

## PISA Dry He3 continuous 350mK system – Installation and test report

- System approved and shipped by customer. System arrived week beginning 9/12/22. Engineer arrived in PISA 12/12/22
- **Install day 1 -13/12/22**

Upon arrival at customer site preliminary checks were undertaken on boxes to check for external damage before moving onto unboxing components and system. The system was partly assembled to the point in which it could be mounted within the customers support frame. Ovc was removed and all internal packing removed, system was given visual inspection, all plates were cleaned before reassembling. Pump was attached to OVC and began pumping before mounting the coldhead within the sock and securing. The ICE temperature control software was installed on the local PC as well as ICECube software. The wiring check revealed the magnet sensor was not reading, the OVC was also struggling to pump below 10-2 mbar. The system was vented, disassembled and wiring checked. 1 of the constantan wires to the magnet sensor had been severed, the magnet wiring loom was removed for repair.
- **Install day 2 – 14/12/22**

System was reassembled and OVC was placed back on pump. Helium 4 circulation was constructed with all necessary connections between dump, cryostat and circulation pump made. System was still struggling to pump down. Fault was found to be with customer pump, the pump was changed and OVC continued pumping. Began pumping on Helium 4 circulation in preparation for leak checks. All connections for helium 3 circulation setup and began pumping in preparation for leak checks.
- **Install day 3 – 15/12/22**

Leak checks undertaken on Ovc, He3 circulation and He4 circulation. All leak rates within specification.

<b>Preparation:</b>	He4	He3
Leak Rate OVC	3.00E-08	3.00E-08
Leak Rate Circuit	4.50E-05	4.50E-05
Leak Rate Circuit to OVC	4.10E-09	2.80E-08
Sensors Reading	OP	OP
Electronics Working	OP	OP
Software Logging	OP	OP
Test Sheet Ready	OP	OP

Sensor connections made to lakeshore and running with software. All inputs confirmed working and needle valves and heat switches confirmed to be functioning. Water circulation for compressor and turbo constructed and tested. He4 circulation opened and running, cold head powered on for initial cooldown.

- **Install day 4 – 16/12/22**

Engineer returns to UK.

Sergio continuing cooldown of system to base.

- **Install day 5&6 – 19 and 20/12/22**

Helium 4 system reached base over the weekend. System reached sub 2k in 32 Hours with base temperature of <1.52K on the 1k pot achieved.

Date	Elapsed Time	Sensors					Ancillaries			Notes
		50K Stage	4K Stage	Magnet Top	1K Stage	He3 Stage	Nv 1 He4 (%)	Flow (mBar)	Dump (mBar)	
Test Begin 24/11/2022		AB-270	AB-270	AB-270	Dual-ICE	CX				ICE N2 COLD TRAP
15/12/2022 14:46	0.0	299.6	293.6	N/A	T.OVER	293.19	100.00	8.0	940	Compressor on, 17.45bar, 10mbar flow set
16/12/2022 07:40	16.9	102.0	100.00	N/A	112.00	116.00	34.00	10.0	906	Heatswitch 1 D/E
16/12/2022 16:05	25.3	63.0	3.7	N/A	1.82	3.40	27.00	10.0	570	Heatswitch 2 D/E
16/12/2022 18:05	27.3	61.0	3.5	N/A	1.82	4.80	27.00	10.0	505	Base reached for 10mBar Flow cooling, (Cool down time XXHrs)
16/12/2022 18:55	28.2	57.6	3.2	N/A	1.66	5.06	28.00	8.0	315	Base reached for 8mBar - Dump stable
16/12/2022 19:20	28.6	56.3	3.0	N/A	1.55	5.12	27.00	6.0	240	Base reached for 6mBar - Dump stable
16/12/2022 19:40	28.9	55.0	2.8	N/A	1.52	5.16	26.80	5.0	200	Base reached for 5mBar - Dump stable
18/12/2022 19:00	76.2	53.0	2.6	N/A	UNDER	5.80	25.00	3.0	150	Base reached for 3mBar - Dump stable
18/12/2022 19:30	76.7	53.0	2.6	N/A	UNDER	5.80	100.00	3.0	150	COMPRESSOR OFF, NV1 to 10 mbar (auto), then to 100% manual
18/12/2022 19:45	77.0	68.0	17.0	N/A	14.00	5.80	100.00	80.0	600	HS2 engaged
19/12/2022 03:00	84.2	240.00	100.00	N/A	95.00	68.00	100.00	15.0	930	HS1 engaged

Sergio undertook multiple flow tests, temperatures at each flow are shown above.

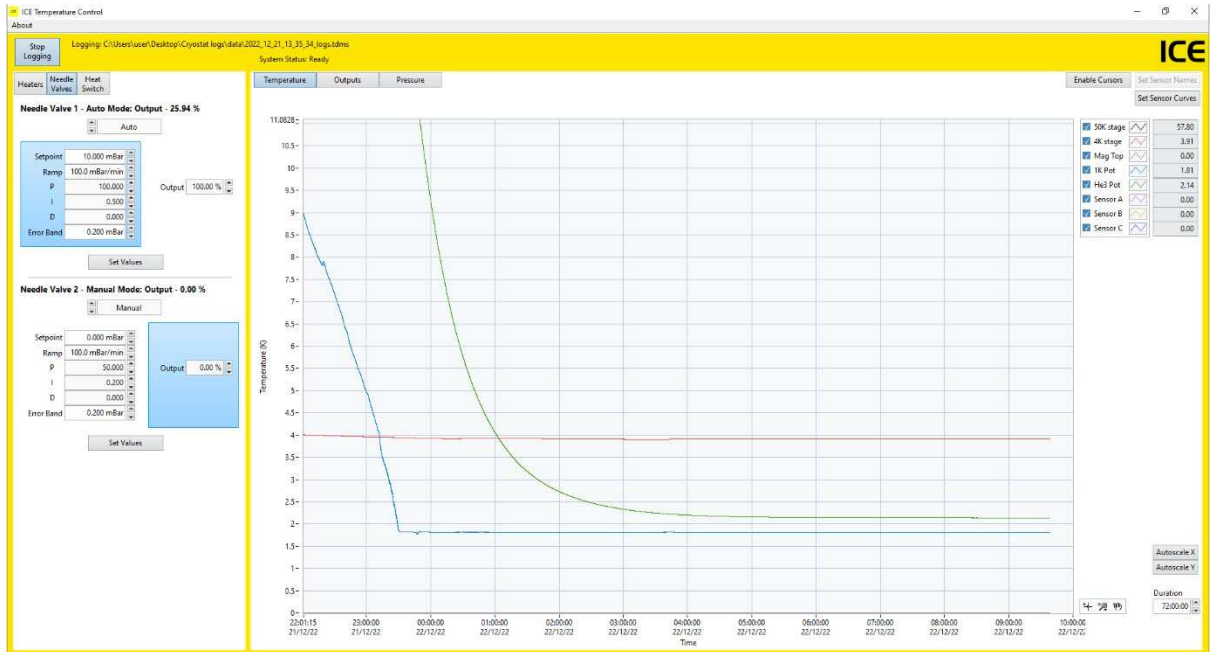
Planned utilities shutdowns on 19<sup>th</sup> and 20<sup>th</sup> therefore system warmed on 18/12/22.

- **Install day 7 – 21/12/22**

System turned back on, Sergio undertaking cooldown with engineer monitoring remotely.

System cooldown to sub 2K in 32 hours.





- **Install day 8 – 22/12/22**

He3 condensed into system. using ICECube control.

With helium circulating NV was opened to 40% to fill he3 pot. NV was then closed to single shot pot. Once temperature stabilised turbo was turned on and left overnight to reach base. 330mk base single shot was reached as seen in screenshot below.

- **Install day 9 – 23/12/22**

With helium 3 at base temperature NV was opened to 8% to allow continuous flow.

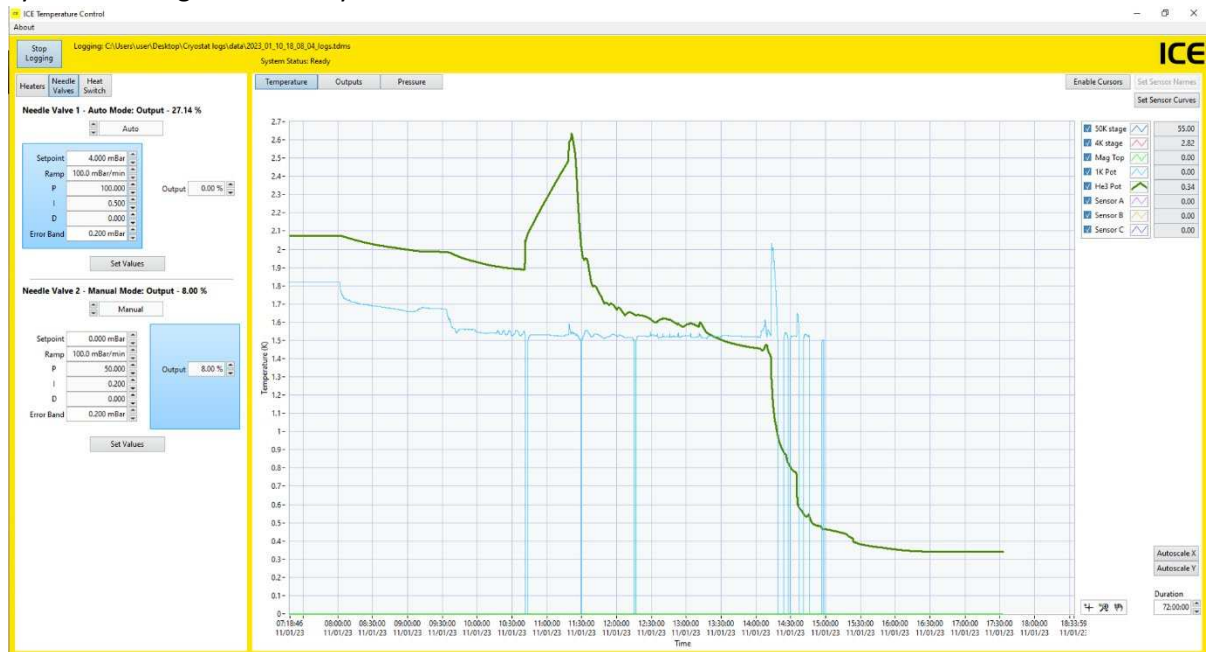
Continuous temperature of 336mK was achieved in this condense.



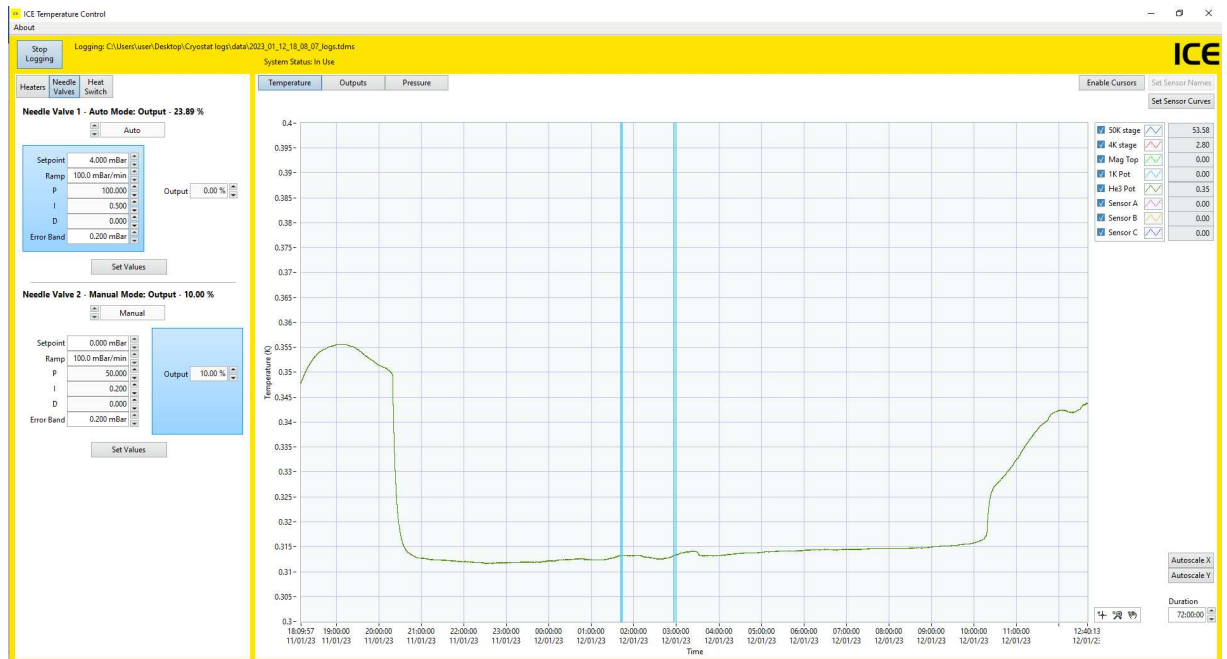
System shutdown and warmed up for Christmas break.

- **Further testing 09/01/23 – 25/01/23**

Between the dates above final tests were undertaken on the system. The helium 4 circulation was once again cooled down in the expected time and Sergio condensed in and circulated helium 3 following routine. Helium 3 cooldown was achieved overnight with system running continuously at 341mK



After leaving overnight to stabilise system reached a continuous base temperature of 315mK. Base in continuous mode: T=310-315mK (NV1=4mbar, NV2=8%; P1,3=50mbar)



Sergio undertook cooling powers of 50  $\mu\text{W}$  and 100  $\mu\text{W}$  to find expected temperatures with different heat loads on sample plate. Results seen below.



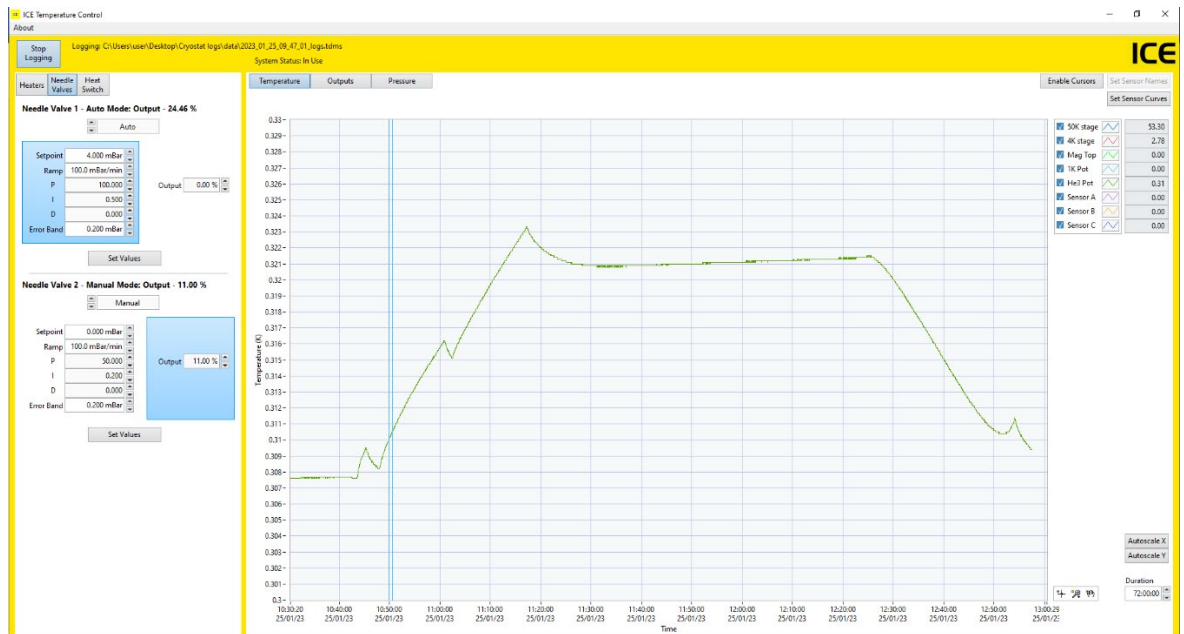
50  $\mu\text{W}$  cooling power (0.6% on Heater2): T=347mK (NV2=10%; P1,3=260mbar)



100  $\mu\text{W}$  cooling power (0.89% on Heater2): T=352 (jump to 360mK at some point) (NV2=10%; P1,3=293mbar)

- **Magnet testing 25/01/23**

Sergio condensed and circulated helium 3 back to base temperature. NV was opened to 11% to increase cooling power slightly for magnet run. Magnet was ramped up to full field in steps to ensure no quench occurred (0T -> 0.5T -> 4T -> 8T (60min hold) -> 0T). Temperature at full field was 322mK. Ramp down was achieved in 45mins. And helium 3 was left to return to base temperature. He3 and 4k plate temperatures can be seen below.



All ICE assisted tests completed.

Project Engineer:

Date:

08/02/2023

COO NEST Laboratory, SNS