Liquid Helium, supply and demand: the case for recycling

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BOC LHe surcharge.

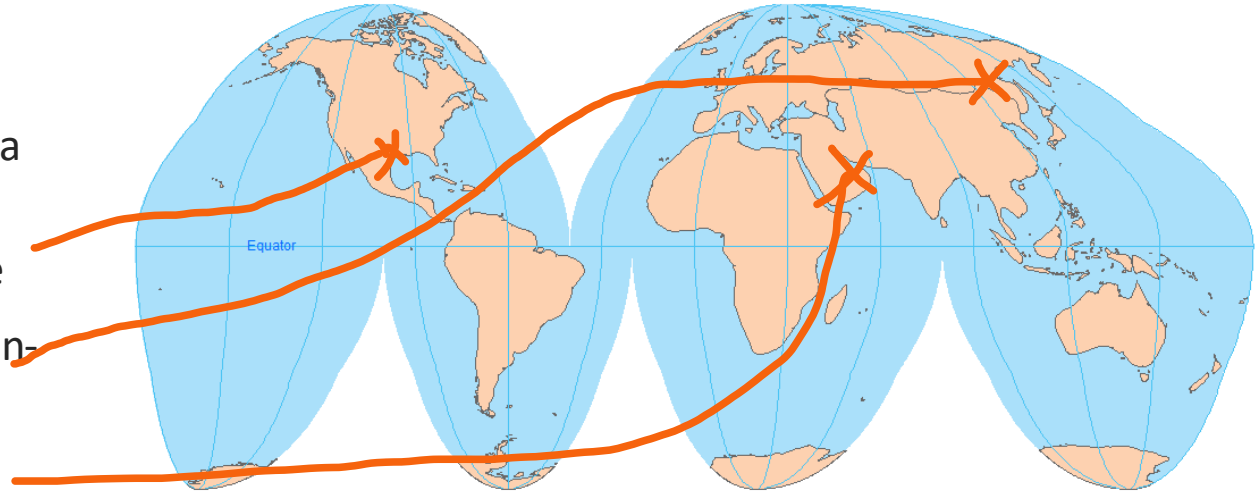
We introduced a surcharge to helium supplies earlier this year and this was communicated to all pricing contacts within customer organisations. The reasoning behind this surcharge is due to increased costs and volatility within the global helium supply chain. We have seen significant operational challenges from several sources and been notified of further unexpected product cost rises. It was also hoped that the logistics costs would stabilise throughout the year, but unfortunately, they continue to significantly impact the cost of sourcing helium from our global supply chain for supply into the UK market. These costs, and the costs associated with the operational challenges, are now expected to continue to impact our business throughout 2022.

Why do we use LHe?

- Traditional superconductors operate at liquid helium temperatures.
- Most NMR magnets are at the LHe boiling point at ambient (ish) pressure, 4.2K
- "Pumped" magnets are at lower temperature (2.7K). Uses a lot more helium
  - pumped 800: 27L/wk
  - unpumped 800: 8L/wk
- Superconducting technology improves, only necessary to pump magnets at ultra high field, or because your magnet is 10 years old (800 MHz). But would still take >30 years to recover the cost of a new magnet.
- How soon to a LN2 temperature 400MHz magnet?
- Helium coldheads are also improving. Nearly all SQUID/EPR is cryoplatform based. Not stable enough for NMR (yet?). There is a 600MHz "cryogen-free" system out there (1 ppm central homogeneity 0.1 ppm drift/hr).

Where does LHe come from? Why do we get shortages?

- *Helium is generated deep underground through the natural radioactive decay of elements such as uranium and thorium. It takes many, many millennia to make the helium that's here on the Earth.*
- It is trapped in natural gas pockets
- Cliffside Helium Plant in Texas shutdown in Jan because of a leak
- Amur, Siberia, shutdown because of an explosion *Ukraine
- 2/3 Qatari plants have had scheduled maintenance, back on-line
- It always escapes, to space eventually.
- US helium reserve has kept prices unrealistically low, and the market price is adjusting to that, and this also suppressed the ability to keep He production financially viable.



Environmental costs

- Linked to extractive carbon industry (natural gas). This should be decreasing if global warming is to be ameliorated. Better to burn the methane than to have it as exhaust...
- High energy consumption associated with cooling/liquefaction.

Recovery options

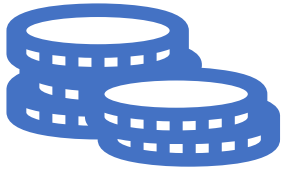
- Liquefy at source (Aeon) (pulse tube/ cryoplatform)
- Collect and liquefy at lab (mini liquefiers)
- Collect and compress at lab, liquefy "nationally" (BOC)
- Collect and liquefy regionally (local physics department)

Regulations

- Some of the pressure regulations were new to our infrastructure.
- Pressure Systems Safety Regulations (PSSR) 2000 & Pipelines Safety Regulations (PSR) 1996; The Pressure Equipment (Safety) Regulations 1999, 2016 deal with the design, manufacture and supply of pressure systems.
- Requires a Written Scheme of Examination; which is followed every year to check safety shut-offs and relief valves are functioning, and high-pressure hoses are intact.
- This needs to ratified by insurers....

HSE

Hidden costs and maintenance.



Compress and return:

Costs:

- Servicing costs £1.5k per annum; about 25% of the "cost saving"
- Spare sets of over pressure valves
- Hoses need replacing every 5 years.
- MCP hire and collection (not a significant amount)
- Electricity

Maintenance:

- Compressor requires weekly drain of accumulated moisture
- Arranging monthly MCP swap by BOC.
- Moving "overflow" cylinders and emptying into system...

None of these costs are high compared to a cryoservice.

How big a collection bag do I need?

- This is actually the biggest consideration; do you have room?
- Thanks to Juraj for numbers here....
  - LHe expansion ratio liquid to RT gas ~ 760
  - He gas expansion ratio 4K to RT ~ 100
  - For our typical fill, 170L of liquid helium are transferred. 10L are lost (possibly due to purging of transfer line. There are 170L of displaced gas plus 10L liquid boil off. ~25m^3 produced in a fill.
  - We only have a 10m^3 collection bag, which takes ~35 min to empty. He fill takes ~45 min, so we lose ~5 m^3 LHe gas during fill (4% over the cycle).
- So we don't attempt to collect everything produced while filling. The point is that the majority of the helium (>95%) stays in the magnet and is released slowly.

MIB installation

Magnet connections through NRV to stainless steel bellows. Over-pressure managed by 20mbar NRV T-ed off at wall

BMPC outlet also attached, with T-ed off NRV. Stainless steel belows attached to magnet outlet during fill.

Over-pressure valve opens to atmo-sphere in event of compressor failure

Control panel reads the pressure in the collection bag, and activates and deactivates compressor at set pressures, also controls over pressure valve. This should be on UPS.

Dewar farm

Gas bag 10 m^3

This set up dealt with a quench of one magnet.

MIB - Outside

Captured gas comes in here: -->

And volume recorded by old school domestic gas meter

Before being compressed by a Paramina Typhoon Ar/He 18

Compressor outputs to 12 cylinder MCP, which usually fills to around 135m^3 or to overflow cylinders, which are dumped back into the bag when there is capacity.
BOC collect these (in theory)

It would have been better to have remote monitoring, and potentially telometry with BOC, but this wasn't offered. It is a raspberry pi project for someone with time.....

Conclusions

- MIB has collected ~6500 m^3 of helium in 6 years.
- Worth £22k at today's prices (£3.45/m^3).
- Installation was not perfect, and there are still some safety features I would like to add.
- We use ~2000 L per year. Initial outlay was £38k + VAT (+ estates.....)
- Environment surcharge is extra £2 /L
- Hard to make the case on cost alone.

Thanks

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