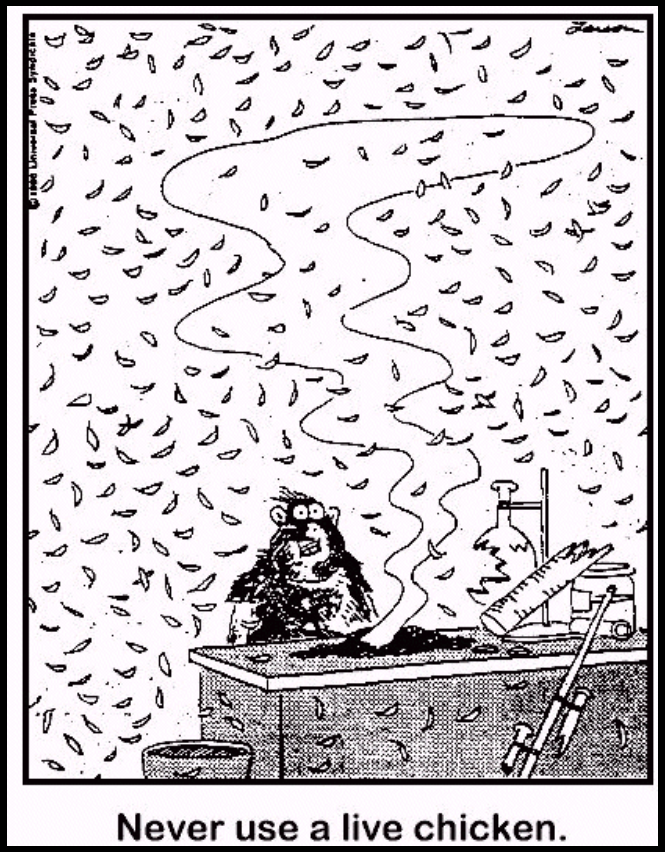
Compressed Gases and Cryogens



Never use a live chicken.

For First Aiders

Compressed Gases and Cryogens - Three Major Potential Hazards …

- **Containers**
  - Manual handling
- **Pressure**
  - Sudden release of energy
- **Contents ……**

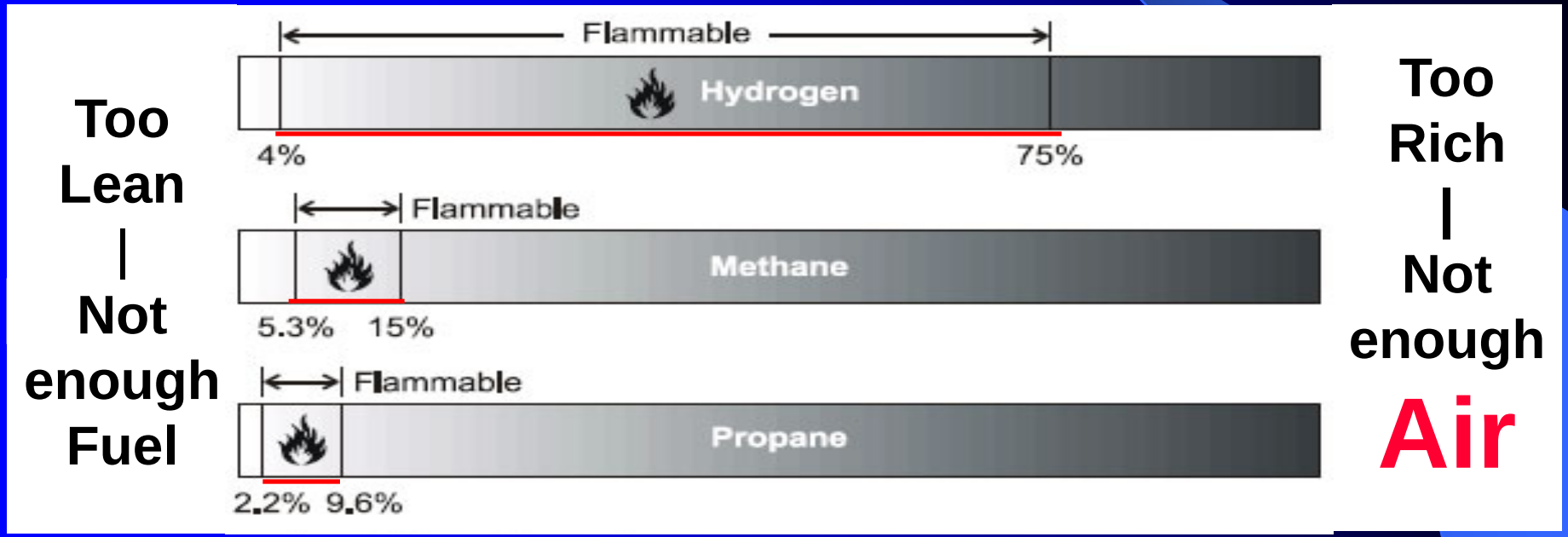
Potential Consequences of Contents

- Oxygen Depletion Hazards
- Chemical Hazards
  - Route of exposure = Inhalation
- Fire and Explosion Hazards…..

Fire and Explosion Hazards Arising from Flammable Gases ???

Likelihood of developing flammable / explodable atmosphere(s)?

Flammable / Explosive Ranges for Gases….



Fire and Explosion Hazards

Flammable gas leak = DO NOT ENTER

Remember: Likelihood of the presence of ignition sources, including electrostatic discharge or sparks ?

Ventilate if safe to do so?

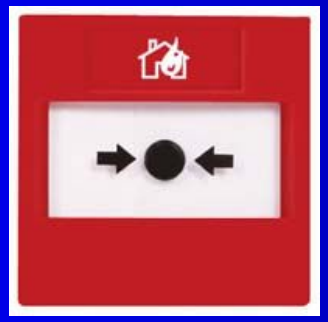
EVACUATE casualties

- **Burns - Ambulance?**
- **Oxygen depletion – Fresh Air - Ambulance?**

EVACUATE building ????

Remember

- If ‘you’ need to evacuate the building…..

HOW  **??????**

This should have been considered by the Department BEFORE the incident !!!

Fire and / or Explosion ?

- Fire = Burns?
- Explosion = Burns? and / or Injury ?
  - Explosion in a room
  - Explosion in equipment

Spark from pressure gauge caused University of Hawaii explosion, fire department says

Email | Print

Postdoc Thea Ekins-Coward, who lost an arm in the incident, was using a gauge not specified for work with flammable gases

By Jyllian Kemsley

[+]Enlarge

The explosion that injured Ekins-Coward on March 16 cracked the glass in the door of the lab where she was working.
Credit: Allyson Blair/Hawaii News Now

An explosion last month that caused a University of Hawaii, Manoa, postdoctoral researcher to **lose an arm** was caused by a spark from a digital pressure gauge that was not designed for use with flammable gases, says a **Honolulu Fire Department investigation report**.

Thea Ekins-Coward was combining hydrogen, carbon dioxide, and oxygen gases from high-pressure cylinders into a lower pressure tank when the incident occurred. She has not given the university permission to release information about her condition, said spokesman Daniel Meisenzahl at an April 18 press conference.

The gas mixture was "food" for bacteria being used to produce biofuels and bioplastics. Ekins-Coward was working for the Hawaii Natural Energy Institute under researcher Jian Yu. A 2013 paper by Yu indicates a set-up in which gases are plumbed through a mixing device called a gas proportioner directly into the bioreactor (*Int. J. Hydrogen Energy* 2013, DOI: **10.1016/j.ijhydene.2013.04.153**). The gas gauge identified in the paper is an "intrinsically safe" model designed to prevent ignition.

But after Ekins-Coward started in the lab last fall, she purchased a 49-L steel gas tank, a different gauge not rated as intrinsically safe, a pressure-relief valve, and fittings, and she put them together, Yu and Ekins-Coward told fire department investigators, according to the report. Ekins-Coward would add the gases to the portable tank, which would then be connected to the bioreactor. She was using a mixture of 70% hydrogen, 25% oxygen, and 5% carbon dioxide for her experiments, the report says.

In the week before the incident, a similar set-up with a 3.8-L tank resulted in a "small internal explosion" when Ekins-Coward pressed the off button on the gauge, the fire department report says. She also occasionally experienced static shocks when touching the tank, which was not grounded. She reported the shocks and possibly the small explosion to Yu, who told her not to worry about it, the report says.

Postdoc

70% hydrogen
25% oxygen

Spark from a digital pressure gauge NOT designed for use with flammable gases

Week before a 'similar set-up' resulted in a "small internal explosion"

She had reported static shocks and 'possibly' (???) the small explosion and was told…

" Not to worry about it "

Lost an Arm

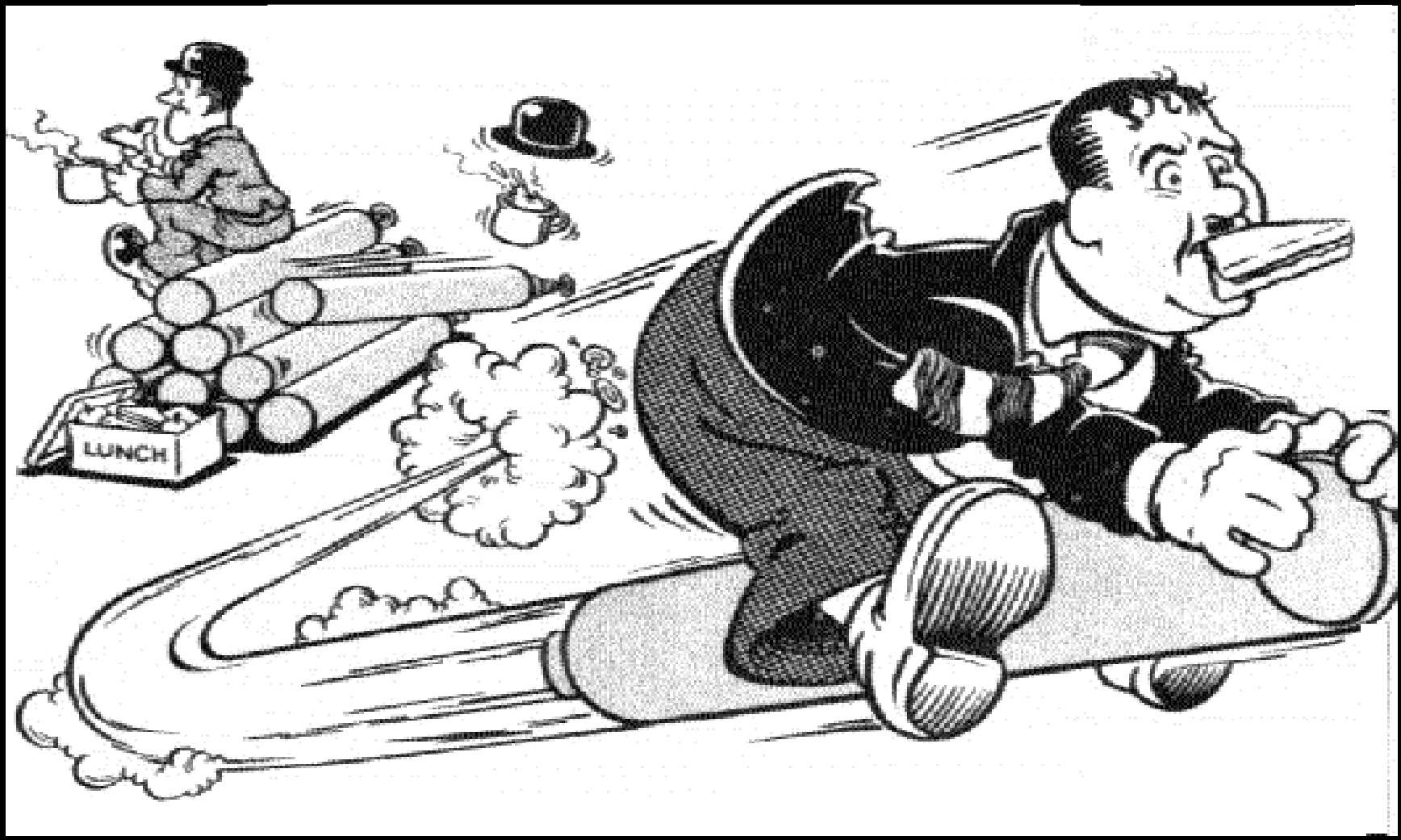

FIRE LINE DO NOT CROSS


EXIT
KEYBOX


Fisher Scientific
BIOHAZARD


VACUUM
GAS
COMPRESSED AIR

Compressed Gases



HAZARDS PRESENTED BY ALL COMPRESSED GASES

- **Pressure / energy release**
  - sudden release of gas pressure can cause large-scale destruction and injuries.

BAR	KPa	PSI
300	30000	4350 **= A lot of energy !**

HAZARDS PRESENTED BY ALL COMPRESSED GASES

- **Pressure / energy release;**
  - sudden release of gas pressure can cause large-scale destruction and injuries.
  - Cylinder Valves rarely fail..

- But can break if a cylinder is knocked over….


Discovery


Discovery


32
142 kg

Plumber killed in a barrage of 66 flying gas cylinders at 170mph !!

Demonstrates Value of Valve Guards

HAZARDS PRESENTED BY ALL COMPRESSED GASES

- **Pressure / energy release….**
  - Gas cylinders **must be firmly secured ….**

Secure – NO – Safe ??????????

Secure – NO – Safe ??????????

Regulators

Gas cylinders **MUST** be used with the **correct regulator !!!!**

- **Regulators “Rarely JUST Fail” ????**


PGS
PGStraining.com
Safety Ltd
Training
Handbook

Regulators can fail !!!

Cambridge News -> News

Published: 26/02/2013 15:17 - Updated: 27/02/2013 13:50

Like 45 Tweet 7

UPDATE: Cambridge University buildings evacuated in chemical alert

Written by Debra Fox

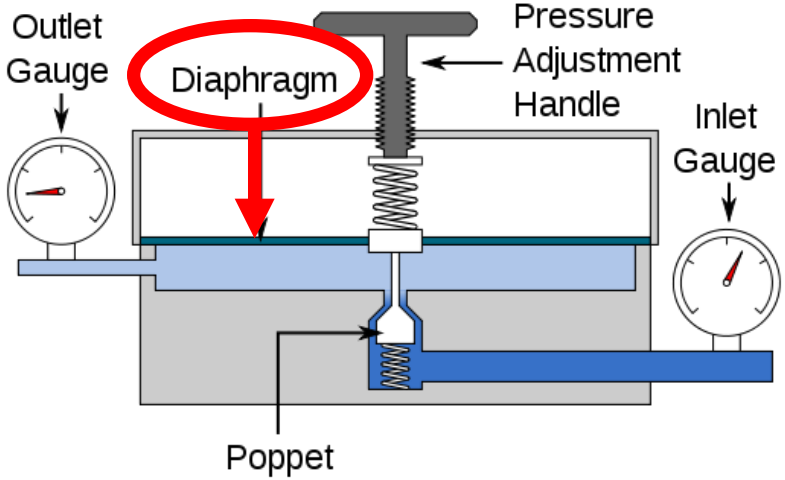
Five university buildings were evacuated during a chemical alert yesterday.

Firefighters at the scene of the chemical alert on the Cavendish site

Around a thousand students fled the West Cambridge Site after a leak of ethylene gas was discovered at the Cavendish Laboratory buildings at 1.30pm. Students also had to leave the CAPE Building, the Nano Science Building and two others.

The leak was caused by a fault on a 50-litre cylinder containing the gas, and fire crews from Cambridge and St Neots set up a 200m exclusion zone around the area before entering the buildings to monitor the gas levels inside.

A hazardous material team also attended.



Carbon Dioxide Gas Cylinder Explosions


Flüssiger
Sauerstoff
Inhalt
2000 Ltr.

Ooops !!!!!!!!!!!!!

Spontaneous Ignition of Hydrogen ???

Reverse Joule/Thomson Effect

Transport

Manual handling injuries

- cylinders are heavy and unstable,

cylinder trolleys must be used..

- and appropriate PPE **should** be worn e.g. **safety shoes, gloves, goggles / safety glasses.**

but…

Cylinders Should NOT be Moved with Regulators Still Attached


HELIUM
GASMARC
HELIUM
0 – 10
BAR
300 BAR SERVICE

LEAK - What is releasing gas ?

Liquid Nitrogen Tank

45,000 litres ~ 30,000 cubic metres of gas

or to this?

Group 1 Compressed Gas Hazards

- **Toxic gases** e.g. **carbon monoxide**, fluorine etc
  (WEL: Workplace Exposure Limit for fluorine : 1ppm)
- **Corrosive gases** harm humans and damage equipment e.g. sulphur dioxide, fluorine, hydrogen chloride etc
- **Carcinogenic , toxic to reproduction** e.g. carbon monoxide (R61: May cause harm to the unborn child)
- **Pyrophoric gases** may spontaneously ignite in air
  e.g. diborane, **silane**

Don’t Rely on your Sense of Smell !

- Odour perception threshold varies between individuals and substances
  - Fluorine 0.042 ppm
  - Hydrogen sulphide 0.00047 ppm
  - Carbon monoxide **NO ODOUR !!!!!!!**
- Presence or absence of odour may have no relationship to harmful biological effects
- May be interference from other substances !
- Strong initial odour may completely disappear
  - Hydrogen sulphide
    - **100–150 ppm olfactory nerve paralyzed**
    - **320–530 ppm - pulmonary oedema - possibility of death!!**

Monitors !!!

Do not enter or remain in a room if an alarm is triggered !

Group 1 Compressed Gas Hazards

- **Flammable gases** are also potentially explosive
  - e.g. Methane, Ethane, Propane, Butane, Carbon Monoxide, Hydrogen, Acetylene …….

Acetylene

- Explosive range 2% to 82% **BUT**
- **Unstable……**
  - Heat
  - Pressure
- Colourless, ‘smells of garlic’
- **NEVER approach or move an acetylene cylinder that has been..**
  - **In or near a fire !**
  - **Is hot and or rattling**
  - **RUN**

Gas Cylinders in Fires !


HICKORY
KMOV-TV


KMOV-TV

Group 1 Compressed Gas Hazards

- **Oxidant gases** react with flammable and combustible materials such as oils and greases

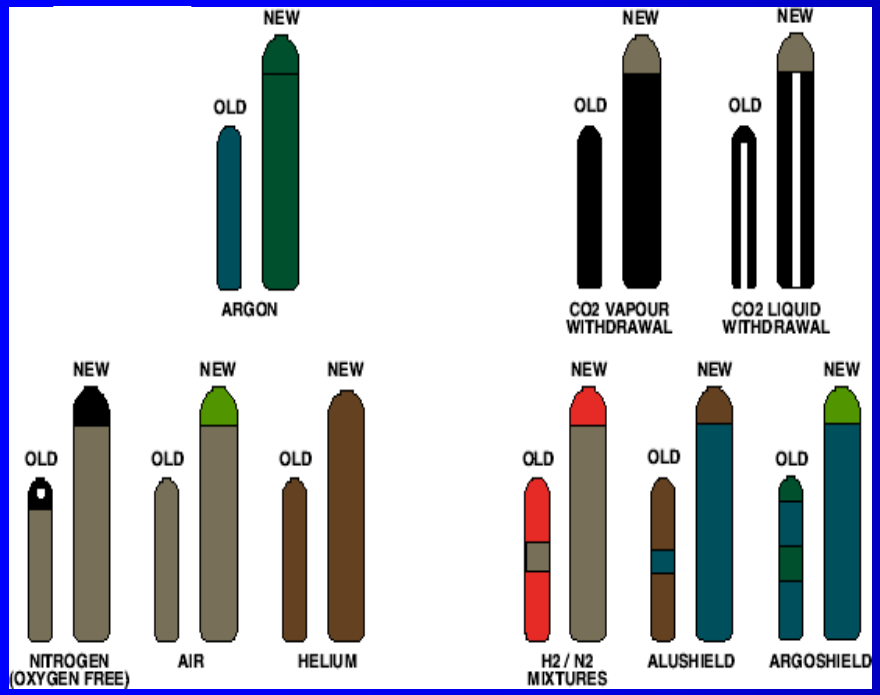
- e.g. fluorine, nitrous oxide and **oxygen**

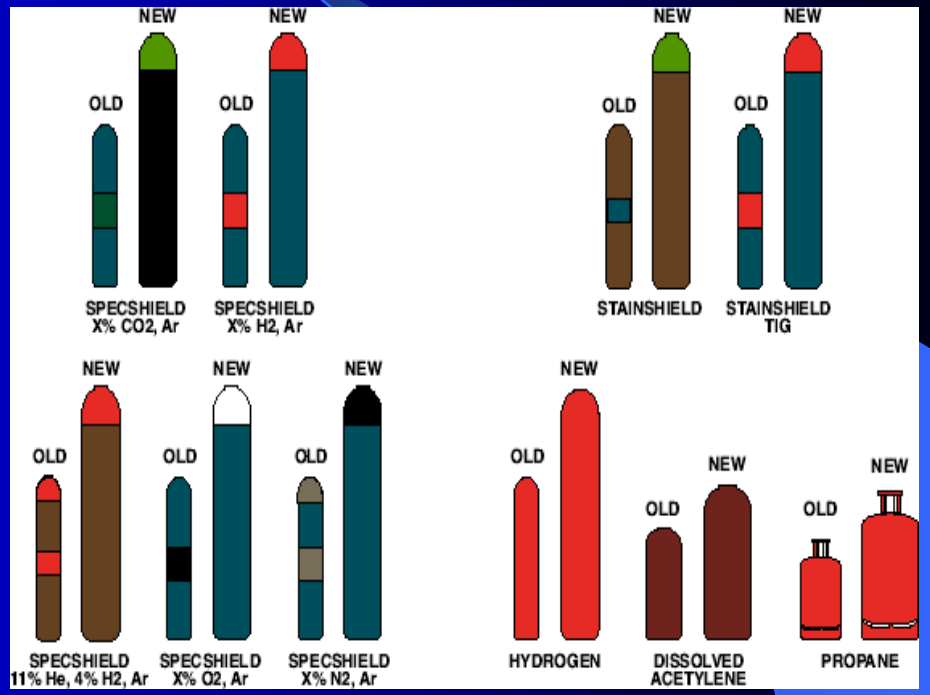
Oxygen Enrichment

- 21% - ‘normal’
- 24% - fires are very intense
- 40% - 10 x risk of fire
- 100% - spontaneous ignition !

Oxygen Depletion

Any Gas other than Oxygen will deplete Oxygen.





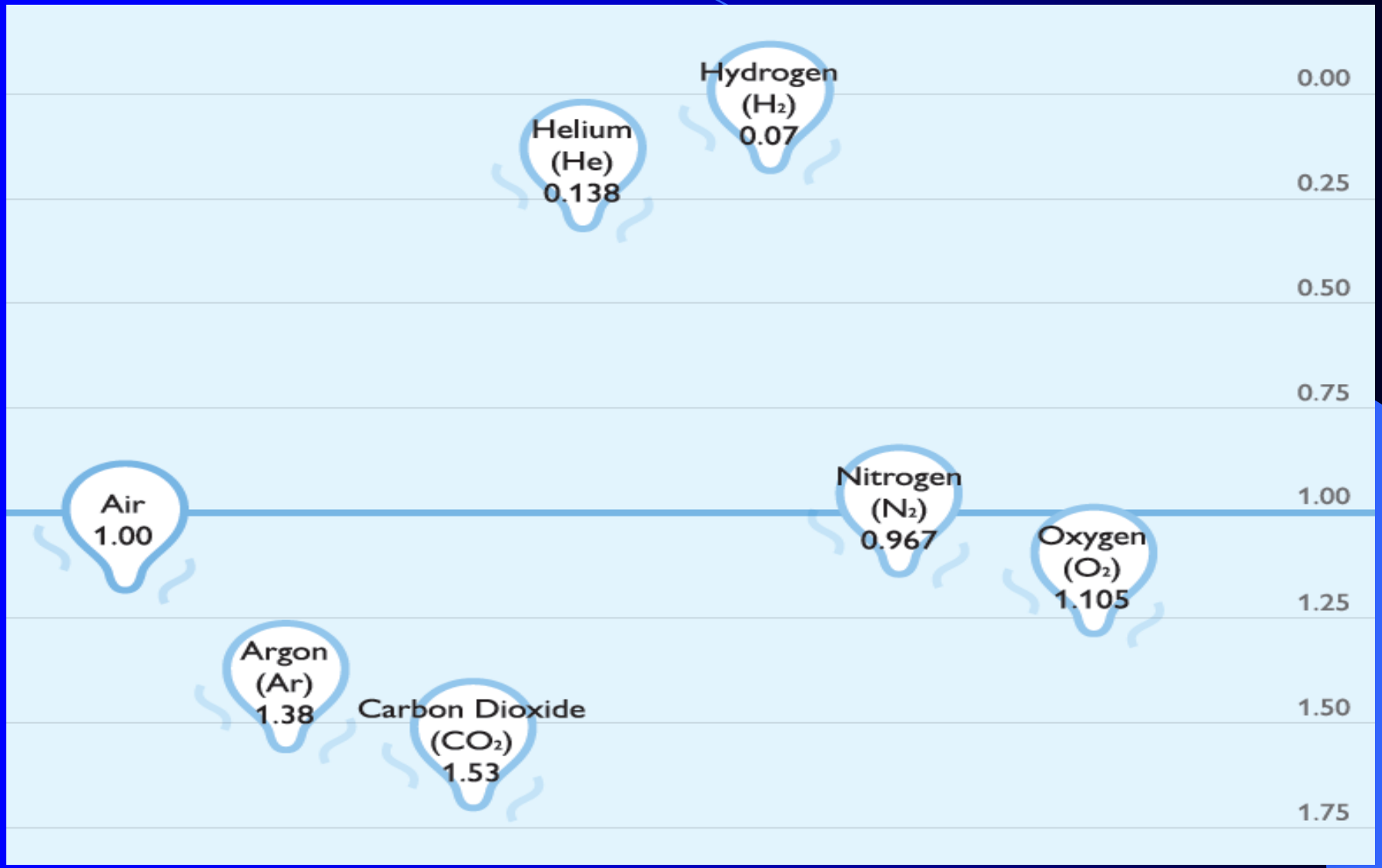
Cryogenic Hazards

Common Cryogen Temperatures

Substance	Boiling point/ degrees C	Volume expansion/litre*
Liquid Nitrogen	**-196**	**680**
Oxygen	**-183**	840
Argon	-186	820
Helium	-269 (ie: 4.2K)	740
Carbon Dioxide	**-78 (sublimes)**	**550 (from 1 kg solid)**

* Asphyxiation risk arises from dramatic change in volume on vaporisation.

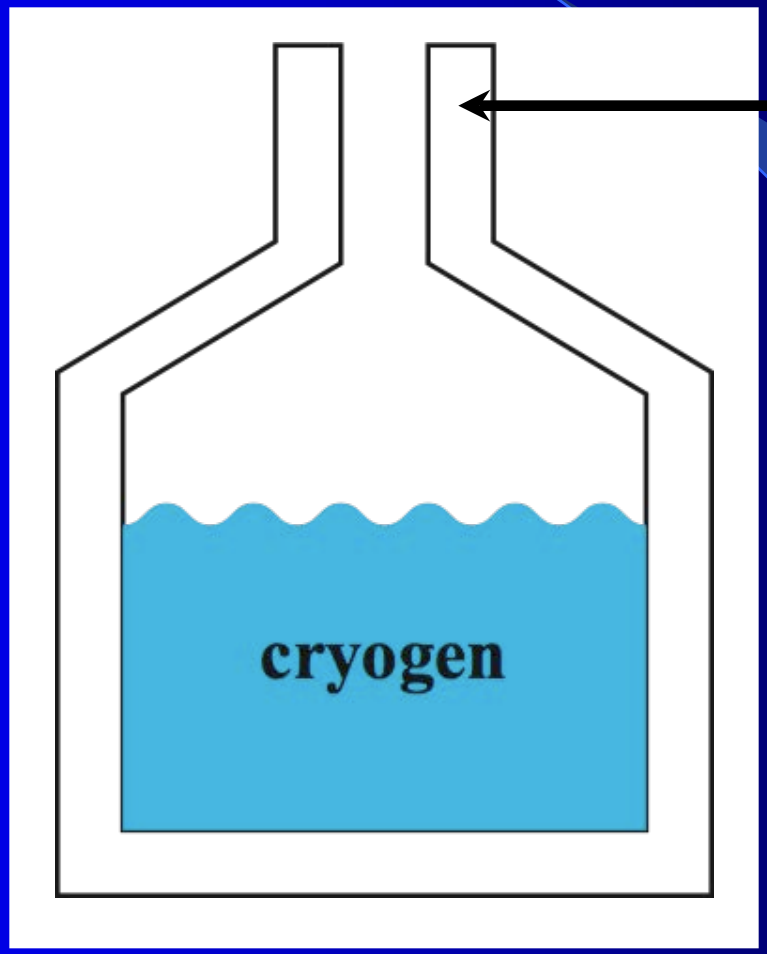
Gas Densities at Room Temp



Cryogenic Dewars / Vessels

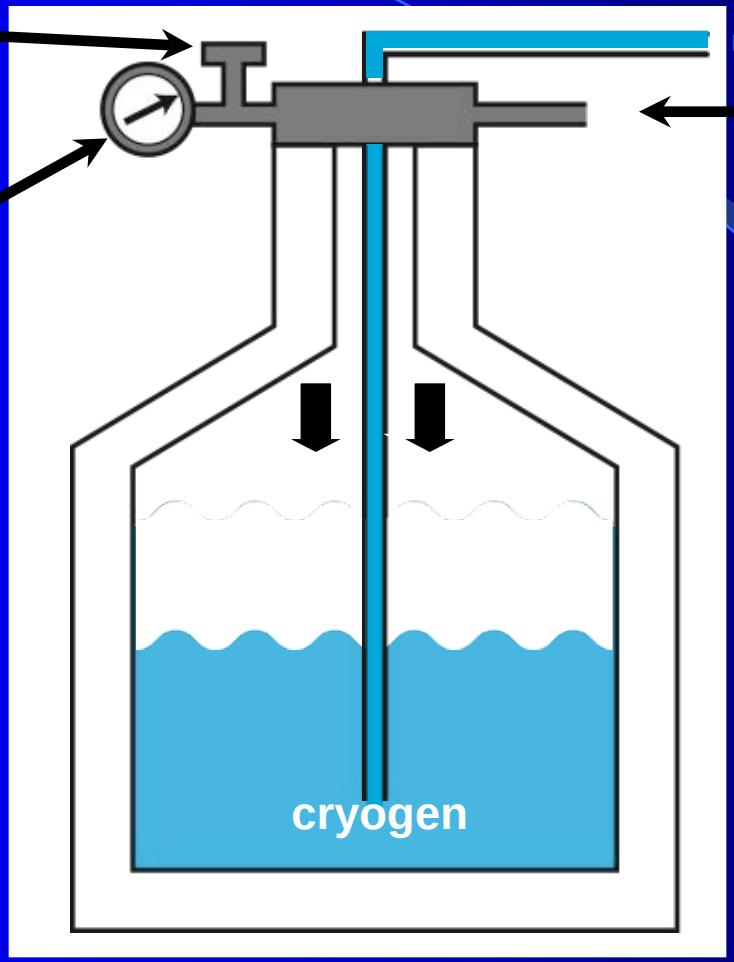
Storage of Liquid Cryogens

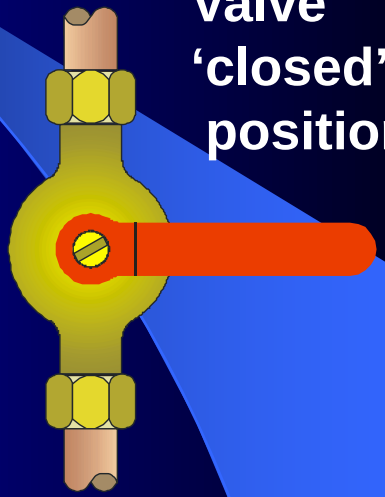
Principle of a Simple Dewar



Vacuum or Insulator

Pressurised Dewar - Vessel





Remember to return all valves to safe positions when transfer finished

Liquid Nitrogen Dewar

Hole in a concrete floor made by a cryogenic dewar that built up too much pressure and ruptured its bottom and jetted upward through the ceiling and into the room above.

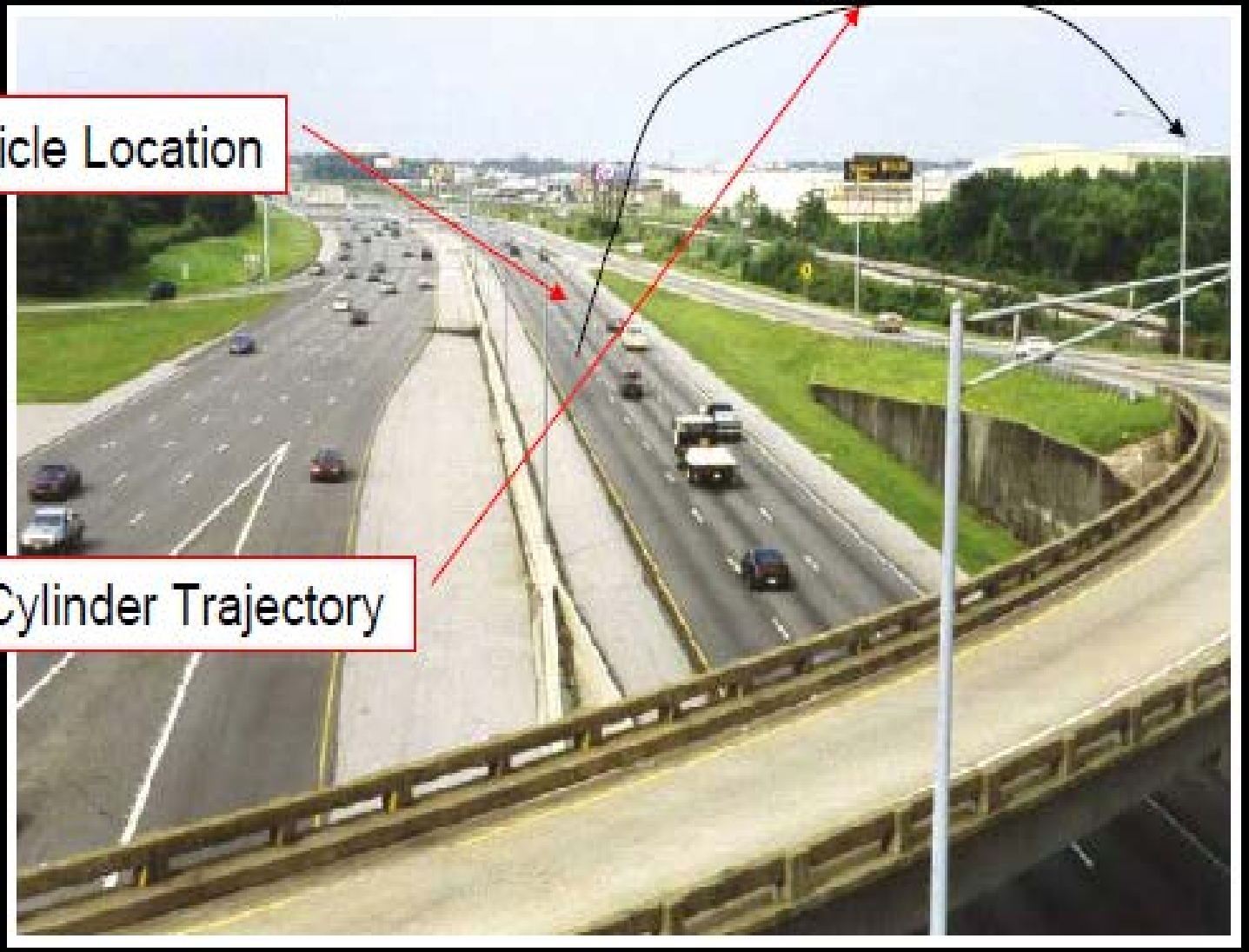
*The gas discharge also blew out the walls of the lab where the tank **was** stored.*

The pressure relief devices had been removed and plugged using a threaded cap

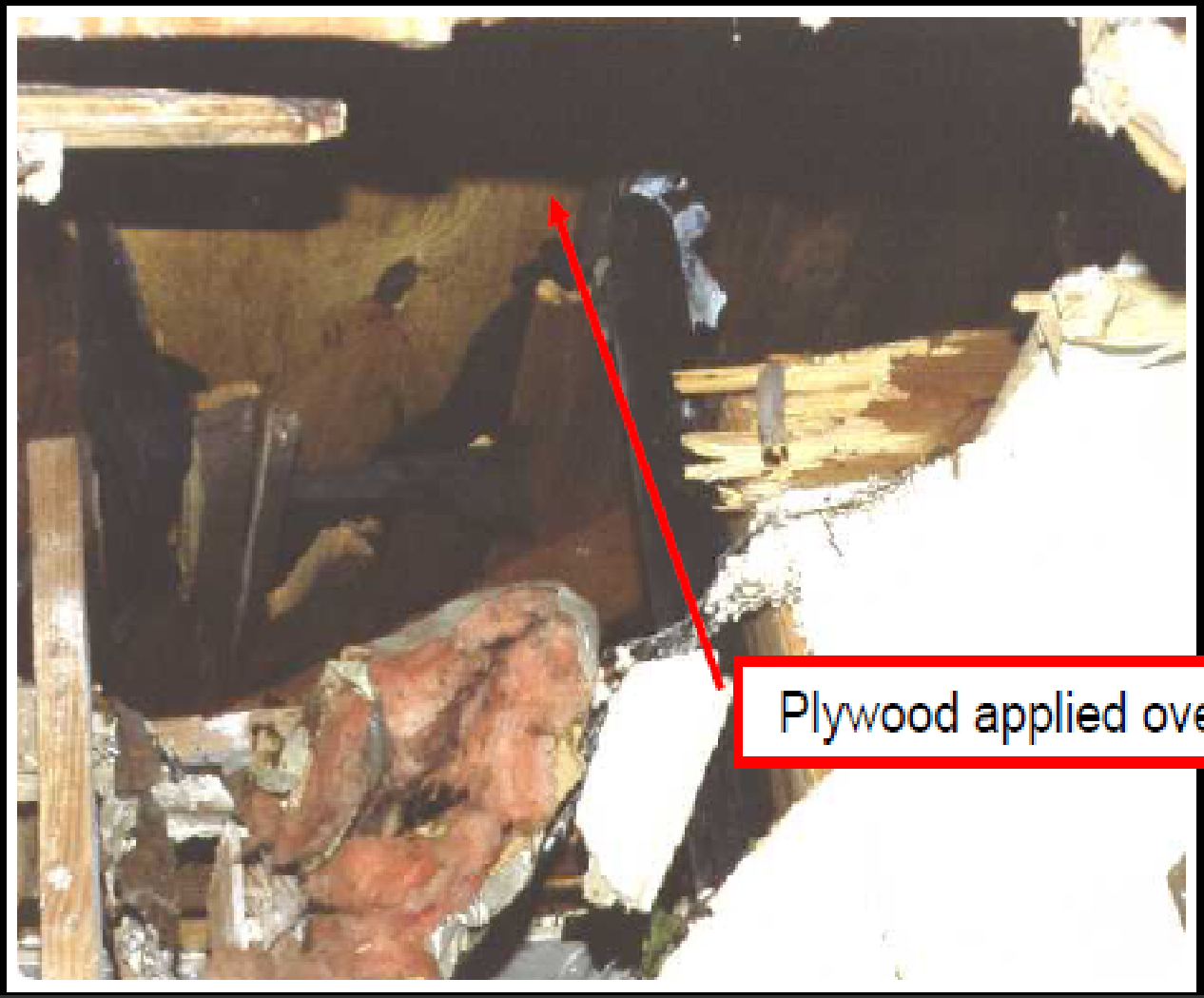
The blast blew one individual across 5 lanes of traffic.
The other was blown approximately 40 feet.
Both men survived

The scrapper's pickup truck on which the Oxygen GP was being transported.

Cylinder exploded at 12:40 PM while transport vehicle was parked on busy Interstate highway



Cylinder flew approximately ¼ mile before plunging through the roof of an apartment, severing a main natural gas line and coming to rest in the living space



Cryogenic Dewars/Vessel

These can be VERY heavy and difficult to move – **could cause injury**

If they have fallen over they can fail and could cause **serious injury**

Do Not attempt to move the vessel !

If ‘degassing’ retreat with any casualty to a safe distance???

Cryogen Hazards

- **Cold burns**
- **Asphyxiation**
- Changes in material properties (brittleness)

- Condensation of water vapour / frost clouds

- Pressure build up from gas boiling off liquid in a confined space - Blockages and the risk of **explosions**


Canon
FX10
Cartridge

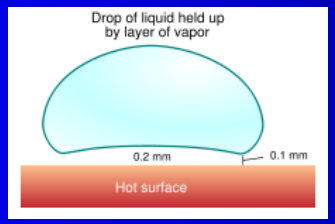
Cold Burns

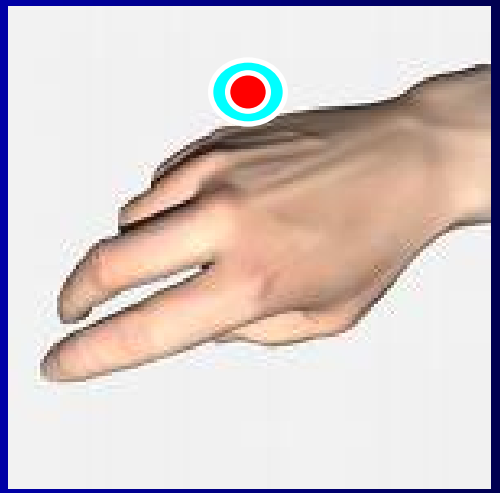
- **Cryogens cause damage similar to heat burns**
- **If skin sticks to a cold surface - flesh may be torn**
- **Pain is reduced whilst the damage is occurring (but not during thawing)**
- **Use insulating gloves** and safety glasses.
- **For small burns, hold under cold or tepid water**
- **Dress the burn and report it**

Cold Burns (cont)

- **Liquid can soak through woven gloves / other clothing**
- **Small amounts of liquid splashed onto bare skin MAY cause no damage, if not trapped against the skin**

Leidenfrost effect





Oxygen Depletion

Risk of Asphyxiation By Oxygen Depletion

- All gases except oxygen deplete the proportion of O_2
- Reduction of O_2 from **21%** to **18%** is potentially dangerous
- Reduction below **12%** results in fainting, brain damage and death
- Onset of O_2 deficiency often not apparent to the individual affected, they may appear ‘drunk’ !
- A single breath below 6% oxygen could kill YOU –
- **two breaths will !**

Oxygen Depletion

If below 19% recommend:

- Oxygen depletion monitor
  - fixed / hard wired
  - portable

Alarm at 19.5%

In the presence of Helium it may **over estimate** the remaining Oxygen !

Fools Rush In
Where Angels Fear to Tread

Cautionary Tale: MRC in Edinburgh

- Nitrogen gas from a liquid nitrogen supply leaked into a freezer room depleting the oxygen
- The alarm had been turned off !
- A laboratory technician **died** from N2 asphyxiation
- He had 10 years experience of working with cryogens
- Four others who attempted to rescue him were lucky to survive….

September 17th 2012

Rugby player who died in a slurry pit was trying to save father

Attempt to rescue dog leaves three dead on the family farm

Scene of the tragedy: The family farm in County Down, Northern Ireland

Future star: Nevin Spence

Investigation into hospital scientist death

Posted by Emma Heseltine on Oct 31, 11 09:56 AM in News

A 32 year-old researcher has been found dead at work at the Chelsea and Westminster Hospital.

The Health and Safety Executive have launched an investigation after Damien Bowen, from Clapton, East London, was found by colleagues turning up for work on Thursday (27) morning.

He was a scientist working in St Stephen's Centre, a research and treatment centre for HIV and other sexually transmitted infections, adjoining the hospital in Fulham Road.

A hospital spokesman said: "Our thoughts are with the family of this member of staff at this very distressing time."

Emergency services were called to what was described as a 'chemical incident' at the hospital just after 6.30am, after Mr Bowen was found dead on the fifth floor of the centre.

It was shut for the rest of the day while firefighters helped make the scene safe, and it was handed over to the police and the Health and Safety Executive to investigate.

Carbon Dioxide inc: Gas, Liquid and Dry Ice

- *The HSE's Workplace Exposure Limit (WEL) for CO_2 is 0.5% for 8 hours or 1.5% for 15 minutes.*
- At concentrations above 2%, carbon dioxide causes
  - increases in respiratory rate and blood pressure,
  - nausea, dizziness,
  - headache and mental confusion.
- If the gas concentration reaches **10%** or more, suffocation and **death** can occur in minutes.
- The oxygen concentration will still be ~19% - oxygen depletion alarm **may** not have been activated !

CO_2 Fatality

Need CO_2 monitor, **NOT** an oxygen depletion monitor !

“Carbon dioxide is poisonous even if there is an otherwise ‘sufficient’ supply of oxygen”

DANGER TOXIC GASES MAY BE IN USE

IF TOXIC GAS ALARM HAS BEEN ACTIVATED LEAVE THE AREA

Room

CONTACT
Tel No:

OR

CONTACT
Tel No:

OR

OUT OF NORMAL HOURS

CONTACT
Tel No:

Additional Information:

Finishing thoughts for the day…..

- Know what you have in your ‘area’ and what might go wrong.
- Cylinder, Vessel or Dewar ‘failures’
  - Acute
- Gas / Cryogen Leaks
  - Acute
  - Chronic
- **FOOLS RUSH IN WHERE ANGELS FEAR TO TREAD !**