CMS CO_2 Test Stand and the Hazards of Carbon Dioxide

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Carbon Dioxide Cooling System

- CMS CO_2 Test Stand installed in Lab C
- Research Cooling Characteristics for Two phase Carbon Dioxide cooling for detector upgrade
- Refrigerant like R-134a, but with better cooling characteristics
- More environmentally friendly than CFCs and HCFCs

Hazards of CO_2

- CO_2 is listed as toxic by NIOSH
- Colorless, Odorless, low warning gas
- Heavier than air, so it can tend to pool in low spots
- Air is 21% oxygen and normally 0.04% CO_2
- We breathe in Oxygen, convert it to and breath out around 4% Carbon Dioxide
- This is normally easy for us to do since the partial pressure is much higher for Oxygen, it's a downhill push

Hazards of CO_2

- When Oxygen level goes down this difference in partial pressures between Carbon Dioxide and Oxygen becomes smaller
- We normally just look purely at the Oxygen level (ODH Sensors)
- In the same way, an increase in CO_2 levels reduces this difference in partial pressure as well

Hazards of CO_2

- Even with 21% Oxygen, an increased level of CO_2 can cause the same hazards as an Oxygen deficient environment
- Its no longer easy for our lungs to convert Oxygen to CO_2 since there is already a large amount of CO_2 in the air, it becomes more of an uphill battle
- <u>Renders ODH monitors useless</u>

Hazards of CO_2

- 0.5% CO_2
  - Limit for an 8 hour work day.
- 3% CO_2 – STEL
  - (15 minute Short Term Exposure Limit)
- 4% CO_2 – IDLH
  - Immediately Dangerous to Life and Health
- 10% CO_2 – Fatality Factor = 1
  - (Like 8.8% O_2 Content, Extremely Hazardous)

Fatality Rate Curves for CO_2 and ODH

$$F_i = 4.28133 * 10^{-8} e^{169.6641647*(\frac{L}{Q}+P)}$$

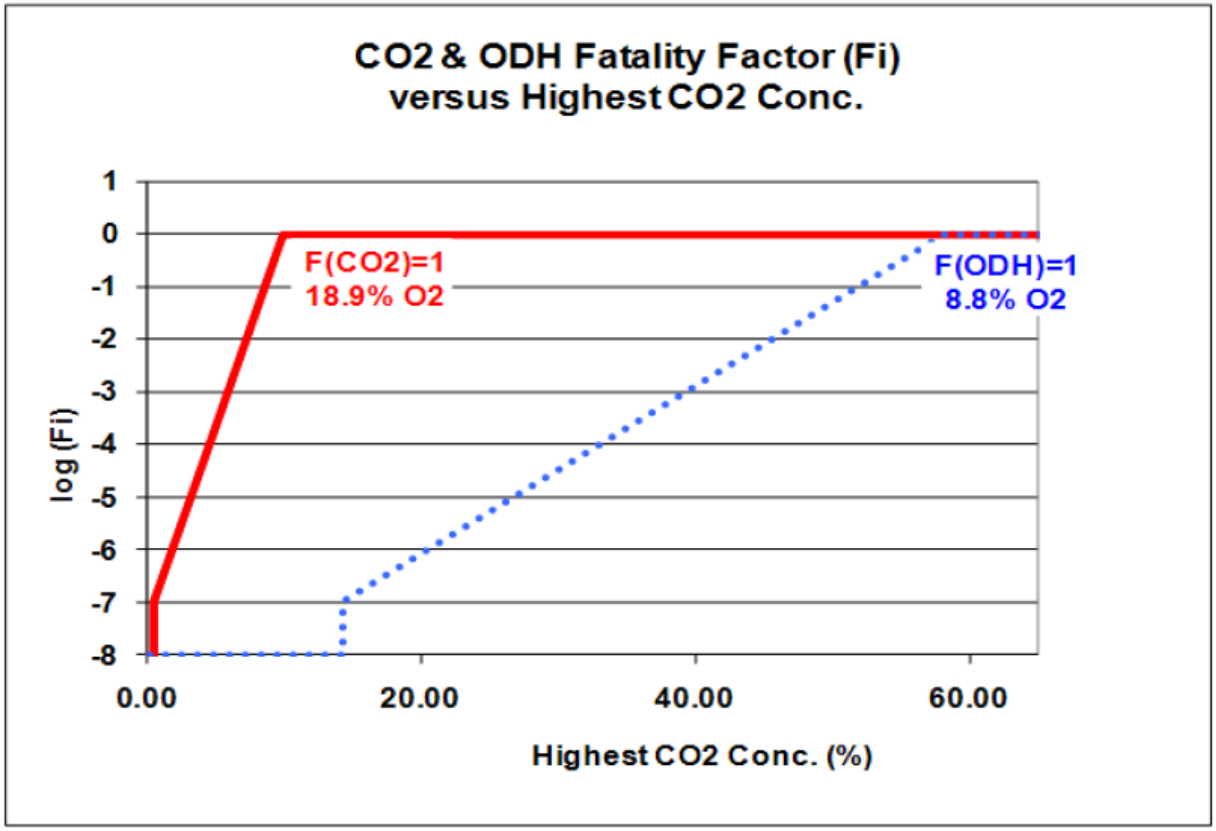


Chart by Mark Adamowski

Hazards of CO_2

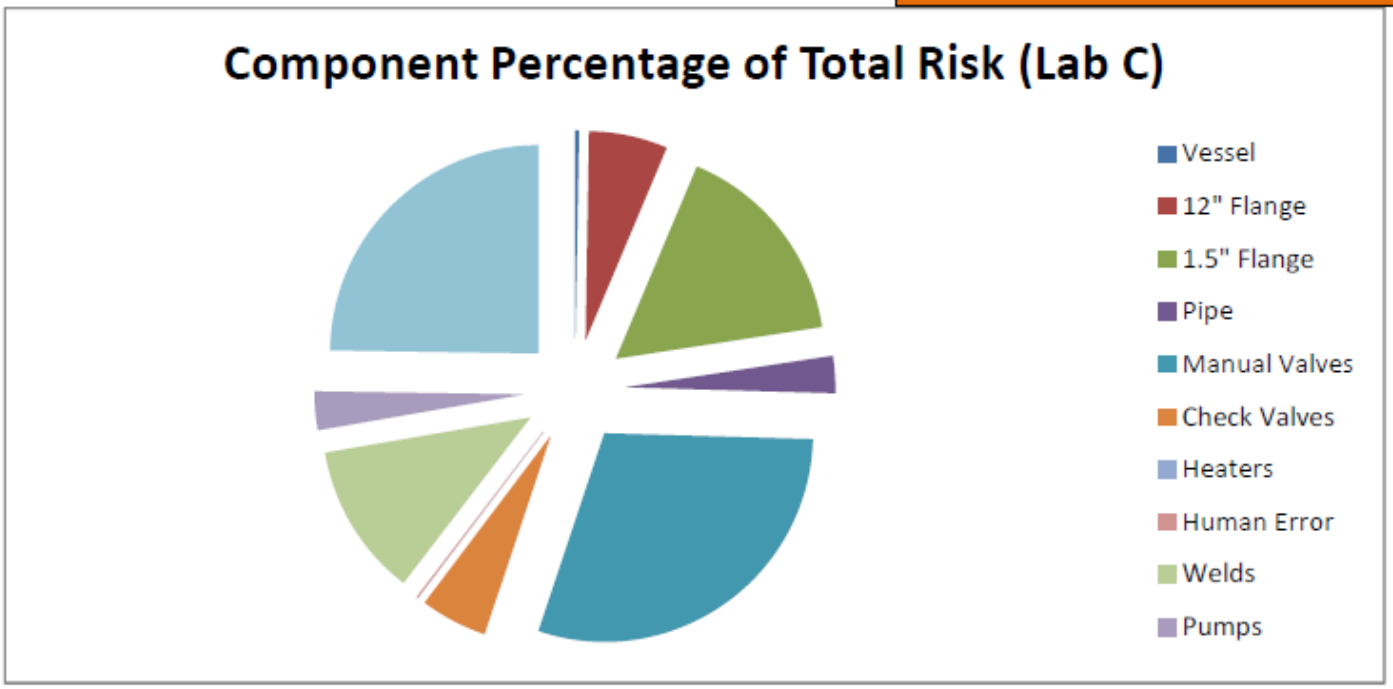
- Fatality Rate of CO_2 increases and becomes 1 before Oxygen Deficiency is noticed.
- ODH alarms would not sound at 18.9 percent O_2, as this level of Oxygen is relatively safe.
- Symptoms of High CO_2 levels are much like those of ODH since essentially the same thing is happening to your body.
  - Not converting enough Oxygen to CO_2
  - Not always symptoms, or symptoms not noticed

Specific Hazards of CMS Test Stand

- 300 lbs of CO_2 housed in storage tank.
- Risk Analysis was performed for both Lab C and the South Cleanroom.
- Risks were low (comparable to ODH class Zero)
- Regardless, additional precautions were taken to ensure safety.
- Piping system pressure tested at 1320 psi, can hold extreme pressure of warm CO_2.

Risk Analysis in Lab C (shell)

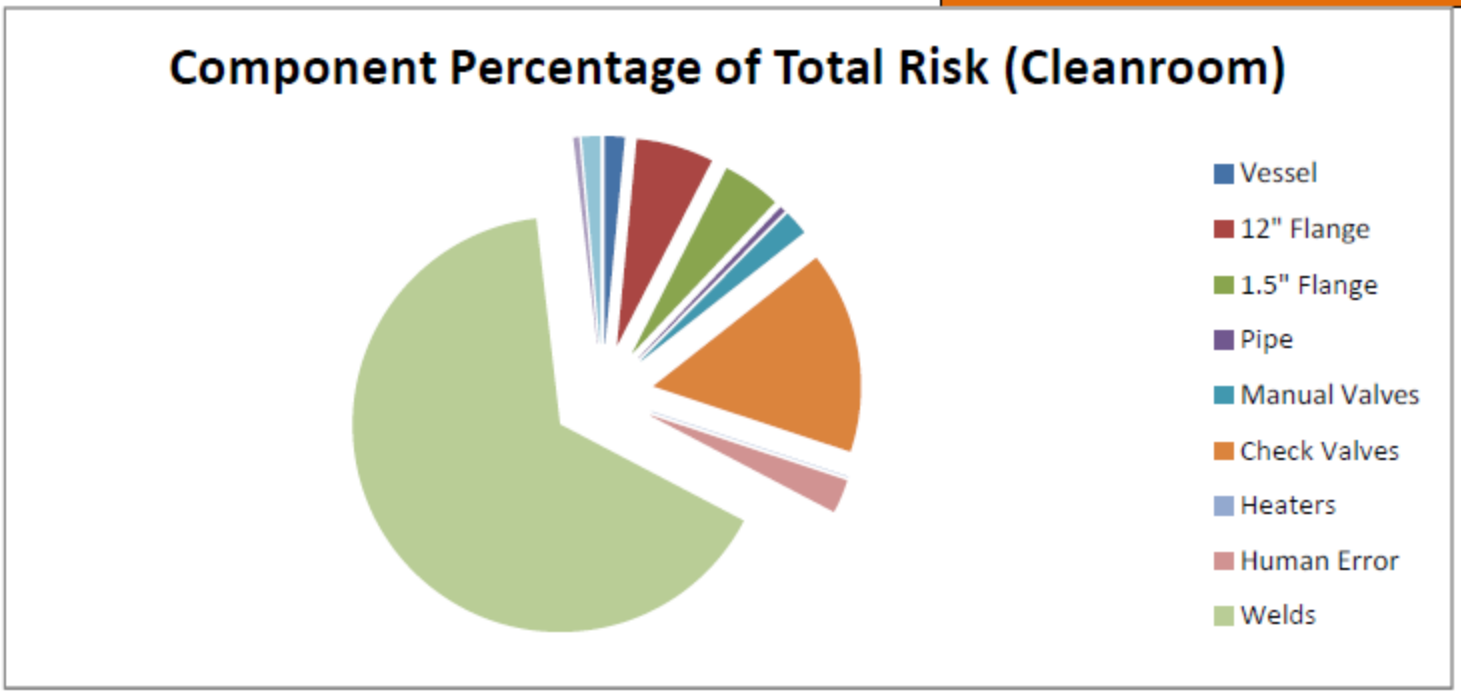
Fatality Rate from Ruptures	1.16E-12
Fatality Rate from Leaks	4.63E-11
Total Fatality Rate of Lab C	4.75E-11
CO2 Assessment comparable to ODH Class Zero	



Fatality Rate > 10^{-7} would be equivalent to ODH class 1

Risk Analysis in South Clean Room

Fatality Rate from Ruptures	2.00E-08
Fatality Rate from Leaks	4.53E-08
Total Fatality Rate of Clean Room	6.52E-08
CO_2 Assessment comparable to ODH Class Zero	



Fatality Rate > 10^{-7} would be equivalent to ODH class 1

Additional Safety Precautions Taken

- MSA CO_2 monitors installed in Lab C Hall way and South Clean Room (*best money can buy*)
- Also handheld devices located in each area.
- Wired Directly to FIRUS, notify fire department in case of an event (>1.5% CO_2 in environment)

Additional Safety Precautions Taken

- Clean Room
  - Monitor the Ventilation in the clean room
  - Trouble Alarm at 0.3%
  - Close Isolation Valve and Stop Pump at 0.5%
    - Ensures only a small amount of CO_2 will leak into clean room
  - Evacuate at 1.5%, this is half the concentration of the 15 minute STEL

Additional Safety Precautions Taken

- Lab C Shell
  - Total release would yield 3.7% in all of Lab C
  - Trouble Alarm at 0.3%
  - Activate Ventilation fan at 0.5%
  - Evacuate at 1.5%, this is half the concentration of the 15 minute STEL
- Both Connected to UPS and will send a trouble alarm if UPS runs out of power, all tested and verified by Dispatch

Most Important Thing To Remember:

If you hear/see this alarm/strobe:

Exit building immediately!