Safety in CCS

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Overview

Safety & Health

- Hazards associated with CO_2 streams in CCS
  - Toxicity
  - Low temperature
  - Dry ice erosion
  - High pressure and corrosion
  - High density
  - Detection
  - Other substances and contaminants

MSDS classifications

CO_2

Label 2.2 : Non flammable, non toxic gas.

SO_2

H_2S

Label 2.3 : Toxic gas.

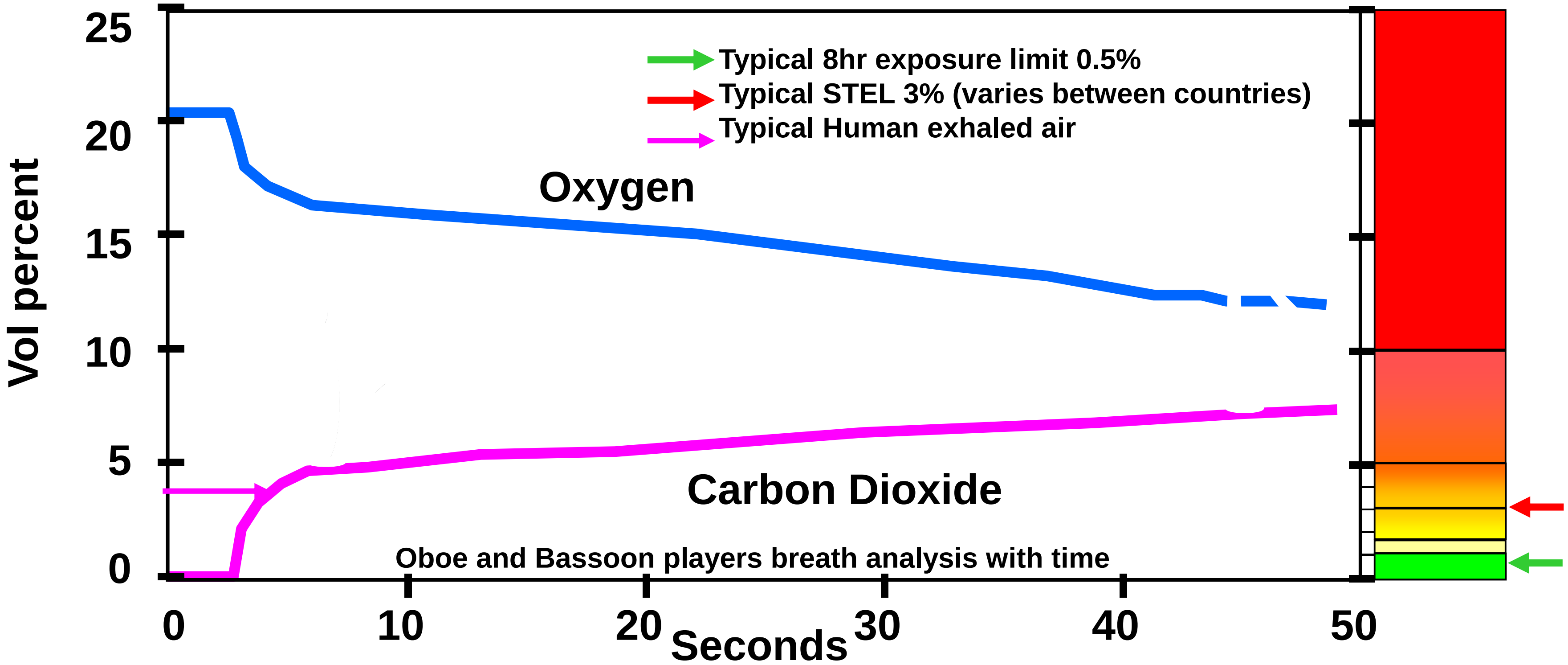
Label 2.1 : flammab gas.

N : Dangerous for the environment

T+ : Very toxic

F+ : Extremely flammable

Health effects of Carbon Dioxide



<1	No effects
1-1.5	Slight effect on chemical metabolism after exposures of several hours
3	Weakly narcotic,deeper breathing, reduced Hearing, headache, increased blood pressure and pulse rate.
4-5	Deeper, more rapid breathing. Signs of intoxication after 30 minutes
5-10	Breathing more laborious, headache and loss of judgement
>10	Unconsciousness in under one minute, further exposure to high levels eventually results in death.

Toxicity of key contaminants

H2S

- TLV 10 ppm STEL 15 ppm

SO2

- TLV 2ppm STEL 5 ppm

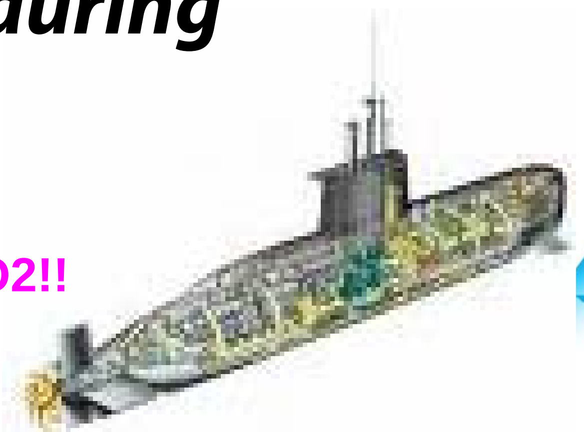
Hence if H2S> 0.1-0.2% or SO2 > 400ppm these contaminants are potentially more toxic than the CO2

Impairment

CO_2 can be tolerated in quite high concentrations without permanent risk to health

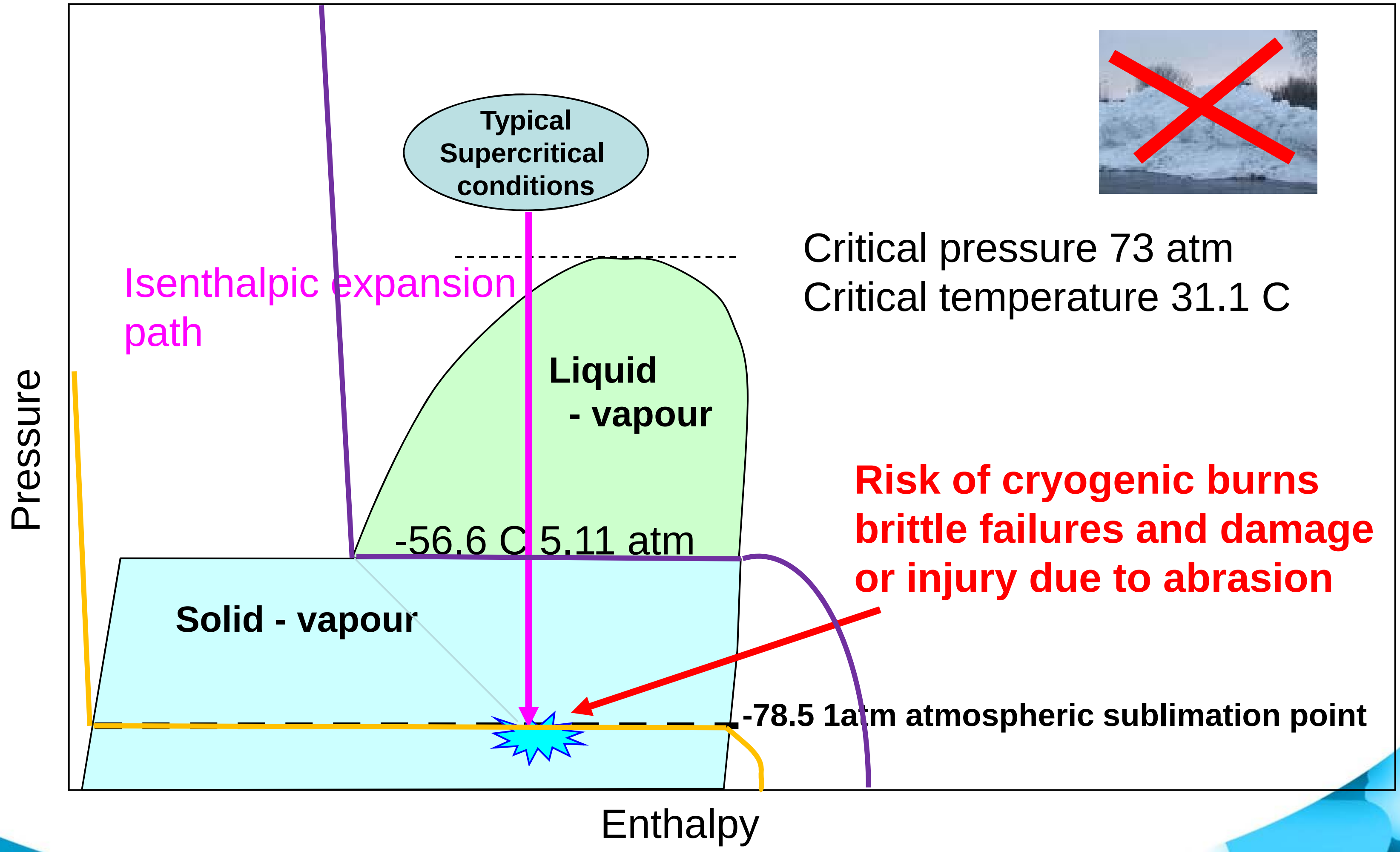
BUT if those exposed have key tasks to execute their response may be impaired

THUS need to consider effects during emergency situations



Atmosphere in submarines is typically 4000ppm CO2!!
Just below the TLV. Crews should not be impaired.
However levels up to 10,000ppm are reported

Low temperature hazard



High pressure and corrosion

Usual risks of vessel or pipe rupture

- Low temperature embrittlement is a risk factor

Consequences

- Flying objects
- Injuries if hit by jet

Have to keep CO_2 dry to avoid corrosion

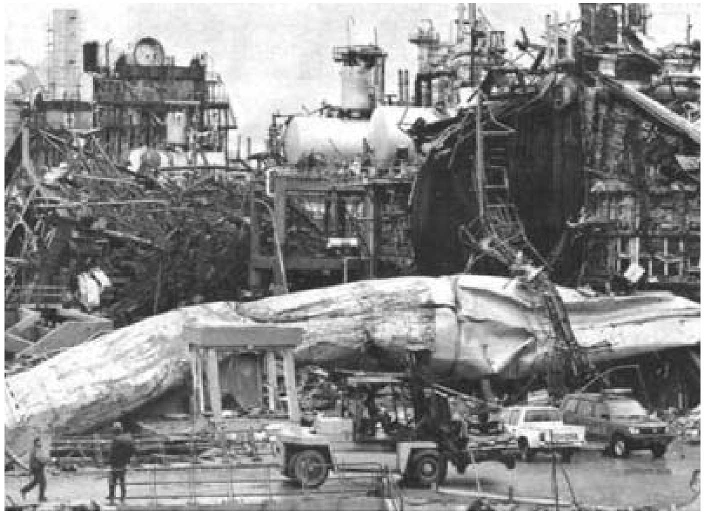
- Effects of other acid gases – H_2S, SO_2?

Effects of trace amounts of oxygen

- Further research needed on O_2 induced corrosion

A running fracture – result of a test

Fractured gasoline line– undetected damage



Results of metal embrittlement

15th January 2009 Vancouver- line rupture

High vapour density

Vapour accumulates in low points

- Need to review layouts to identify areas at risk
- Cold vapour has even higher density and will seek out low areas
- Need to consider pipeline routes

Location of safe haven

- Dilemma offshore – high or low on platform?

Spill collection

- Solid floors prevent CO_2 dispersion

Detection issues

Location of detectors different for heavy gases

Flammable gas detectors do not detect CO_2

- May not work in CO_2 atmosphere
- Low temperatures can deactivate detectors

Other substances

Absorption chemicals

- Amines, can be mildly toxic and mists might be flammable

Oxygen

- Cleanliness, concentration limits - oxygen burning of deposits or steel
- Increased flammability of combustible substances

Hydrogen

- Wider explosion limits but faster dispersion

Other substances – cont.

Ammonia (if chilled ammonia process used)

- Moderately toxic (TLV25ppm STEL 35ppm)

Nitrogen – used to dilute hydrogen

- Increase asphyxiation risk e.g in turbine hood

2008 IEAGHG Study

Study undertaken by UK Health and Safety Laboratory

Systematic identification of hazards associated with all surface facilities forming part of a CCS system

Contributions from power, industrial gas, pipeline and oil and gas industries

Objectives

1. *Establish baseline of non-CCS facilities and activities*
2. *ID CCS additions to this baseline*
3. *ID exposure to new hazards which these bring*
4. *ID possible resulting major incidents*
5. *Assess consequences of major incidents*

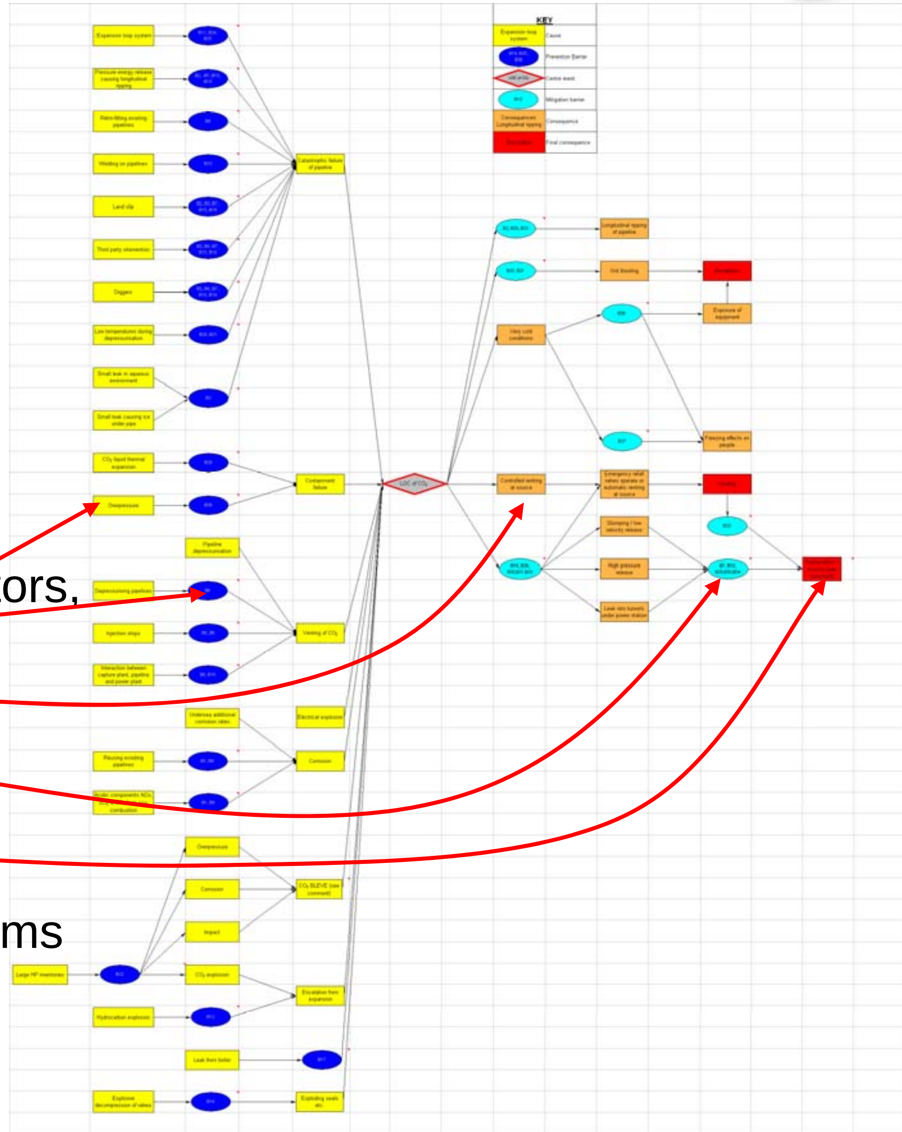
Objectives - continued

6. ***Analyse where change from established practice could be a significant additional factor in causing incidents***
7. ***Propose measures for eliminating risk of incidents***
8. ***ID gaps in ability to quantify risks and evaluate consequences***
9. ***Propose emergency response measures***

Putting it all together

IEAGHG conducted a study of safety in CCS
Resulted in identification of potential hazards.

Results are summarized in “Bow Tie” diagrams. These show “top event” initiators, barriers to their development as well as the further consequences, barriers and recovery measures and further escalations.



Computerised interactive generic diagrams have been published with the report.

Study conclusions

- ***Industry has wide experience in handling CO_2***
- ***No fundamental safety issues found***
- ***Retrofitting CCS into existing plants causes space constraints and increased complexity.***
- ***Sharing of information/ experience will contribute significantly in early years***

Knowledge Gaps

- ***CO_2 source term modelling***
- ***Fracture models for pipelines***
- ***CO_2 dissolving heavy metals & toxics underground?***
- ***Design and operation standards***
- ***Emergency response plans need development***
- ***Stenching agent for CO_2?***

Recommendations

- *Hazards and bow-tie used to design future CCS projects*
- *Continue to develop design standards to CCS and resolve knowledge gaps*
- *Particular attention to layout and interface issues when retrofitting*
- *Training and competency considered at the outset of project*
- *International incident database with free access*
- *Emergency response plan to be developed*

The biggest risk.............

CHANGE

Altering and adapting established designs and practices could be a significant contributor to accidents in the emerging CCS industry

Closing remarks

CCS can be very safe providing:-

- Safety is given adequate attention from an early stage
- Good safety management practices are adopted throughout CCS project lifecycles

SAFETY IS ALWAYS GOOD BUSINESS

Thank you for your attention