors

- Collect maintenance data
 - Monitor wear and tear
 - Monitor Cathodic Protection

Prevention

Mechanical protection system

Process alarms

Safety Instrumented systems

Prevention

- SIL rated systems to protect against;
 - Over pressure
 - Poor quality leading to corrosion issues
- Protection is located at the power plant
 - Before entry onto the transportation system
- Low pressure is an issue to be managed
- Response times need to be understood

Mitigation

Mitigation

- Closure of valves if quality requirement is missed
- HIPPS systems on compressors and pumps to protect against high pressures
- Blending of multiple product streams is possible on multi-user networks.
- Release of poor quality of CO₂ to atmosphere

Plant emergency Response

Emergency response

- Normally un-manned sites
- 24hr 7days per week manned control room
- Call out of emergency response teams

Community Emergency Response

Community Emergency Response

- CO₂ transport not formally classified as a Major Accident Hazard Pipeline
 - But treated as such for the purpose of developing management processes
- Emergency contact phone number
- Emergency plans and contact details