BOC

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MEDICINAL CANNABIS SEMINAR
GREENHOUSE & EXTRACTION CO_2

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BOC – Specialised Markets

- CO_2 Modes of Supply
- Greenhouse Applications
- Super Critical Extraction

Product Supply Modes

- Compressed
  Gas compressed into cylinders at high pressure (15000 - 30000 kPa)

- Liquefied - Under Pressure
  Gases that become liquids under pressure at atmospheric temperatures (CO_2, LPG & Ammonia)

- Liquefied – Cryogenic
  Gases that are held as liquid under pressure and extremely low temperature (< -100°C)
  (Liquid O_2, N_2, Ar, H_2 & He)

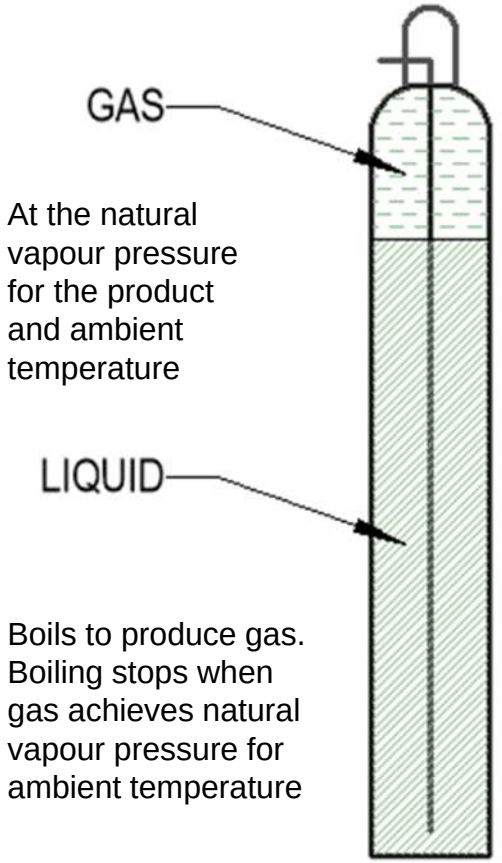
  Liquid CO_2 can also be supplied in this format but is not at 'cryogenic' temperatures

CO2 in Cylinders

- Conventional Compressed Gases
  - Withdrawn as gas from the top of the cylinder
  - Cylinder pressure reduces as product is consumed

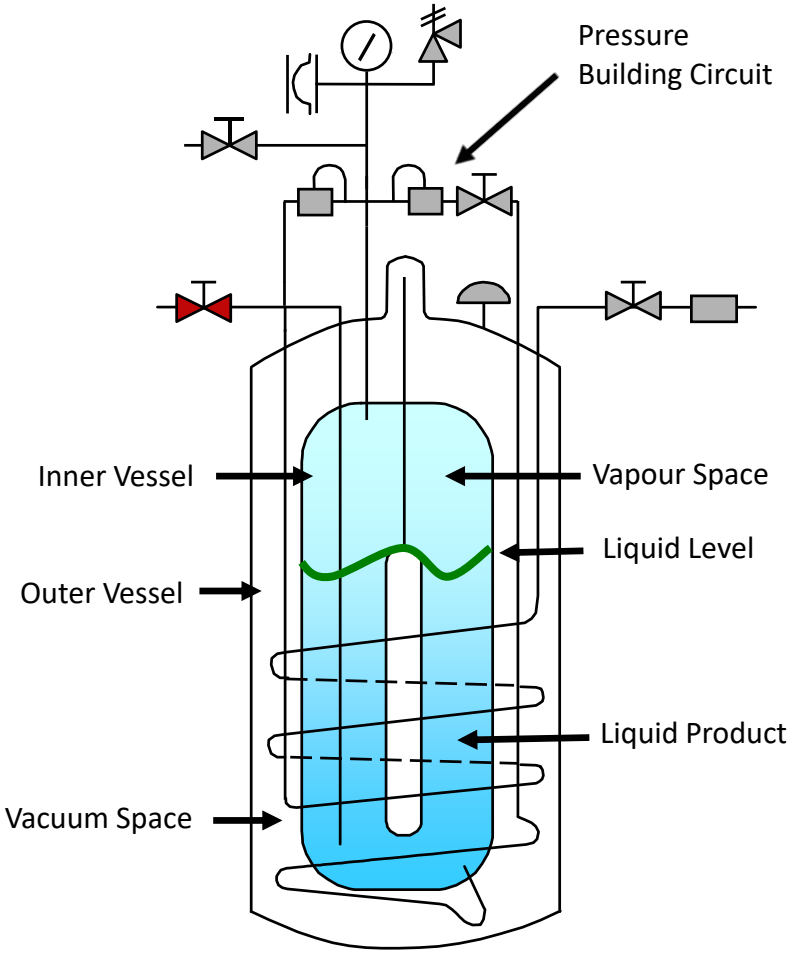
- CO_2 – Liquefied Under Pressure
  - Withdrawn as liquid from bottom of the cylinder via eductor tube
  - Cylinder pressure remains constant as product is consumed
  - Not possible to assess contents from the pressure gauge
  - Cylinder pressure varies with ambient temperature
    - CO_2 @ 25°C ~ 6400 kPa (915 psi)
    - CO_2 @ 0°C ~ 3500 kPa (508 psi)

- Cylinders have a black stripe and an ‘E’ suffix



Bulk Liquid Gases

- Vacuum insulated tank (vessel within a vessel)
- Contains refrigerated liquid
- Not held at natural vapour pressure
- Relatively low operating pressures
- Typically 10 to 20 bar (145 to 290 psi)
- Regulated ‘pressure building circuit’ to maintain required pressure
- Fitted with relief valves and burst discs that may vent suddenly without warning and release product



CO_2 FOR GREENHOUSES

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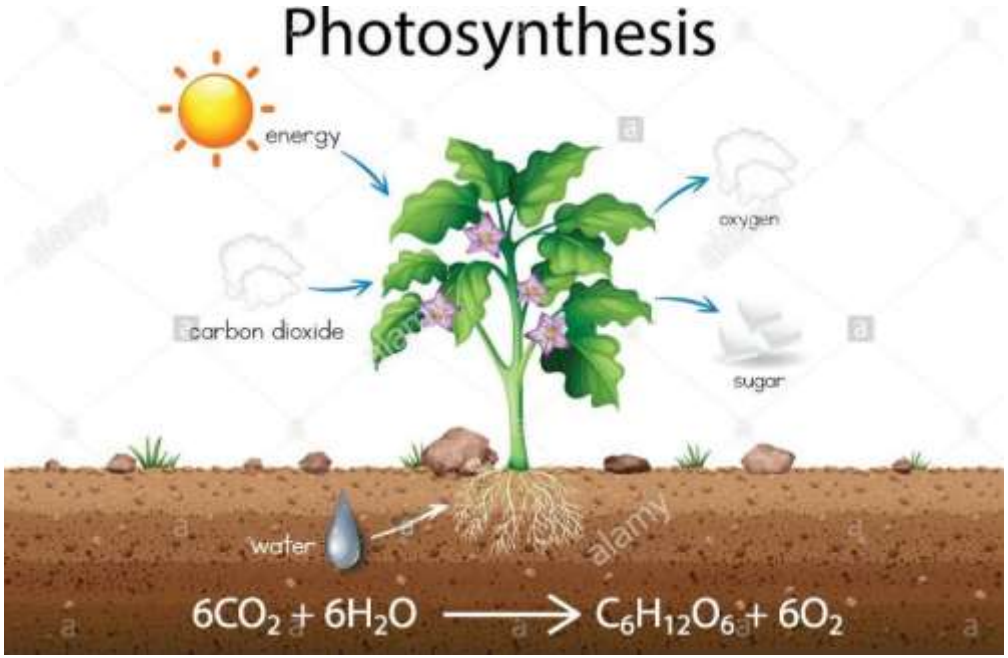
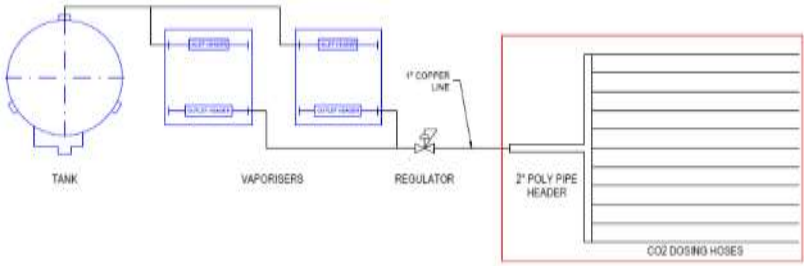
- Sealed greenhouses can result in depleted CO_2 levels
- Additional CO_2 is required to maintain normal levels
- Elevated CO_2 levels accelerate growth and improve yield
- Atmospheric CO_2 levels
  - 400 ppm
- Greenhouse CO_2 Levels
  - 800 to 1200 ppm
- Consumption will depend on design of greenhouse and CO_2 delivery system
  - Venting
  - Semi-closed
  - CO_2 recovery from boilers



CO_2 FOR GREENHOUSES

- CO_2 consumption depends on a number of factors:
  - Size of greenhouse
  - Required concentration
  - Growing hours
- Typical consumption can be < 200 kg/hr/hectare when factoring in leakage and venting losses
- Maximum CO_2 uptake for a full grown plant is 7g/m^2/hr assuming optimum conditions:
  - Saturating irradiance
  - Plant temperature
  - Leaf Area Index (LAI) of 3
- CO2 consumption will increase significantly when artificial lighting is used
  - Conventional crops rely on natural UV (< 9 hrs/day)
  - Cannabis usually artificial (< 18 hrs/day)



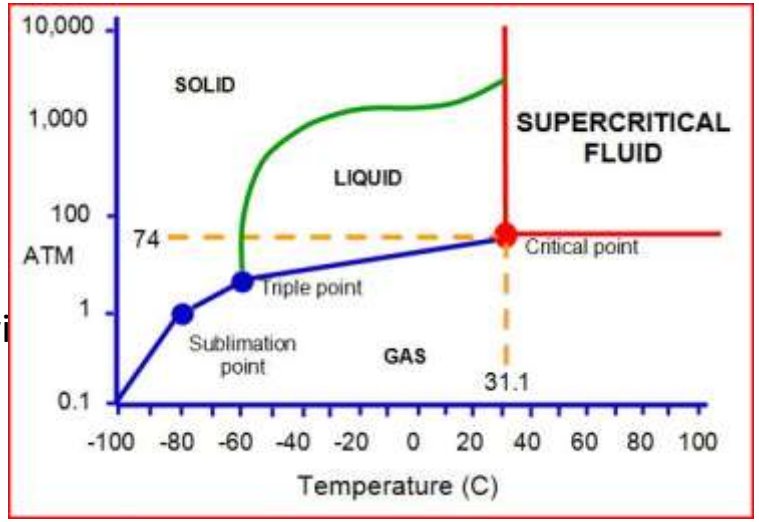
CO_2 FOR GREENHOUSES

- Greenhouse CO_2 Supply Mode
- Bulk liquid tanks
- Vacuum insulated
- 15 to 20 bar operating pressure
- Liquid vaporised to gas in tank compound
- Gas regulated down to ~5 bar
- Large reticulation systems
- Temperature monitoring may be required to protect downstream reticulation materials from excessively cold CO_2
- Most greenhouse reticulation is plastic pipe and hose

SUPER CRITICAL CO_2 EXTRACTION

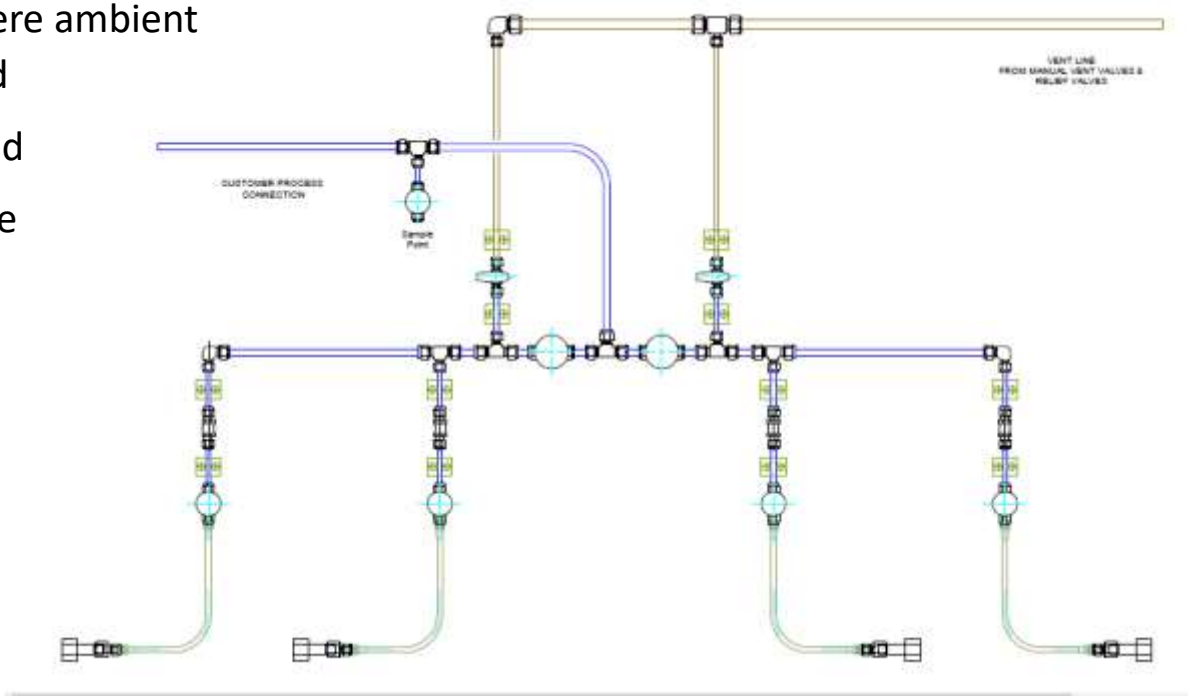
SUPERCRITICAL CO_2 EXTRACTION

- CO_2 supply pressures vary depending on manufacturer specifications
  - High Pressure - 50 to 60 bar (typical liquid cylinder)
  - Medium Pressure - 20 to 24 bar
  - Low Pressure - < 10 bar
- At super-critical conditions CO_2 becomes a non-descript fluid that adopts both gas and liquid properties
- Penetrates plant material like a gas but behaves like a liquid solvent and 'carries away' the essential oils
- When system is depressurised, the CO_2 vaporises leavi no residues behind
- The preferred method in the cannabis industry



CO_2 SUPPLY – HIGH PRESSURE CYLINDERS

- 50 – 60 bar liquid supply
- Pressure dependent on ambient temperature
  - Suited to indoor locations where ambient temperature can be controlled
  - External systems more exposed
  - Long pipe runs also susceptible
  - Heat tracing may be required
- Limited volume:
  - 31 kg in a G size cylinder
  - Manifold systems
  - Multiple cylinder changes
  - Manual handling



CO_2 SUPPLY – MEDIUM PRESSURE

- 20 – 24 bar liquid supply
- Vacuum insulated storage tank
- Limited by design pressure of tank and relief valve set points
- Typical bulk liquid CO_2 tank
  - 22 bar Relief Valve
  - 19 Bar Max operating pressure
- BOC Cryospeed tanks
  - 37 bar Relief Valve
  - 30 Bar Max operating pressure
- Chart Perma-Max 1400 XHP with 50 bar max operating pressure
  - Not currently available in Australia

- Medium pressure applications may require a booster pump if being supplied by Cryospeed or bulk liquid tanks
- Significant capital investment ($20K+) and ongoing running/maintenance costs

CO_2 SUPPLY – LOW PRESSURE (<10 Bar)

- Supplied by vacuum insulated storage tank
- Not limited by vessel design
- Not limited by relief valve set pressure
- In BOC experience this is not a common supply pressure to CO_2 extraction systems
- Most appear to be medium or high pressure systems requiring CO_2 at 20 < 60 bar

CO_2 SAFETY

- Gas monitors are required in all areas where gases are used in sufficient quantities to create a hazardous atmosphere
- Gas monitoring should include:
  - O2 (asphyxiation)
  - CO_2 (toxic in high concentrations)
- All gases displace Oxygen
- Oxygen displacement may be the most significant risk
- Position devices where gases will collect
- CO_2 is a dense heavy gas and will collect at low levels
- Repeater warning beacons & sirens should be installed at the all entrances to the area at risk
- Devices should be recalibrated regularly (6 monthly)
- Consider integration with Building Management System (BMS)

SUMMARY

- There are many different options…
- Each may have different CO2 requirements…
- Impacts equipment specifications, layouts, space requirements, infrastructure and delivery logistics…
- You need to understand the implications early in the plant design process
- We can advise and are happy to work closely with your other equipment suppliers to develop the optimum solution for your plant
- Errors can be difficult and expensive to address retrospectively…
- Get us involved as early as as possible!

Questions ???

More information is available at http://hiq.linde-gas.com