Micropore/JFD Testing of Hyperbaric Conditioning Unit (HCU), External Regeneration (ER) at National Hyperbaric Center 3-21 August 2015

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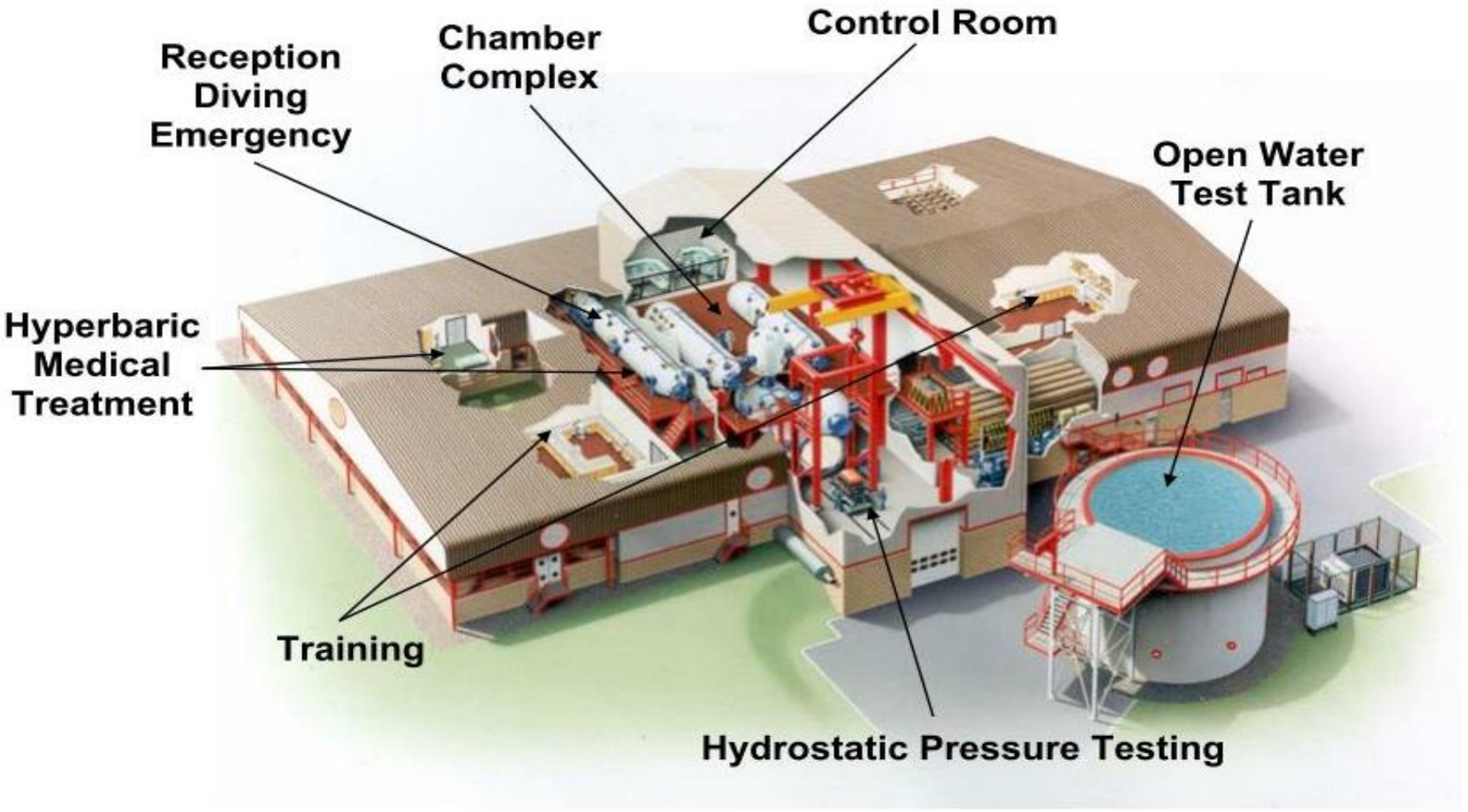
Location – National Hyperbaric Center, Aberdeen Scotland

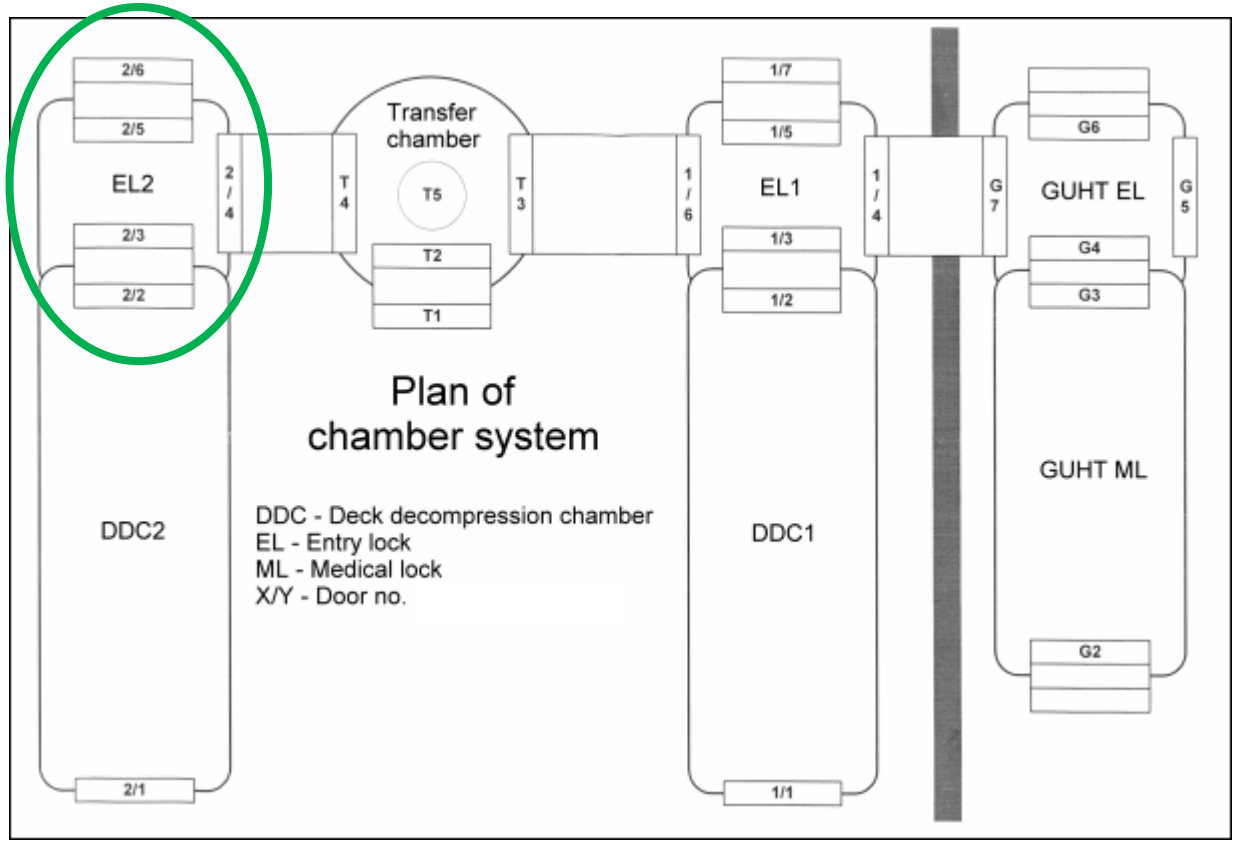
- JFD acquired National Hyperbaric Center in Feb 2015
  - Only facility of this type in the UK



national **hyperbaric** centre

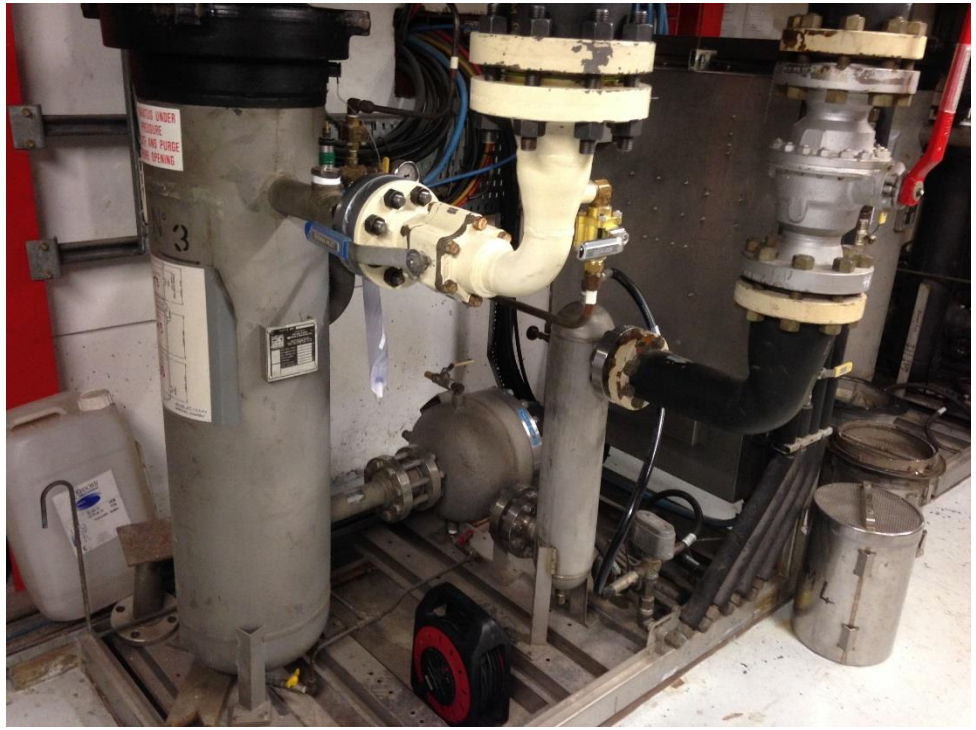
Dive Chamber System

- Unmanned testing took place in Entry Lock 2
  - Approximately 11 cubic meters, run at 100 and 300 msw

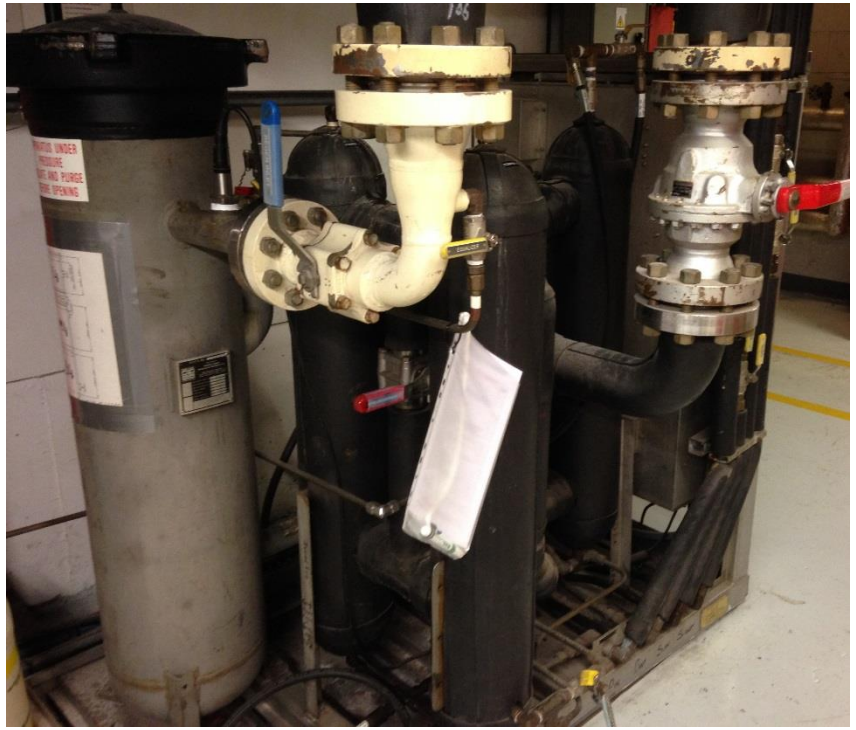


Testing conducted in the HCU-External Regeneration (ER) System

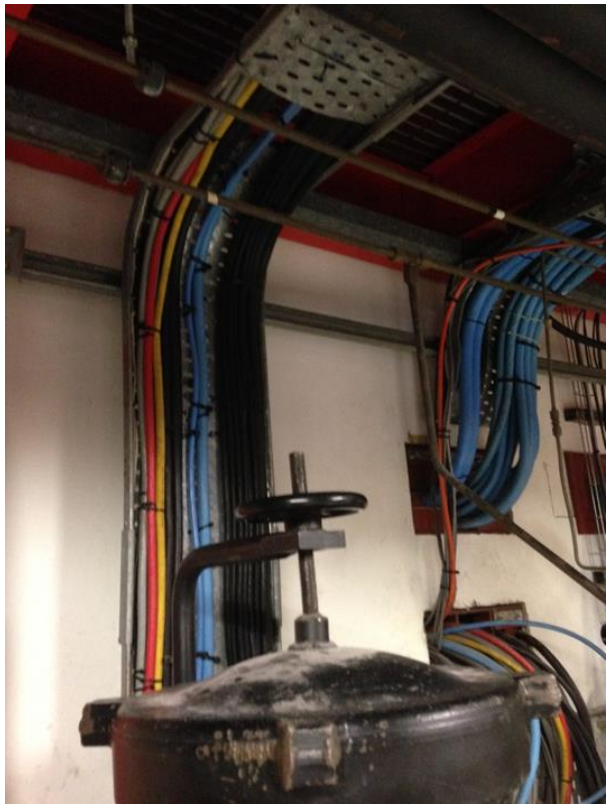
- For Saturation Diving Complex it is necessary to condition the internal atmosphere to maintain a habitable environment. This is achieved by the use of a Habitat Conditioning Unit (HCU) which extracts the gaseous atmosphere, dehumidifies it, removes CO_2 and reheats the gas on its return to the chamber complex.
- HCU w/o humidity control runs at 39 m3/hr



HCU-ER without temperature and humidity control

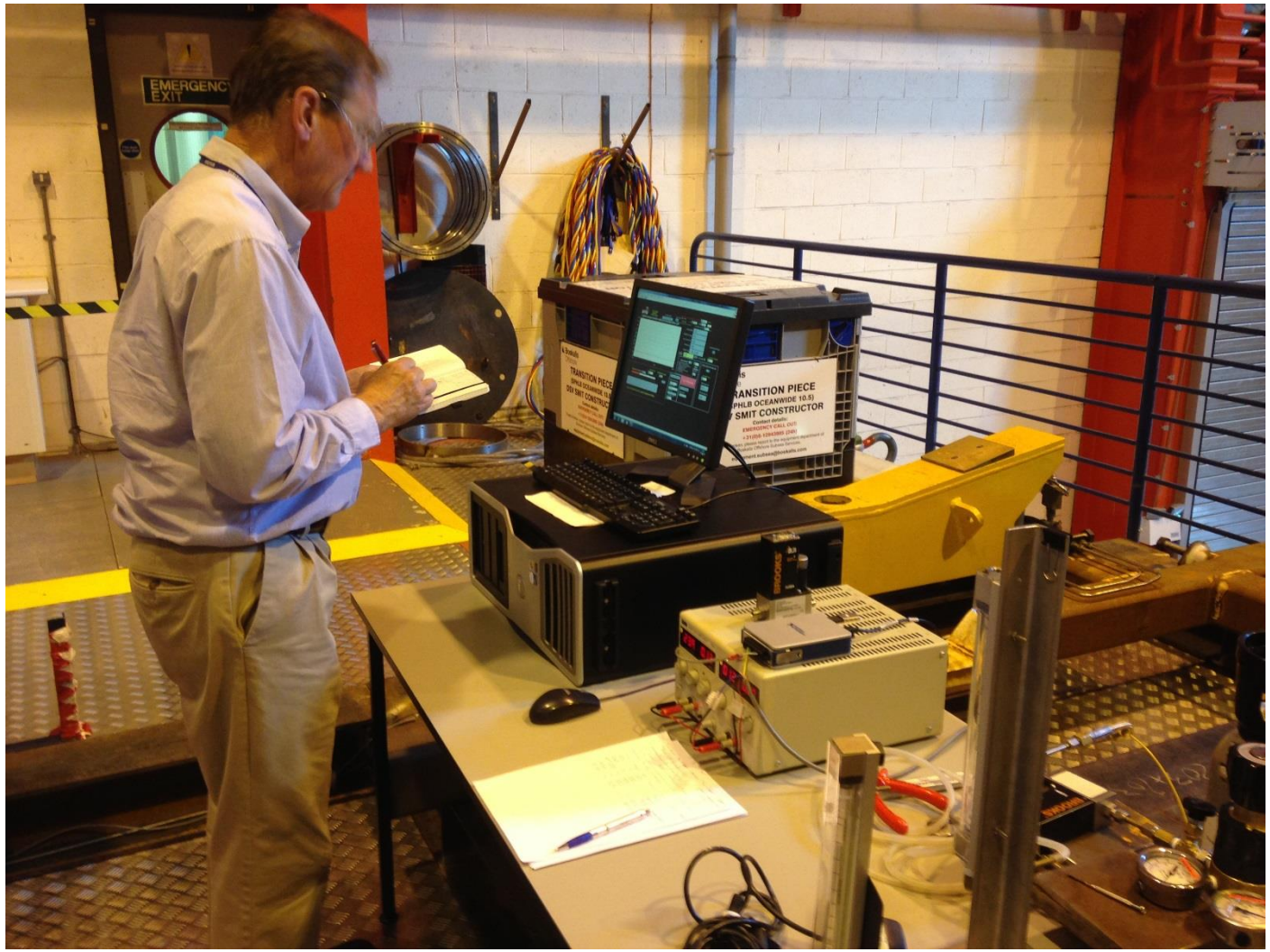


HCU-ER with temperature and humidity control



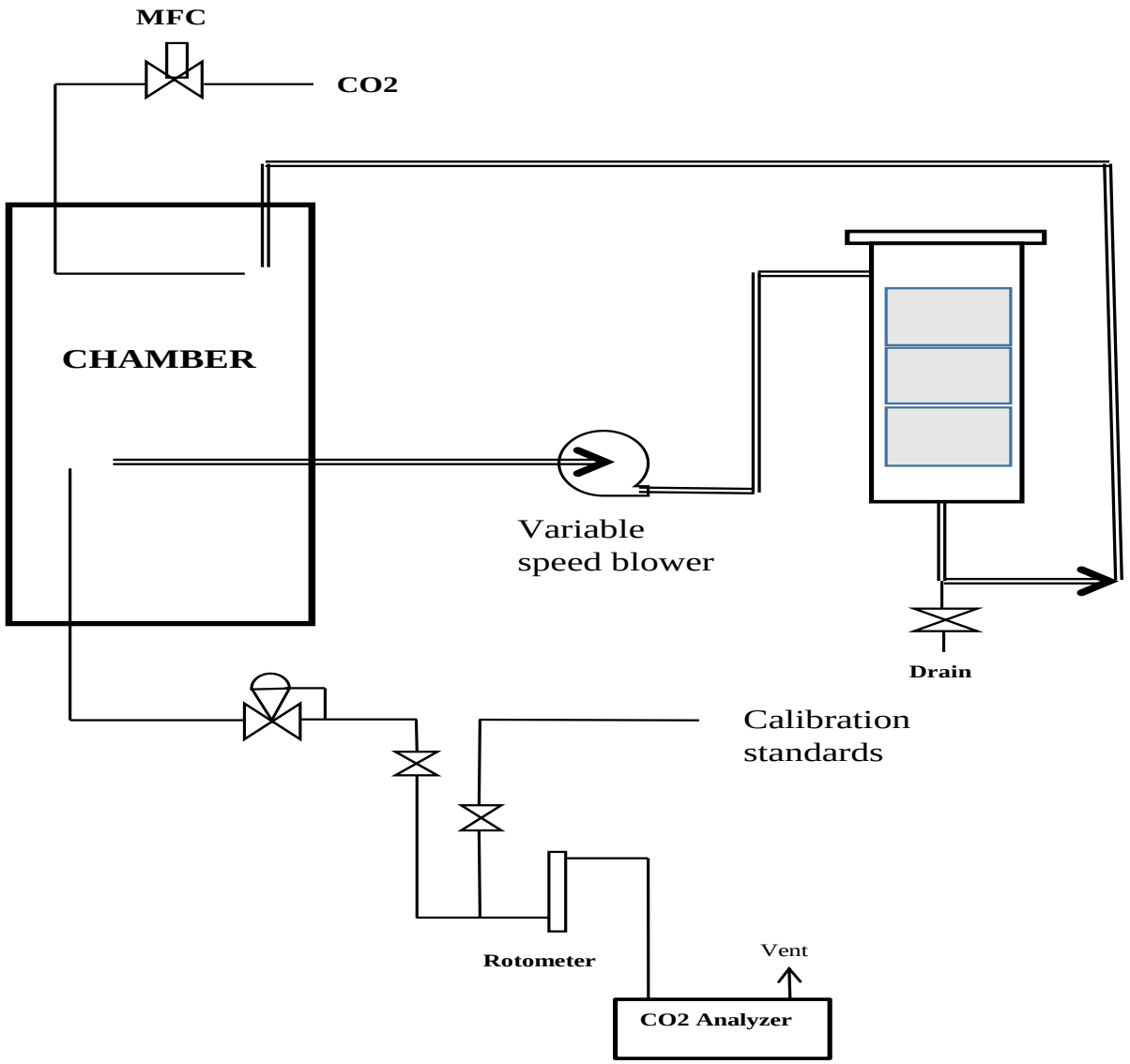
Overhead space for loading baskets/canisters is limited

Test Monitoring



- LabView control software
- National Instruments data acquisition
- DC Power Supply
- 0-15 lpm CO_2 mass flow controller
- Chamber Humidity and Temperature recorded manually

Test Diagram



Test Procedure

- Set chamber to desired depth (100 or 300 msw heliox)
- Record starting temperature and humidity (approximately same starting target for each test; ~55% RH, ~28 C)
  - HCU w/o temperature/humidity control used for first 6 tests
  - HCU with temperature/humidity control used for tests 7 -12
- Load HCU with either granule baskets or ExtendAir® cartridge assembly (approximated as similar volume fills and weights)
- Fill chamber to 2% CO_2 Surface Equivalent volume (SEV)
- Open HCU valve and start HCU blower motor (2000 rpm/39 m^3/hr)
- Run system until chamber reached below 0.1% SEV (Pull-down Test)
- Open CO_2 MFC valves and run at **3.2 lpm** (8 men @ 0.4 lpm/person)
- Run test to 1% CO_2 SEV (Duration Test)

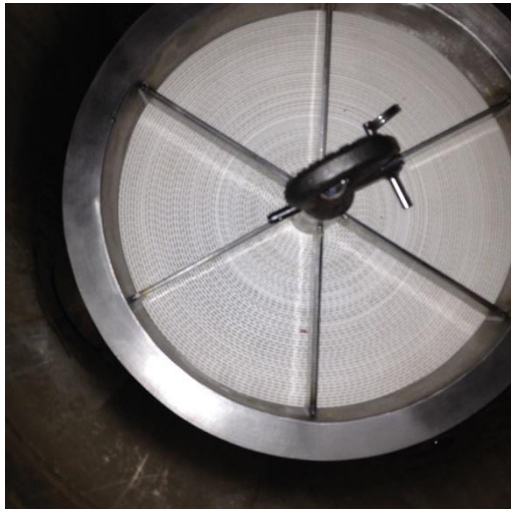
Test Sequence

1. 100 msw, granules, no humidity/temperature control
2. 100 msw, material 1 ExtendAir®, no humidity/temperature control
3. 100 msw, material 2 ExtendAir®, no humidity/temperature control
4. 300 msw, material 1 ExtendAir®, no humidity/temperature control
5. 300 msw, material 2 ExtendAir®, no humidity/temperature control
6. 300 msw, granules, no humidity/temperature control
7. 300 msw, material 1 ExtendAir®, humidity/temperature control
8. 300 msw, material 2 ExtendAir®, humidity/temperature control
9. 300 msw, granules, humidity/temperature control
10. 100 msw, material 1 ExtendAir®, humidity/temperature control
11. 100 msw, material 2 ExtendAir®, humidity/temperature control
12. 100 msw, granular, humidity/temperature control

Granule Basket preparation

- 1 basket fully loaded, 1 basket half loaded with 2.0-5.0 mm granule absorbent
- Mass of granule fill = 20 kg
- Both baskets placed in HCU-ER, serial air flow

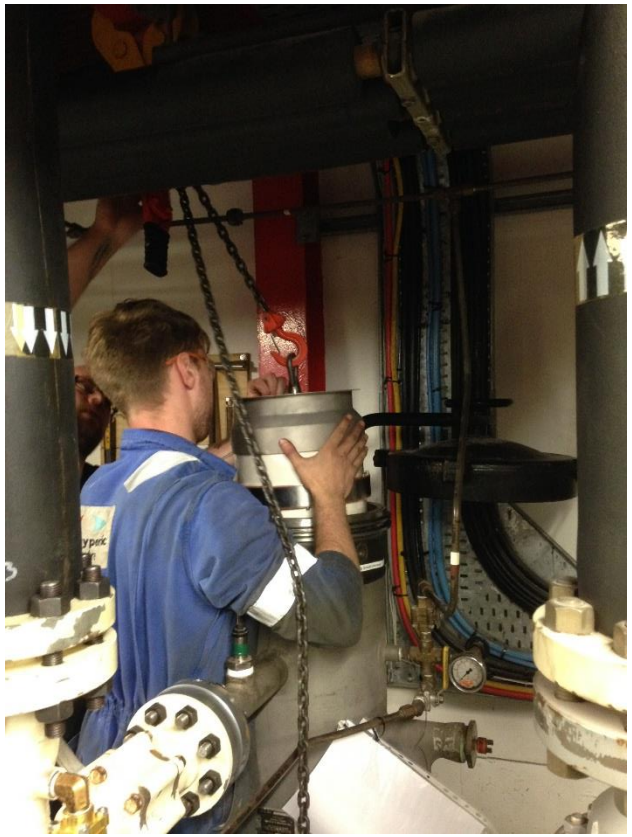
ExtendAir® cartridge assembly preparation



- 3 cartridges stacked, separated by sealing rings and topped with air flow diffusion cap
- Two different materials tested (-1 and -2), both calcium hydroxide based
- Mass of 3 material 1 cartridges = 21kg
- Mass of 3 material 2cartridges = 19.8kg

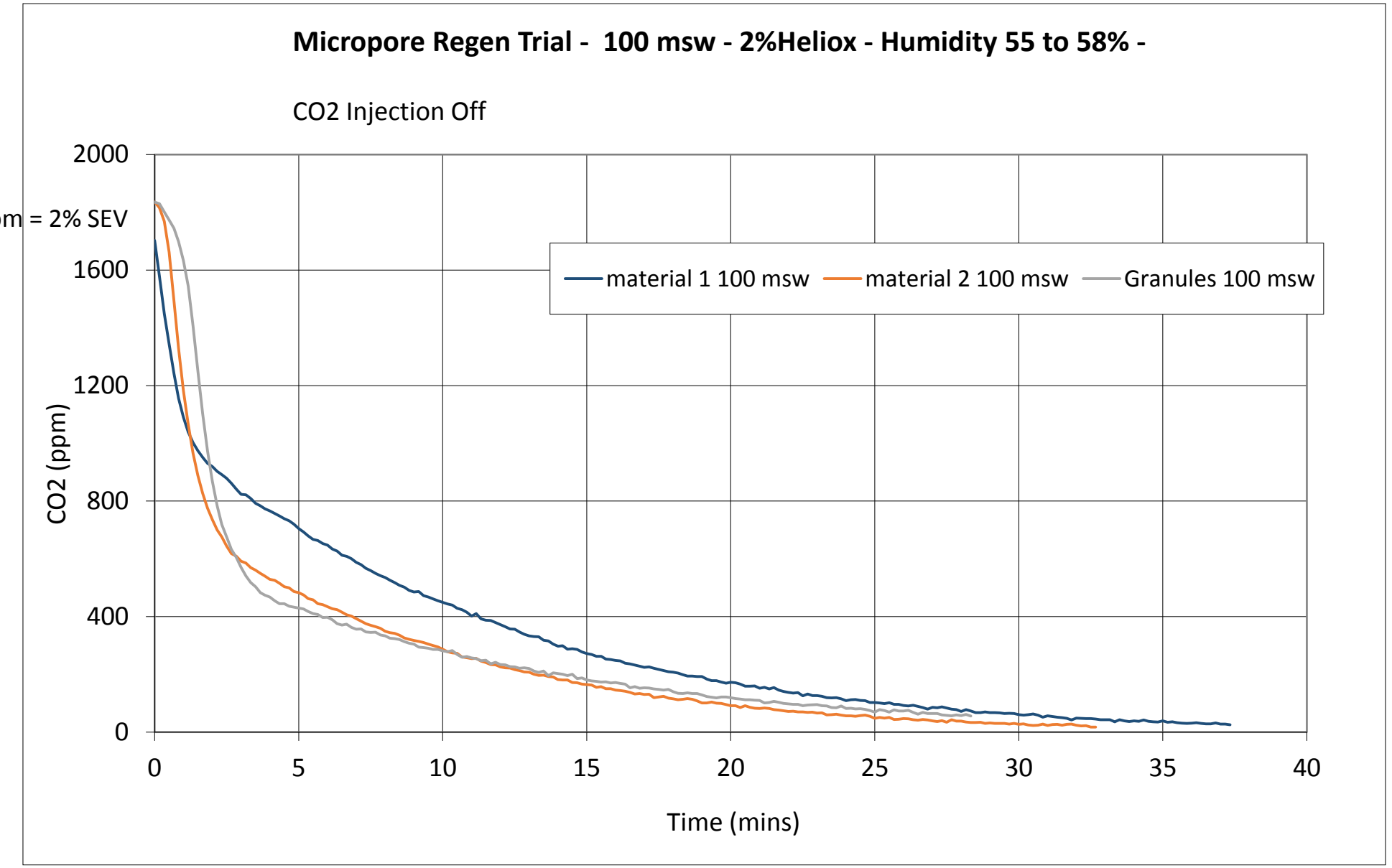
ExtendAir cartridge assembly loading into HCU

Base height adapter and seal; placed ExtendAir assembly in proper flow position

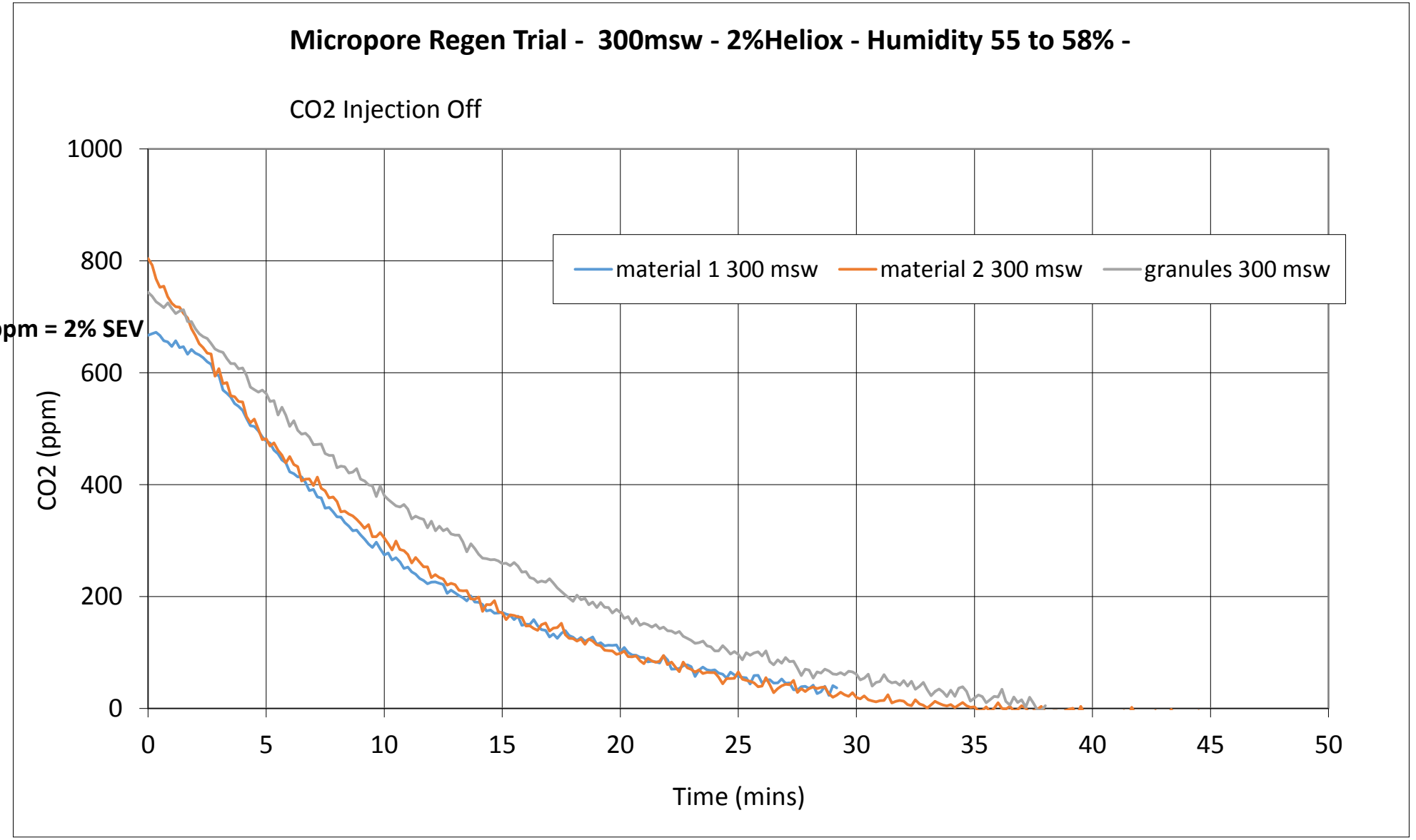


Hoisting ExtendAir® cartridge assembly into HCU

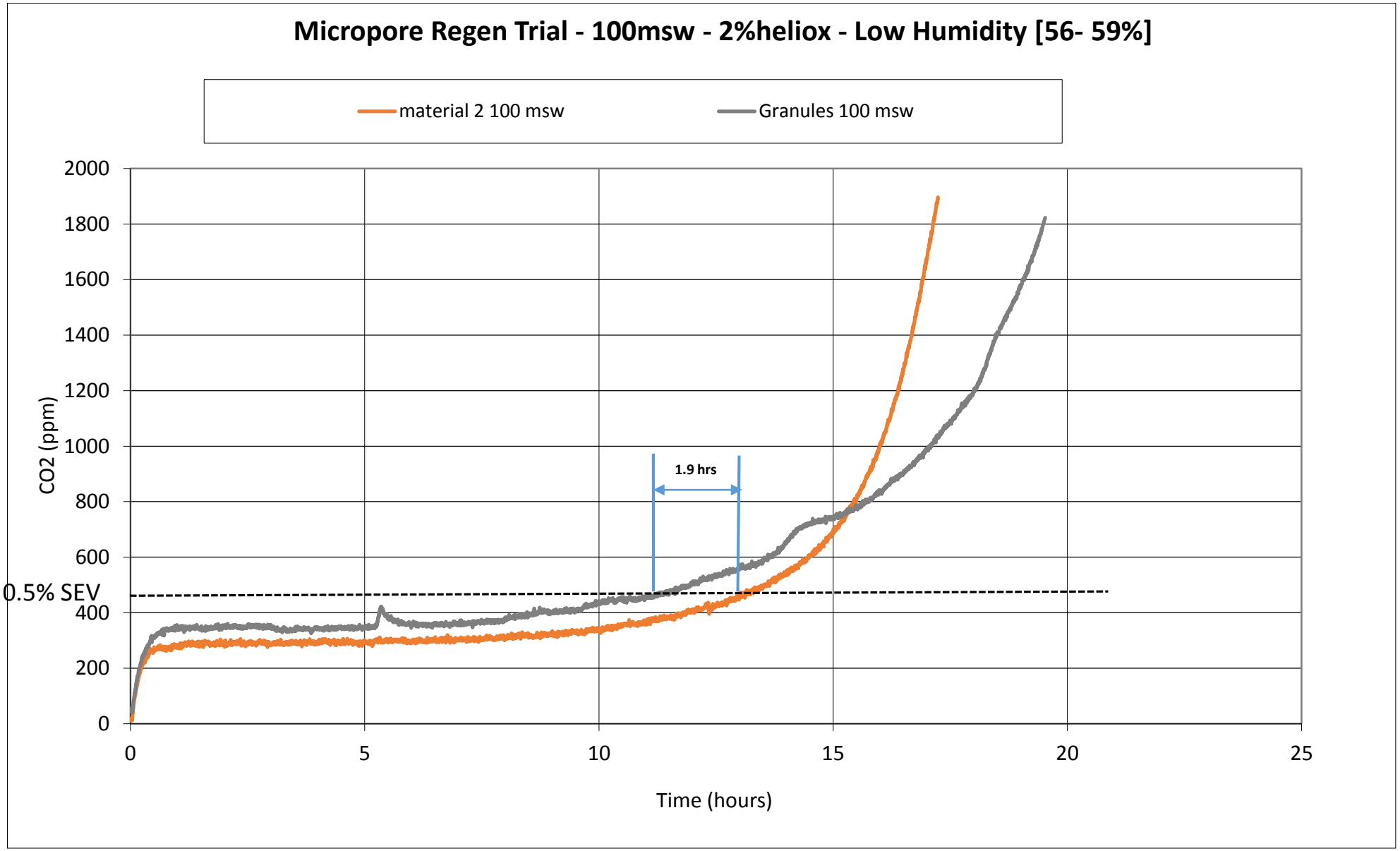
Pull-down graph



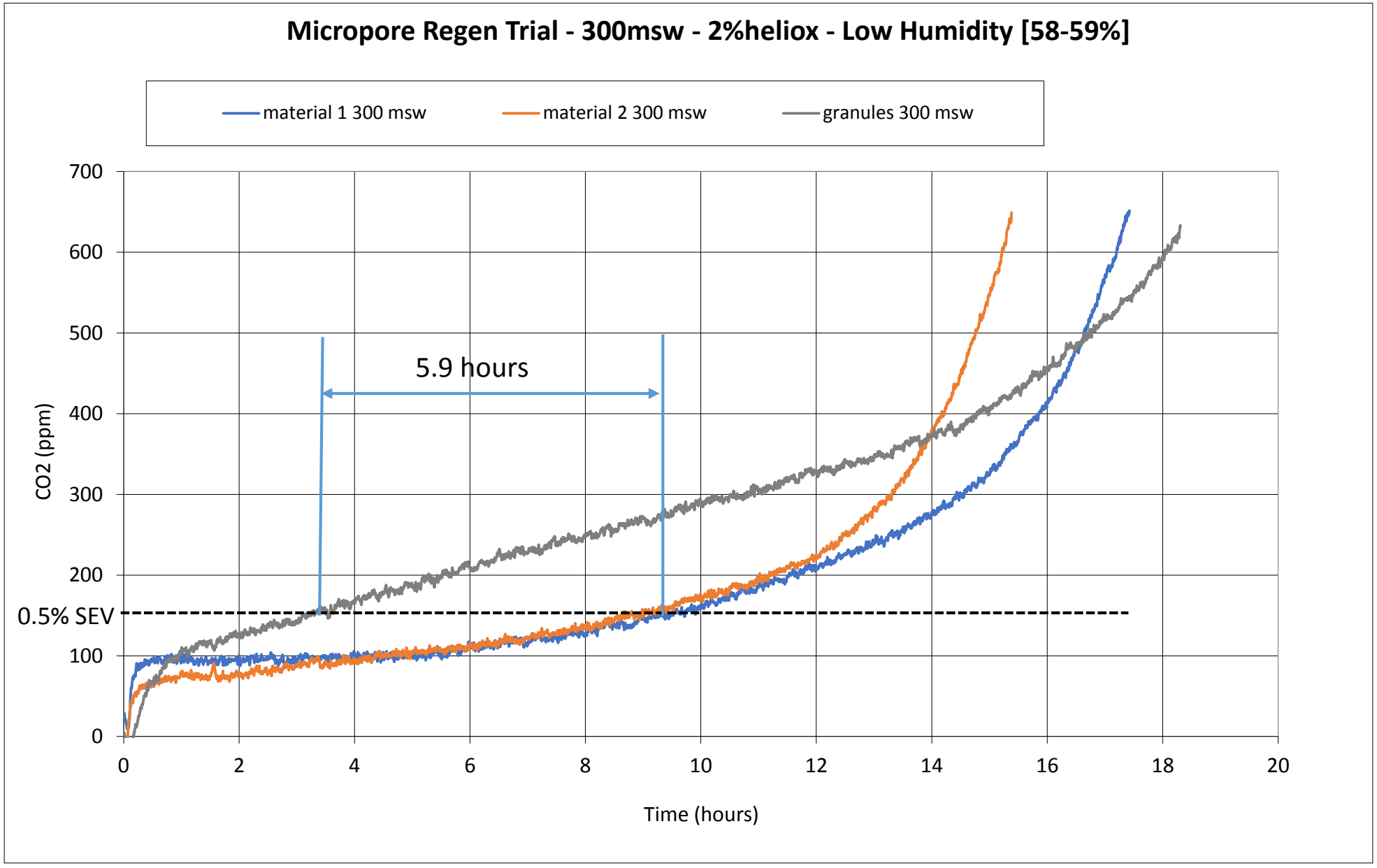
Pull-down graph



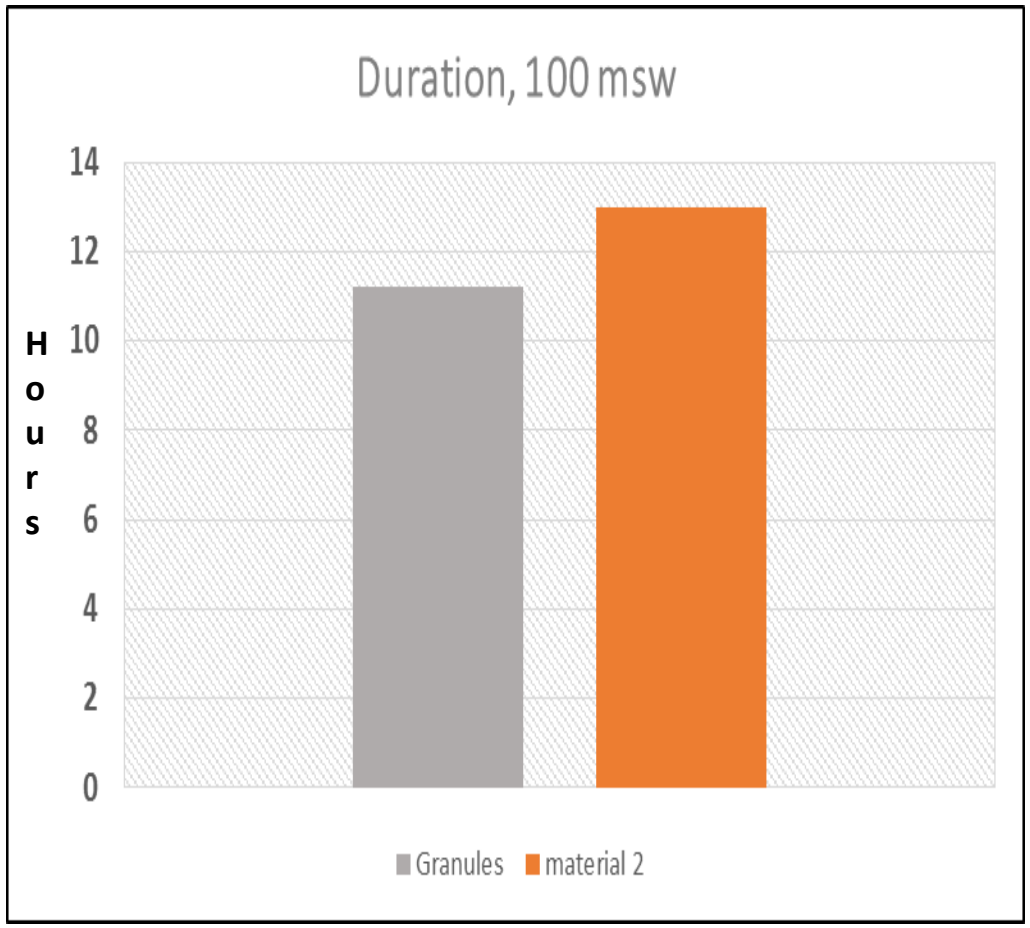
Duration Graph 100 msw

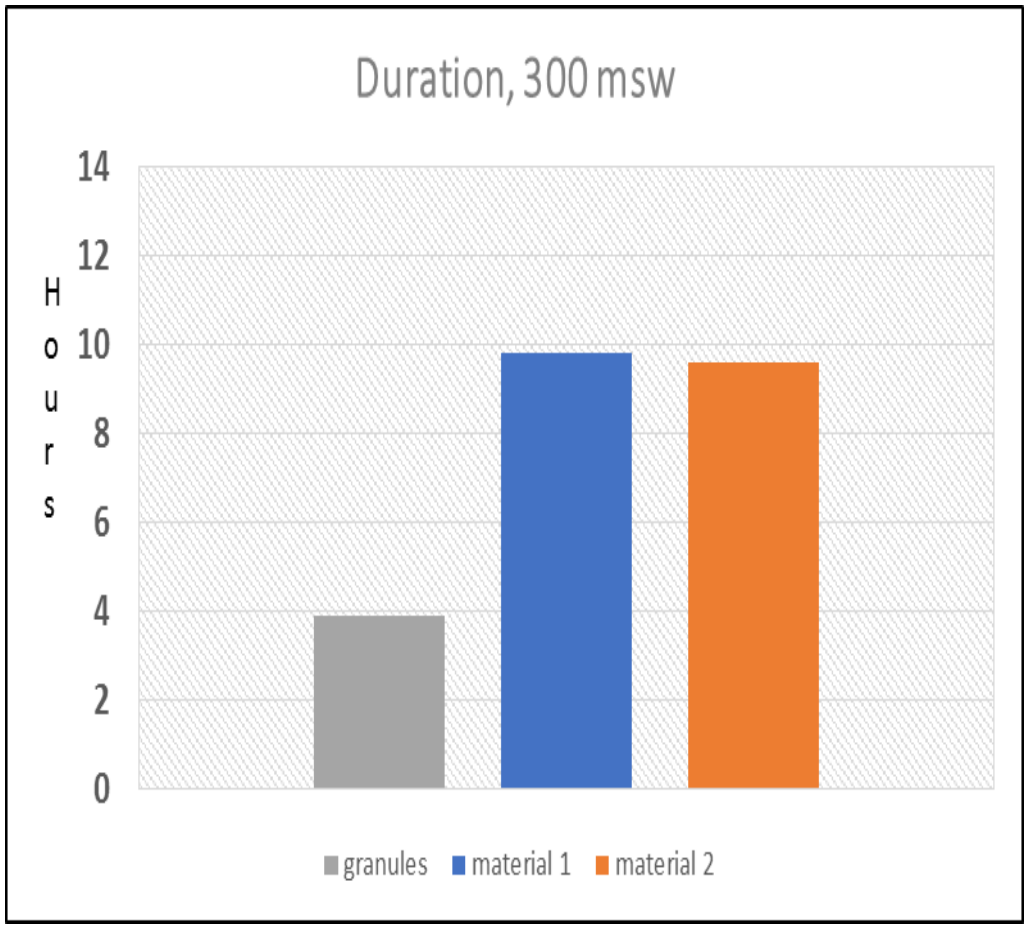


Duration Graph 300 msw

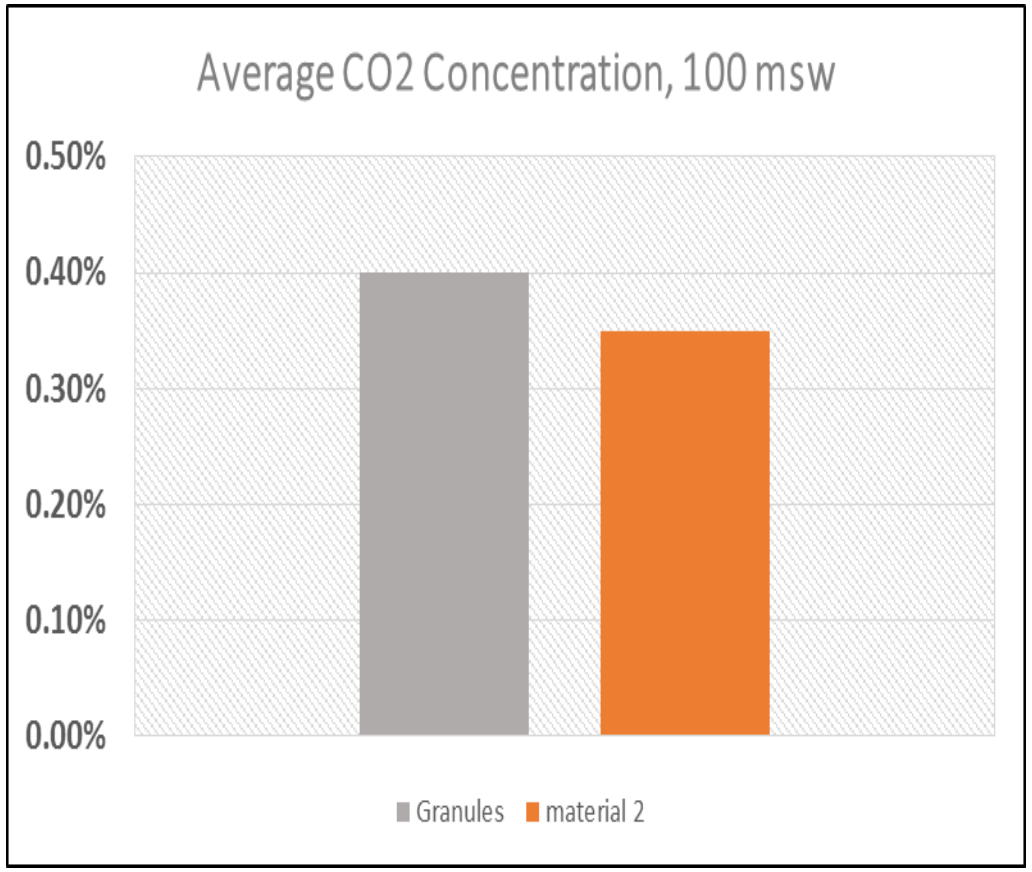


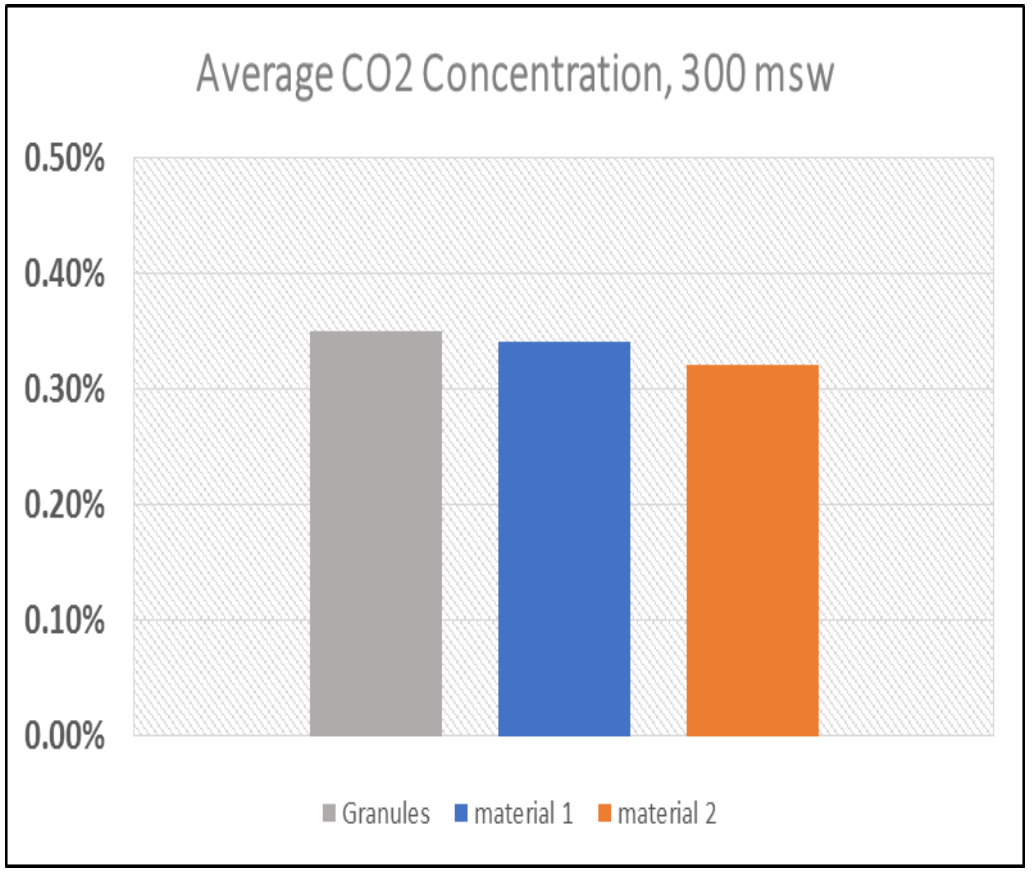
Duration Comparison





CO2 Concentration Comparison

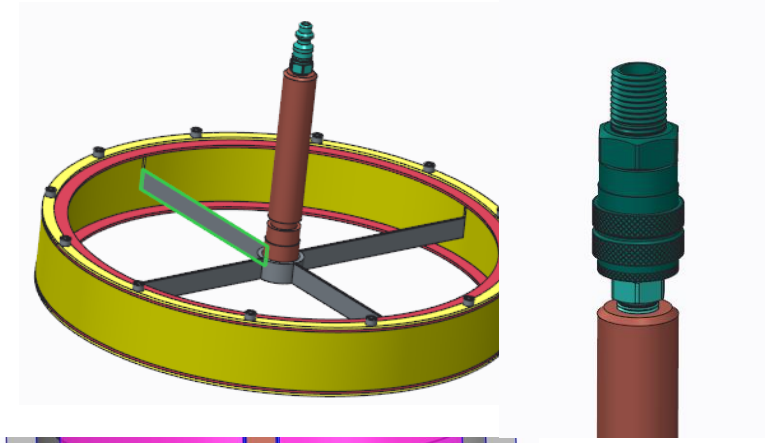


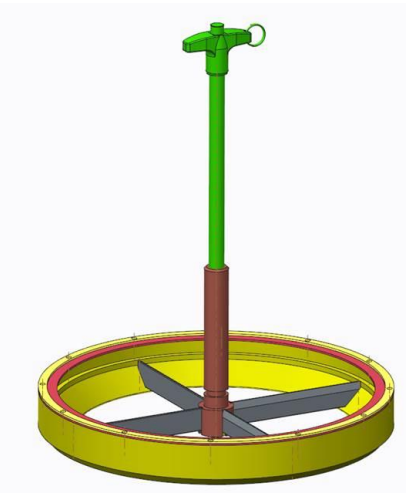


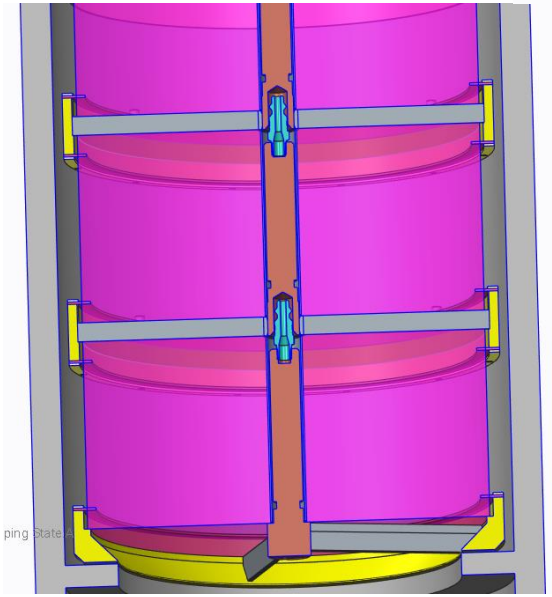
Summary Remarks
SAMAP 2015

- Value added by changing to ExtendAir® cartridge system
  - Longer duration: fewer scrubber change-outs and saves gas by not having to open HCU system
  - Lower average CO_2 exposure: improved breathing environment
  - Elimination of spillage/dust: lower maintenance requirements/costs, platform friendly, and safer breathing environment
  - Reduced weight loading; ergonomic relief from heavy granule baskets (next slide)
- Next steps
  - Improvements to frame housing for ergonomic loading benefits
  - Additional scrubbing improvement through new cartridge design
  - Heliox hyperbaric testing in radial scrubber (estm. ExtendAir® mass increase of 25% over granules)

Ergonomic Improvement Concepts (Aug 2015)

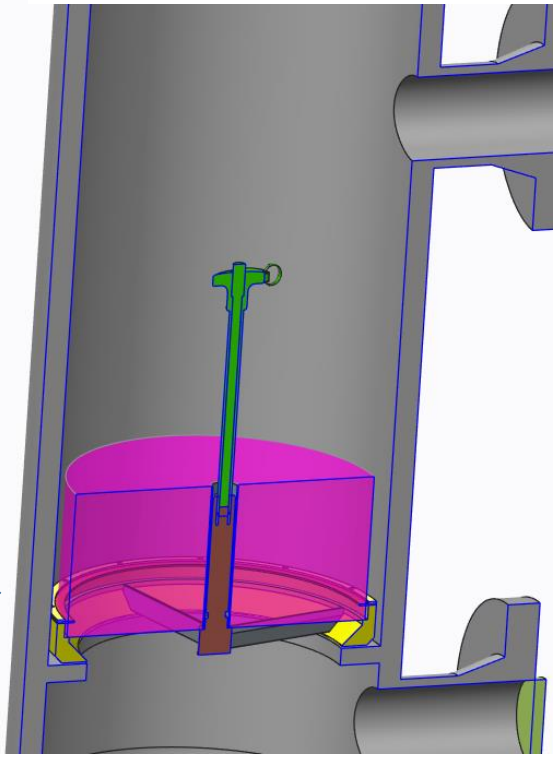






OPTION 1: Use an air-fitting quick connect to create an easy attach/detach handle

OPTION 2: Use a t-handle pin to left the assembly.



QUESTIONS ?

Requirements

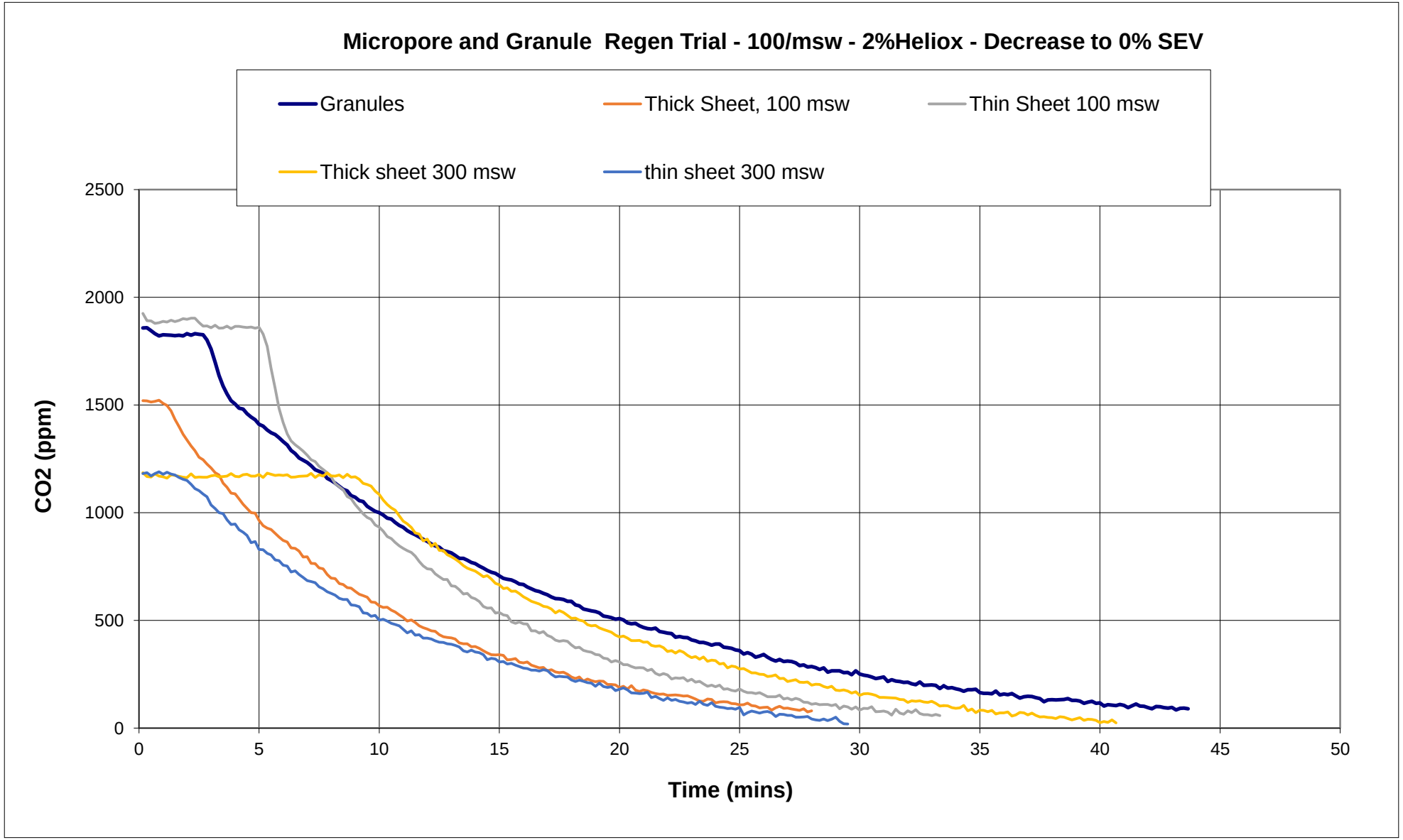
.005 bar limit

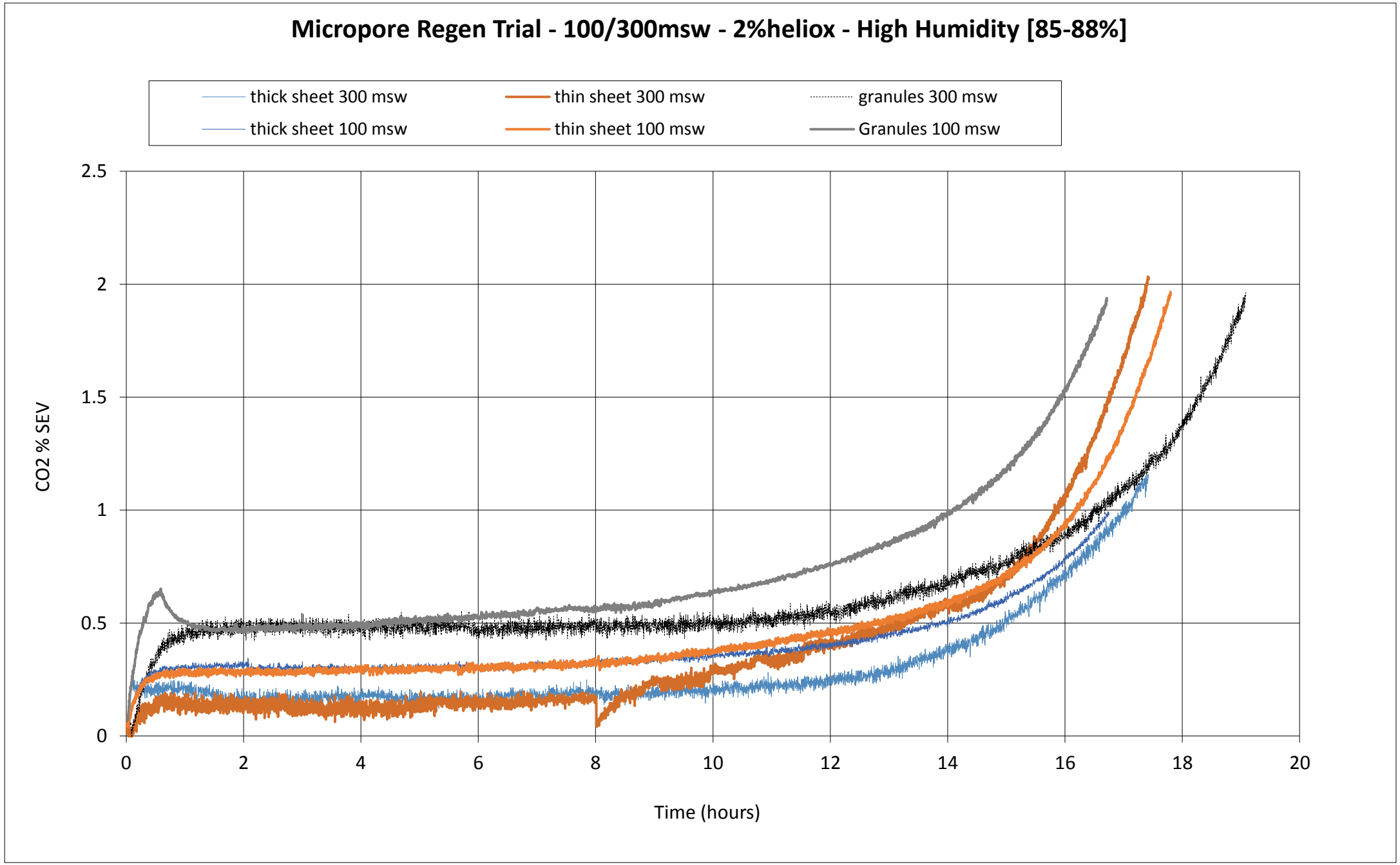
per DNV-OS-E-402 F602

ABS RULES FOR BUILDING AND CLASSING UNDERWATER VEHICLES, SYSTEMS AND HYPERBARIC FACILITIES 5.1

U.S. Navy Diving Manual 0.5% SEV section 15-14

All tests combined - Pull-down graph




Micropore Regen Trial - 100/300msw - 2%heliox - High Humidity [85-88%]
thick sheet 300 msw
thin sheet 300 msw
granules 300 msw
thick sheet 100 msw
thin sheet 100 msw
Granules 100 msw
CO2 % SEV
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
16
18
20
Time (hours)

Performance comparison 100 & 300msw
Equal adsorbent mass

	Granules 100 msw 59% RH	material 2 100 msw 56% RH	Granules 300 msw 58% RH	material 2 300 msw 58% RH	material 1 300 msw 59% RH
Hours to 0.5% SEV	**11.2**	**13**	**3.9**	**9.6**	**10.3**
Avg. CO2 conc.	**0.40%**	**0.35**	**0.35%**	**0.32%**	**0.34%**
CO2 removed Liters, NTP	**2093**	**2439**	**691**	**1786**	**1920**