Magnet Test: preparation and compliance

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KLOE Magnet test @ LNF and FNAL

Test of the magnet must be performed to put it back to service. It can be divided in two sections:

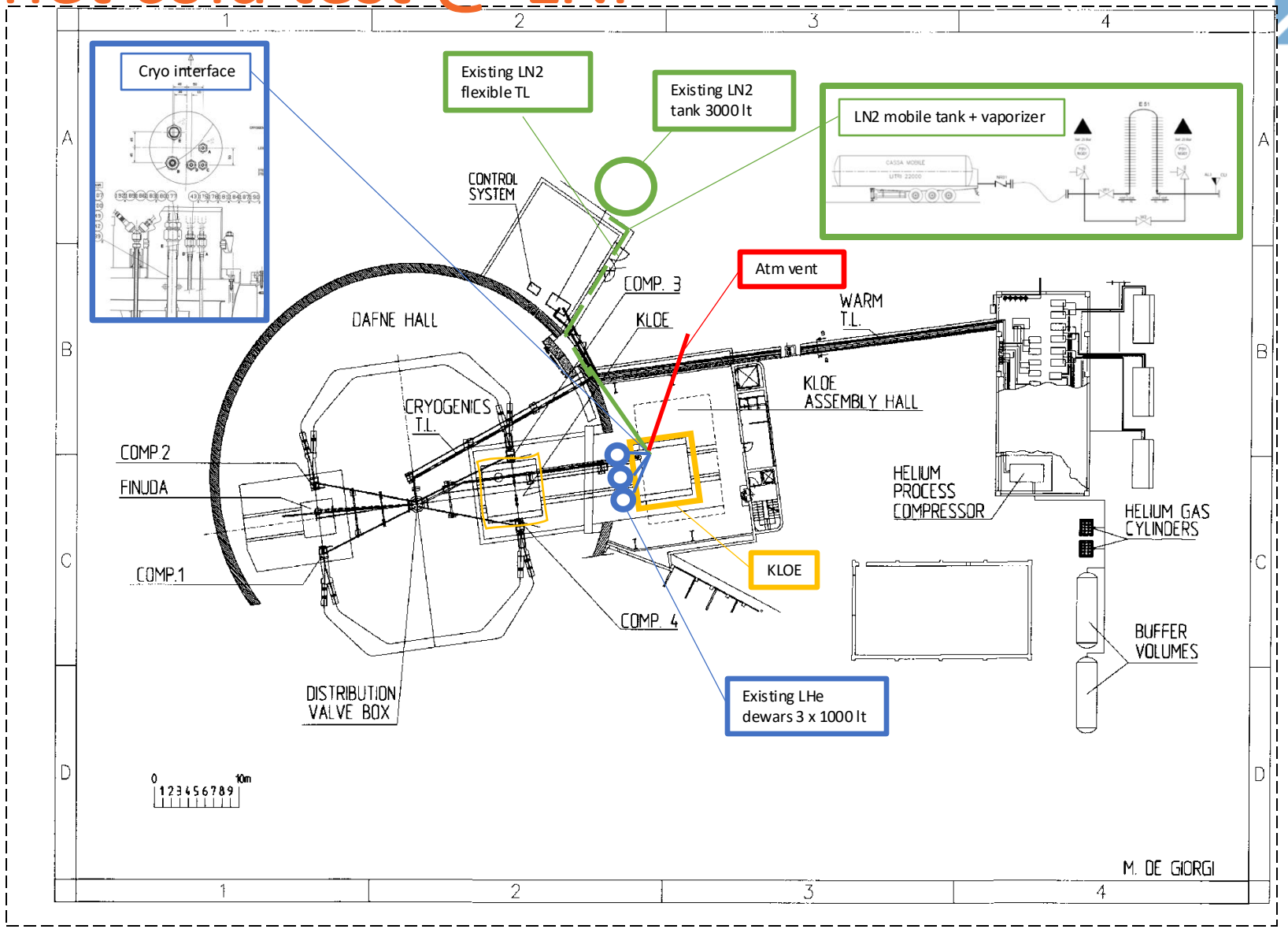
1. Warm test
2. Cold test

Warm test - will check the electrical, mechanical, fluidic and control operational status of all the subsystems at 300 K: vacuum, temperature sensors, pressure sensors, valve leaks, actuators, PS interlocks, heaters, CS etc.

Cold test – will check the previous list at 4.4 K in addition to all the test that must be performed on the PS and the quench detector with the coil energized to a limited current

Tests at LNF will be repeated at FNAL, and both performed in presence of FNAL representatives as part of training program and compliant hand-off

KLOE Magnet cold test @ LNF



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KLOE Magnet Status

Vacuum

- the vacuum pumping system has been reconnected to the cryostat, to the CS and to the power line. It is fully operational.
- Complete revamping of the pumps will occur after the test at LNF (order already placed)

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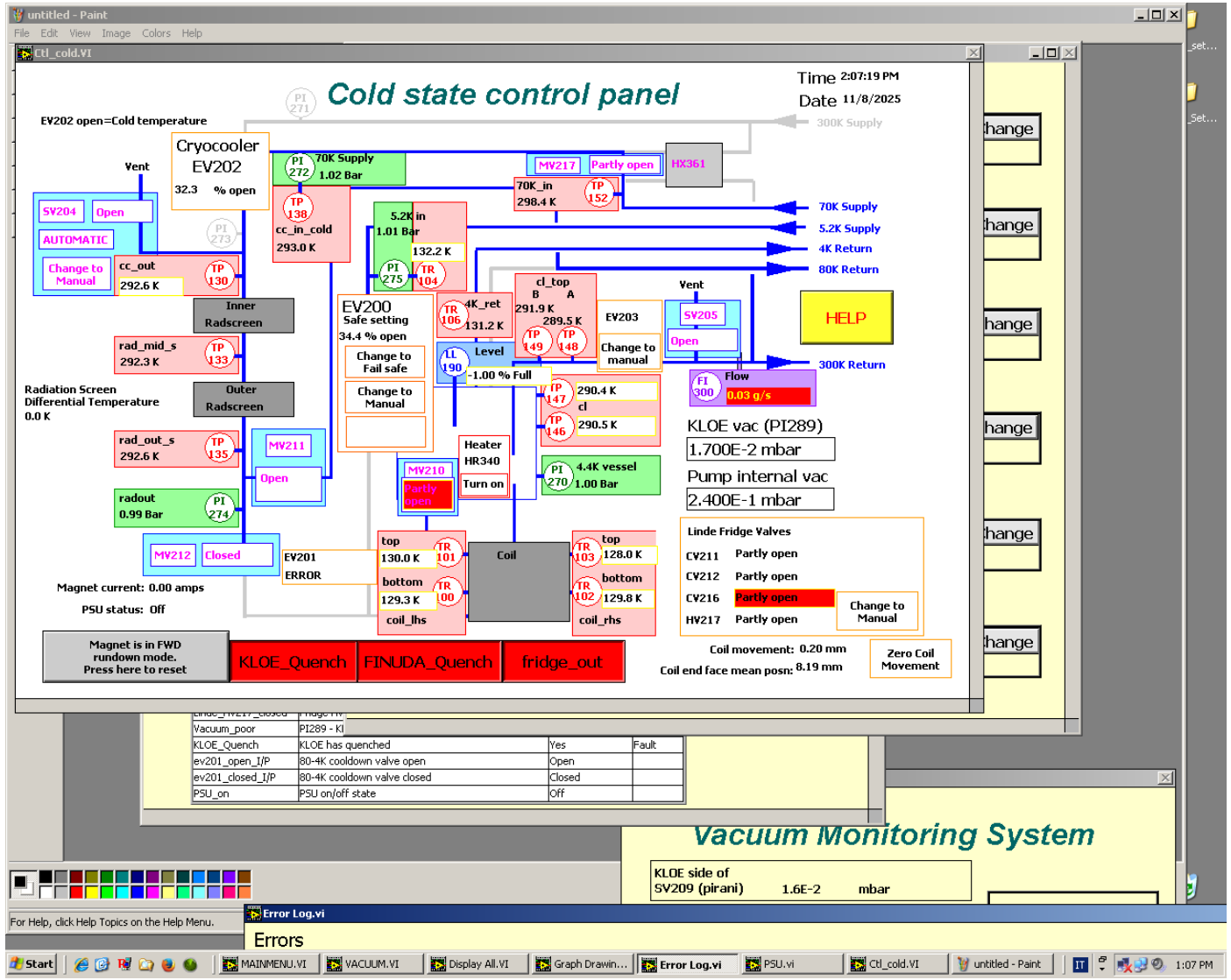
KLOE Magnet Status

Control System

- The actuators of Valves EV 200 and EV 201 have been re-assembled
- The power and signal interfaces have been reconnected

KLOE Magnet Status

Control System



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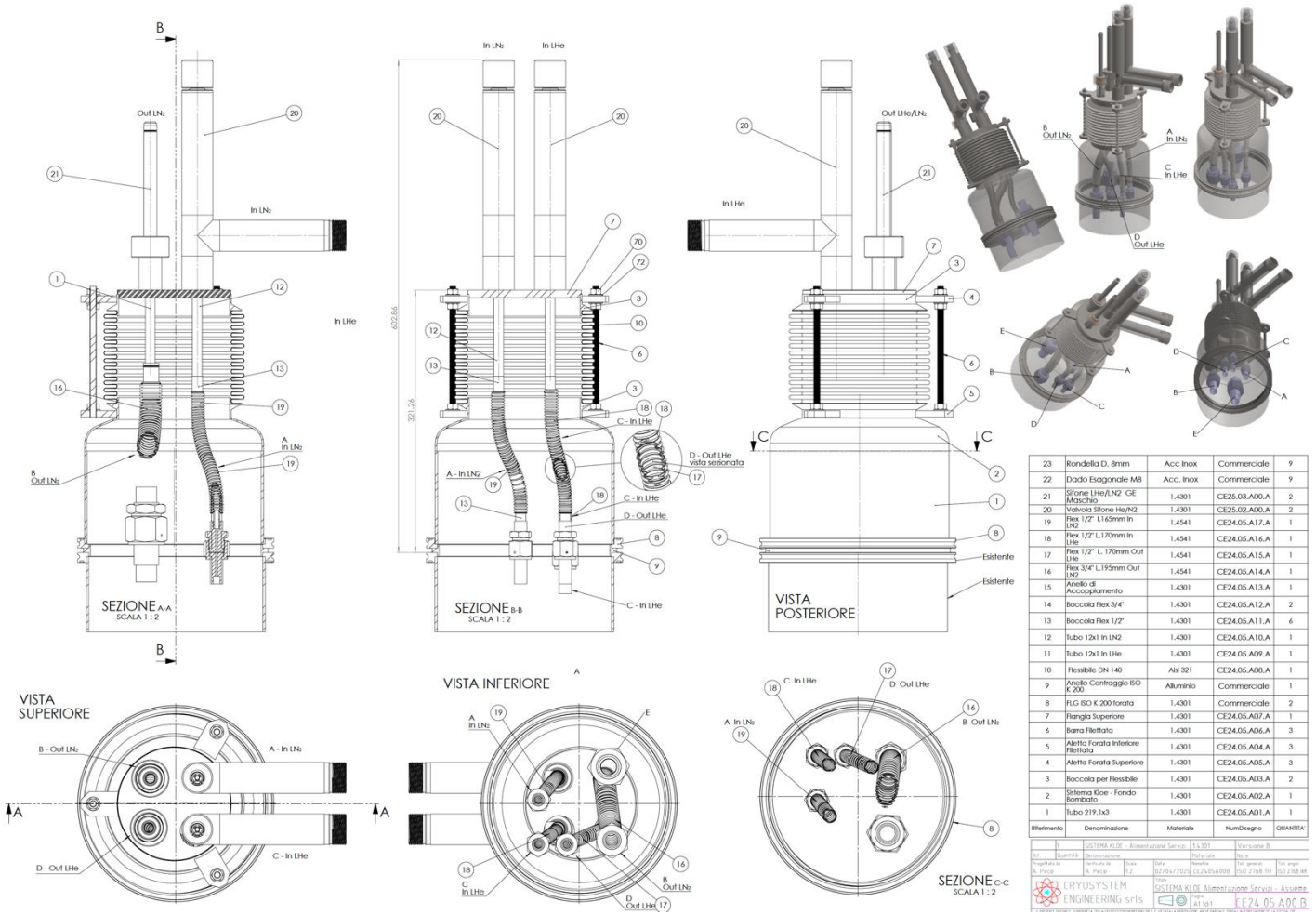
KLOE Magnet Status

Cryogenic interface

- Under construction.

  Delivering date

  Nov. 30th



23	Rondella D. 8mm	Acc Inox	Commerciale	9
22	Dado Esagonale M8	Acc. Inox	Commerciale	9
21	Sifone LHe/LN2 GE Maschio	1.4301	CE25.03.A00.A	2
20	Valvola Sifone He/N2	1.4301	CE25.02.A00.A	2
19	Flex 1/2" L.165mm In LN2	1.4541	CE24.05.A17.A	1
18	Flex 1/2" L.170mm In LHe	1.4541	CE24.05.A16.A	1
17	Flex 1/2" L. 170mm Out LHe	1.4541	CE24.05.A15.A	1
16	Flex 3/4" L.195mm Out LN2	1.4541	CE24.05.A14.A	1
15	Anello di Accoppiamento	1.4301	CE24.05.A13.A	1
14	Boccola Flex 3/4"	1.4301	CE24.05.A12.A	2
13	Boccola Flex 1/2"	1.4301	CE24.05.A11.A	6
12	Tubo 12x1 In LN2	1.4301	CE24.05.A10.A	1
11	Tubo 12x1 In LHe	1.4301	CE24.05.A09.A	1
10	Flessibile DN 140	Alsi 321	CE24.05.A08.A	1
9	Anello Centraggio ISO K 200	Alluminio	Commerciale	1
8	FLG ISO K 200 forata	1.4301	Commerciale	2
7	Flangia Superiore	1.4301	CE24.05.A07.A	1
6	Barra Filettata	1.4301	CE24.05.A06.A	3
5	Aletta Forata Inferiore Filettata	1.4301	CE24.05.A04.A	3
4	Aletta Forata Superiore	1.4301	CE24.05.A05.A	3
3	Boccola per Flessibile	1.4301	CE24.05.A03.A	2
2	Sistema Kloe - Fondo Bombato	1.4301	CE24.05.A02.A	1
1	Tubo 219.1x3	1.4301	CE24.05.A01.A	1
Riferimento	Denominazione	Materiale	NumDisegno	QUANTITA'

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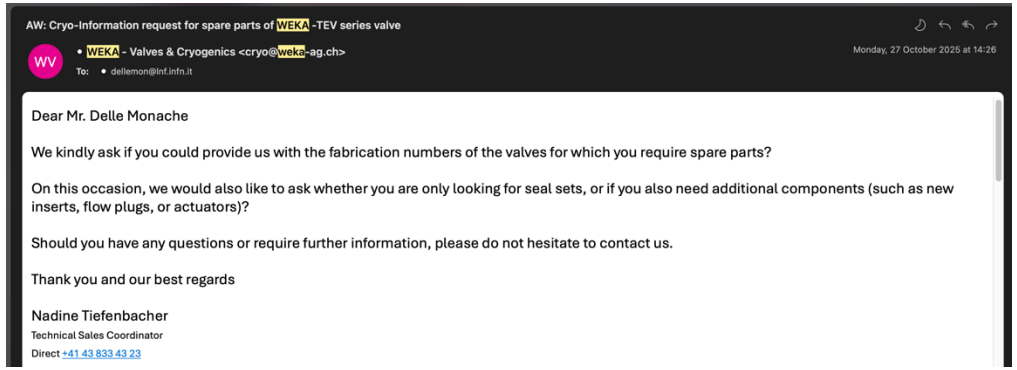
Crio valves maintenance

Spare parts (under procurement)

- Seal
- Insert (?)
- Flow Plug (?)



AW: Cryo-Information request for spare parts of WEKA -TEV series valve

WV • WEKA - Valves & Cryogenics <cryo@weka-ag.ch> Monday, 27 October 2025 at 14:26

To: • dellemon@lnf.infn.it

Dear Mr. Delle Monache

We kindly ask if you could provide us with the fabrication numbers of the valves for which you require spare parts?

On this occasion, we would also like to ask whether you are only looking for seal sets, or if you also need additional components (such as new inserts, flow plugs, or actuators)?

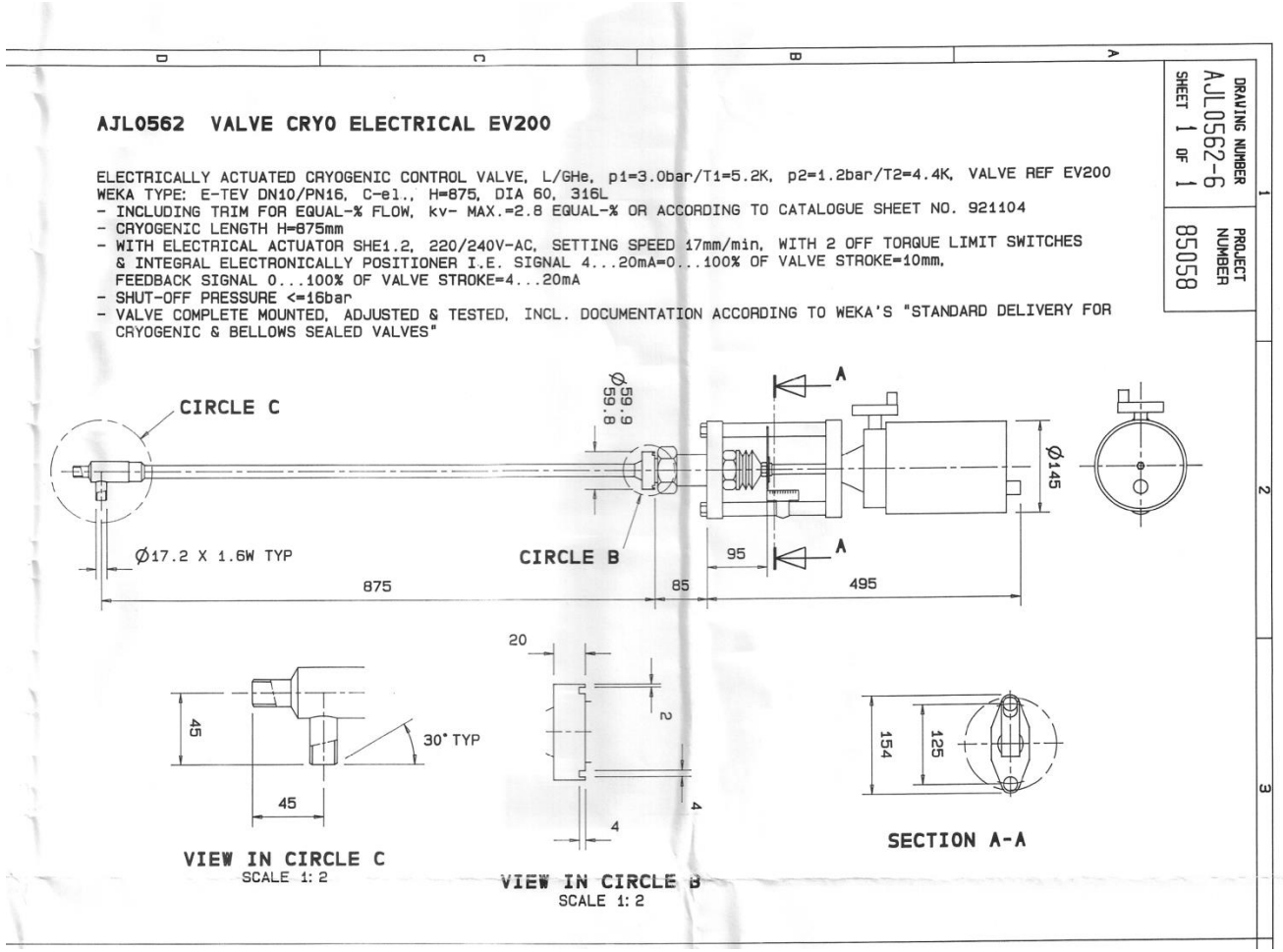
Should you have any questions or require further information, please do not hesitate to contact us.

Thank you and our best regards

Nadine Tiefenbacher

Technical Sales Coordinator

Direct +41 43 833 43 23



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Procurement

PO for most part of the HW and services for the cold test has been emitted to the suppliers, in details:

- All the cryo components connecting the LN2 and LHe lines to the magnet turret + exhaust He and N2 lines
- 36.000 liters of LN2 + 4/6 weeks of renting LN2 mobile thank + manufacturing of evaporator to control the LN2 T inlet to the magnet
- Interface for the connection of the DAFNE compensator TL to the mobile thank + its redeployment
- LHe awarding contract within 2025.

KLOE Magnet Compliance

- KLOE is provided with 150 liters of LHe reservoir aimed to limit its temperature below 20 K in case of a quench, so it must comply FNAL internal regulation for pressure equipment.
- In the past, the safety protocol and methodology described in Fermilab ESH Manual allowed Fermilab Director to accept pressure equipment as “exceptional” after the production of an Extended Engineering Note in case of non compliaces.
- Recently DOE is reconsidering the methodology for operating FNAL equipment built in periods where ASME and PED code did not require data recording of production processes (e.g. design calcs per ASME, FEA, verification of thicknesses, radiography, additional pressure testing, etc.), so it most likely that **FFT “Fitness For Service”** methodology will be applied

FFS ASSESMENT(FNAL Project No. 721261)

Purpose:

- To assess the fitness-for-service (**FFS**) of the KLOE pressure equipment for construction and post-construction.

Conclusions:

1. Construction Conclusion (as per Codes of Fedeal Regulation)

DOE 10CFR851 “Worker Safety and Health Program” Appendix A.4 “Pressure Safety” requires the construction (materials, design, fabrication) of pressure vessels and piping comply with appropriate ASME standards. In the case of the KLOE pressure equipment (vessels and piping) the construction was performed in Europe and the construction records (materials, design, fabrication) are incomplete. Therefore, the pressure equipment construction cannot be demonstrated to be compliant with DOE 10CFR851. Eleven construction verification compensatory measures are recommended, numbered ☆C1 / ☆C11.

2. Post-construction Conclusion (as per Codes of Fedeal Regulation)

FFS is the assessment of the integrity of the pressure boundary (i.e., prevention of leak or rupture of the pressure boundary) for the remaining service life beyond construction. The FFS assessment consists of Periodic inspection and tests, assessment of damage identified during the inspections and repairs according with proper ASME standards. The KLOE pressure boundary is classified as Medium Risk in Section 5. Five periodic inspection measures are recommended, numbered ☆F1 / ☆F5.

KLOE Magnet FFS

Compensatory measure	Owner/Note
C1 – performing PMI on the SS He vessel, SS piping, AL piping, SS inner and outer vacuum cases. This will determine specific grades of steel or aluminum used for construction. This information will then get crossed checked against the drawings and specifications. If SS grades are of low carbon "L", then there will be no need to UT check for evidence of intergranular attacks (measure C2).	CND Control (after the test)
C2 – if needed, perform UT check for evidence of intergranular attacks for welds in non-type-L SS material.	CND Control (after the test)
C3 – prepare (as much detailed as possible) isometric drawings for piping anchored to the inlet and outlets of the cooling channels and analyze for max thermal contraction and compliance with B31.3 or EN13480 requirements.	FNAL?
C4 - determine the rate of cool-down and warm-up and predict the number of thermal cycles from past plus a conservative projection of future opera on. By heat transfer determine the maximum temperature gradient through the wall, from there estimate the through-wall stress and perform a fatigue check for cracking caused by through-wall temperature gradients.	LNF/FNAL
C5 - Estimate the potential for pressure transient up to relief valve set point. If a dynamic pressure rise is credible, apply a dynamic load factor to the pressure rise, and check the stresses in the pipe caused by the total pressure against B31.3 stress limit for occasional loads caused by a pressure surge to relief valve set point.	FNAL? (see KLOE commissioning-acceptance test.pdf for pressure transient up)
C6 – Verify the connection points, sizing, settings of the pressure reliefs and verify that they are adequately set and sized as required by applicable US Codes and Standards, e.g. e.g. ASME B31.3, ASME VIII Div.1, API 520 and CGA S-1.3.	FNAL?

KLOE Magnet FFS

Compensatory measure	Owner/Note
C7 - Perform radiographic examinations (RT) o r ultrasonic (shear w ave U T) o f t he f ollowing welds: 3 random accessible welds in the SS pipe; 3 random accessible welds in the AL pipe; all accessible bi-metallic SS-AL welds; 3 random accessible locations on the inner and the outer vacuum cases; 3 random accessible locations on the He vessel. Use instructions and requirements per ASME (BPVC Section V and B31.3) or PED (EN13445 and EN13480). If the criteria of ASME B31.3 Chapter VI Para.340 applied, do not permit any incomplete penetration (where B31.3 would permit some) as they may indicate poor argon or helium purging of the first pass of the SS welds and even AL welds.	CND Control (after the test)
C8 – perform a pressure test for each pipe segment using 1.1 x design pressure. This is accomplished by test 1 (see above) or by the test done after cooldown & warmup if any welds require repairs.	Cryosystem
C9 – perform a pressure test for helium vessel using 1.1 x design pressure. This is accomplished by test 1 (see above) or by the test done after cooldown & warmup if any welds require repairs.	Cryosystem
C10 – perform a sensitive leak test for all pressure piping circuits and helium vessel. This is accomplished by test 1 (see above) or by the test done after cooldown & warmup or if any welds require repairs.	Cryosystem
C11 - If the PMI results under C1 are satisfactory (confirming the SS and AL alloys), no need for tensile testing. If the PMI results are not satisfactory, the root cause and extent of the material issue needs to be established, and remediation actions implemented accordingly.	TBD

KLOE Magnet FFS

Periodic inspection	Owner/Notse
F1 - At the first outage, when the He vessel is accessible and at ambient temperature, the same welds as were examined in Section 7.4, should be re-examined using the same technique. Once the results of in-service inspections (NDE) are obtained, they shall be evaluated in accordance with the API 579-1/ASME FFS-1 "Fitness-for-Service" standard.	C1-C2 can be performed only after test at LNF (at the first outage) • Welds examination CND Control • Results evaluation FNAL
F2 - When the He vessel is accessible and at ambient temperature, the same welds as were examined in Section 7.4, should be re-examined using the same RT technique.	C1- C2 can be performed only after test at LNF (at the first outage) • Welds examination CND Control • Results evaluation FNAL
F3 - Periodically perform a sensitive leak test, such as He leak test in accordance with ASME Boiler and Pressure Vessel Code Section V Part 10. The periodicity to be established by Fermi Lab depending on the accessibility of the pipes and vessel for leak testing.	FNAL
F4 - Leak tightness and operability of valves should be tested periodically at a scheduled established by Fermi Lab.	FNAL
F5 - Safety relief valves should be tested or replaced periodically as recommended by the valve manufacturer.	FNAL

THANKS

QUESTIONS?

SPARES

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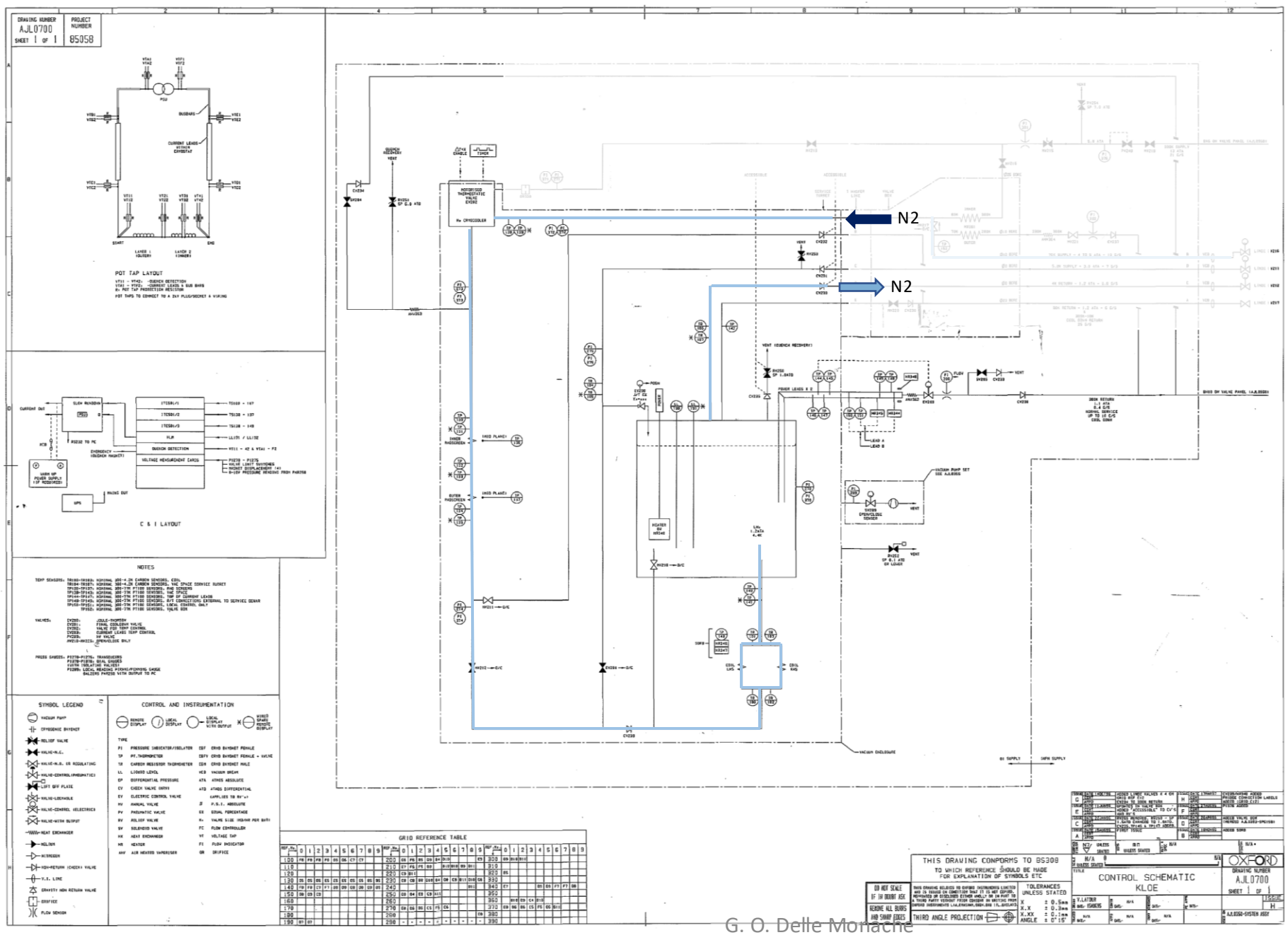
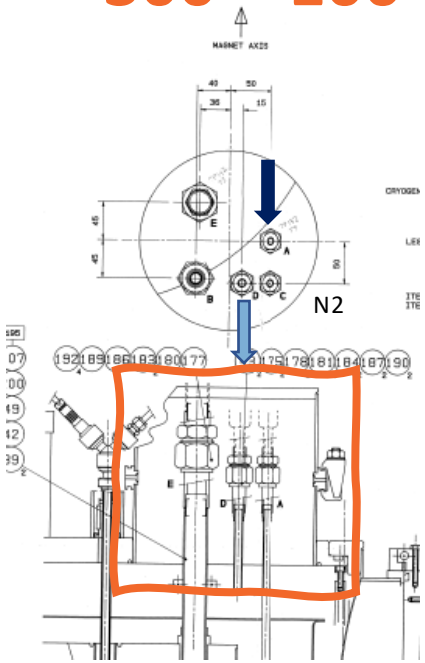
Cool Down 300 – 100 K





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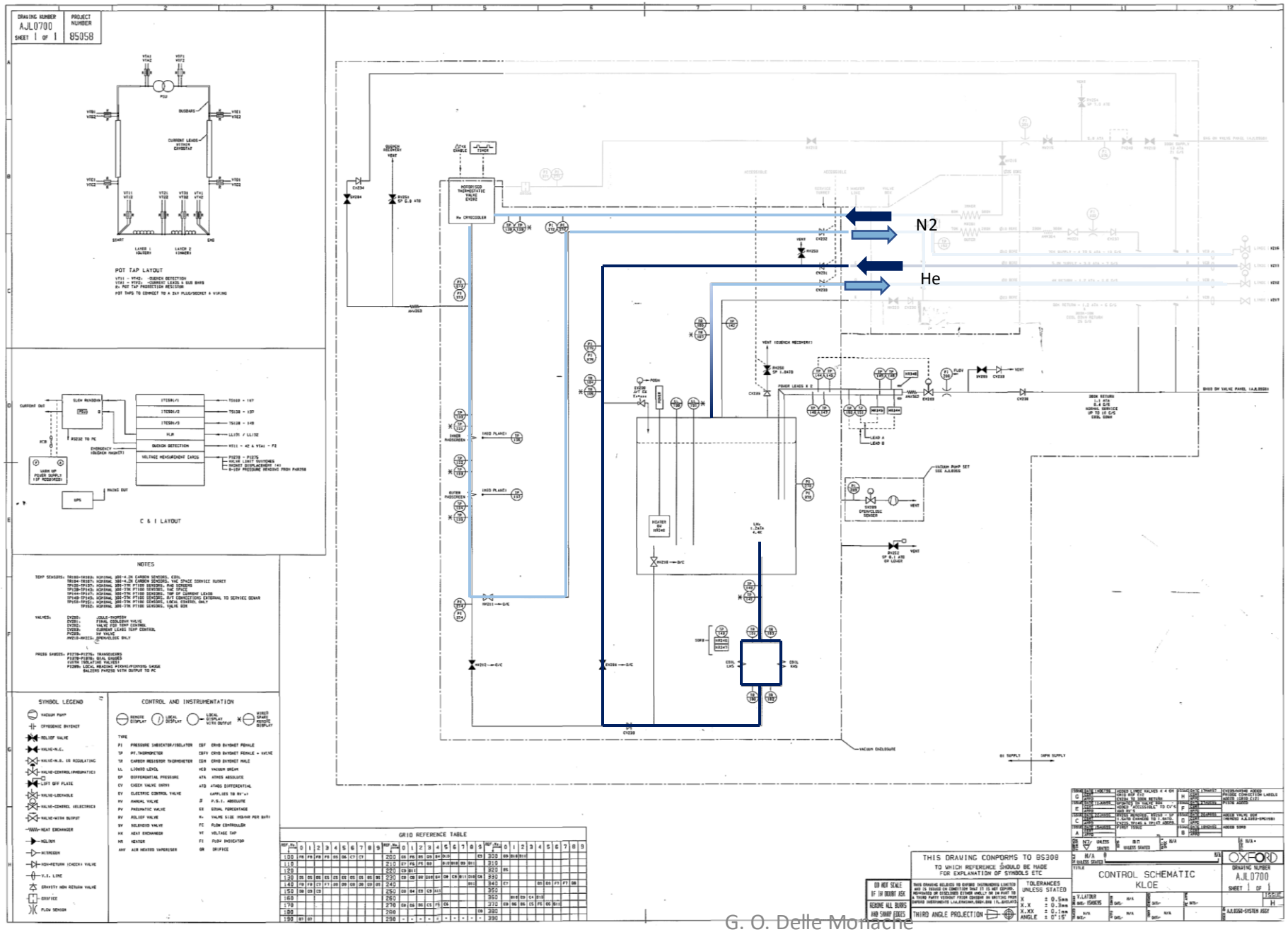
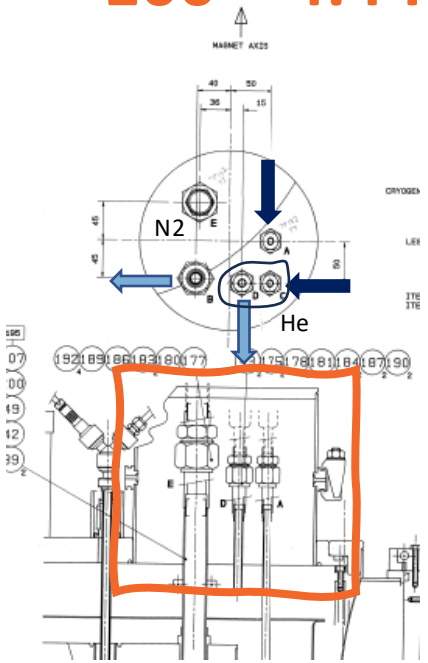
Cool Down
100 – 4.4 K





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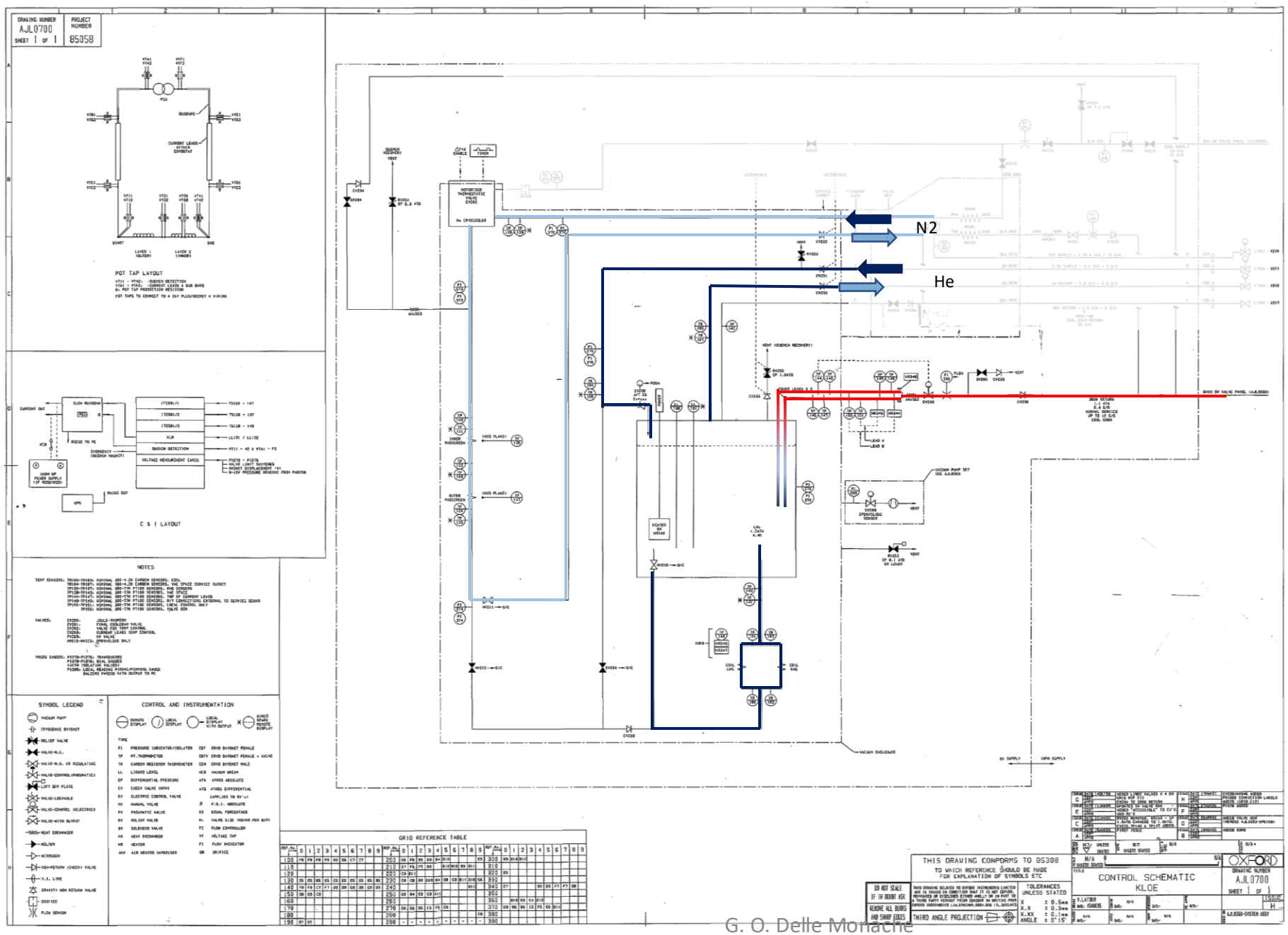
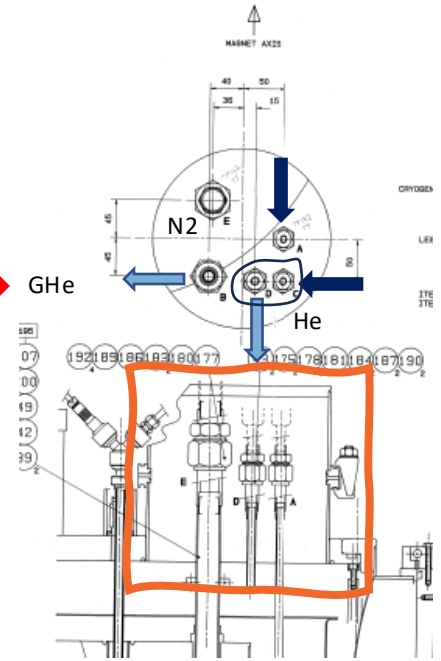
Magnet @ 4.4 K





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KLOE Magnet handling: Service Turret Removal

After the tests before the shipment FNAL the service turret must be removed because of the interference with the hall door. The reverse process has been performed by OI in 1997 at magnet delivery. The main operations can be summarized as in the following:

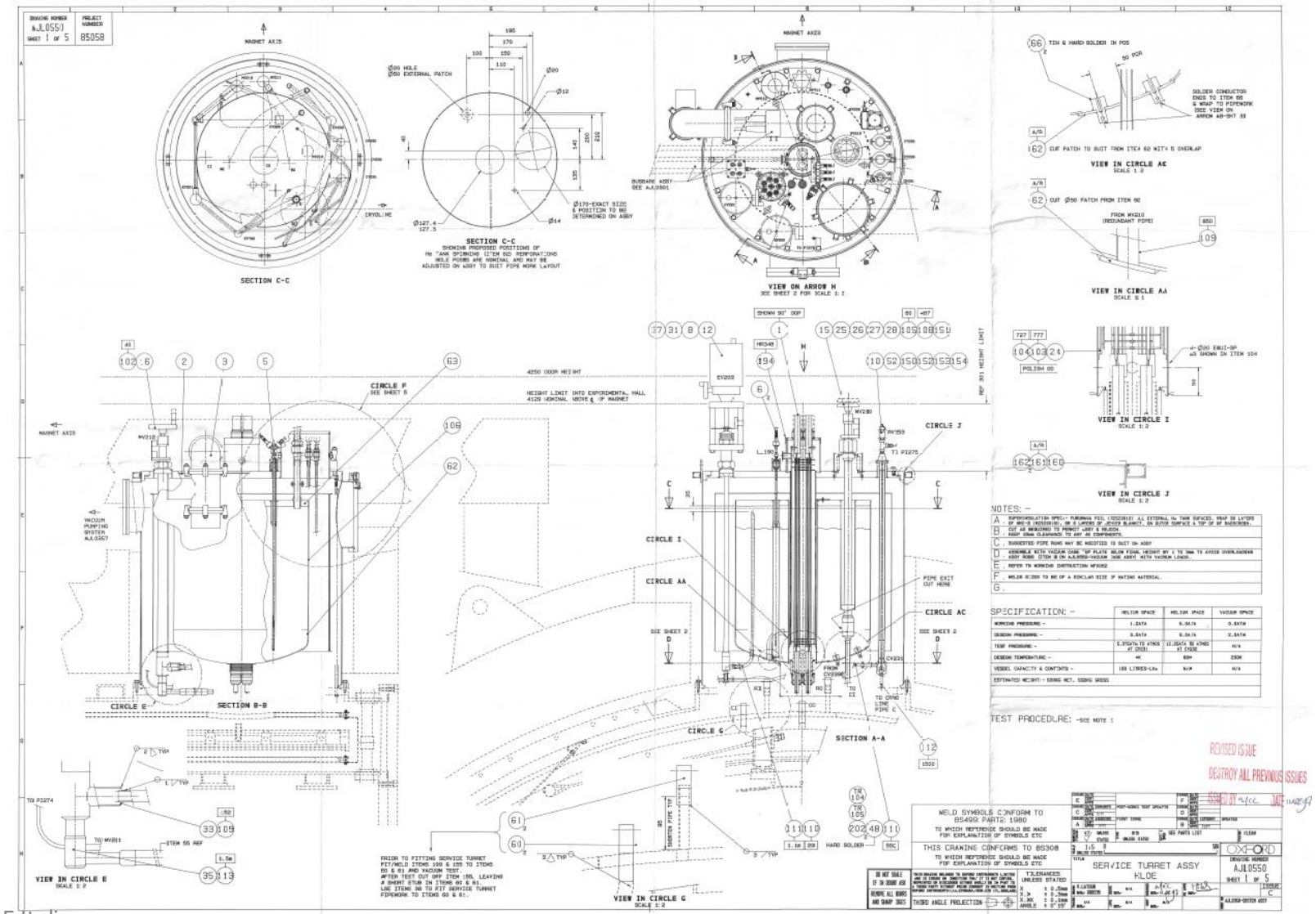
1. Disconnection of the signal sensors cable (air side)
2. Removing of the cylindrical shell of the vacuum case
3. Removing of the MLI
4. Disconnection of the signal sensors cable (vacuum side)
5. Disconnection of the coil terminals
6. Cutting of the 4 cryogenic lines

KLOE Magnet handling: Service Turret Removal

The turret will be reconnected at FNAL and the procedure (to be used in the reverse sequence for the turret removal) is described in the drawing from Oxford Instrument AJL0550 "Service Turret Assy KLOE sheet 1 to 5.

Working Instructions (OI internal procedures) obviously are not available, for this reason due to the nature of this operation INFN will award a contract to ASG Superconductors to perform the entire process of removal and reconnection at FNAL of the service turret.

KLOE Magnet handling: Service Turret Removal



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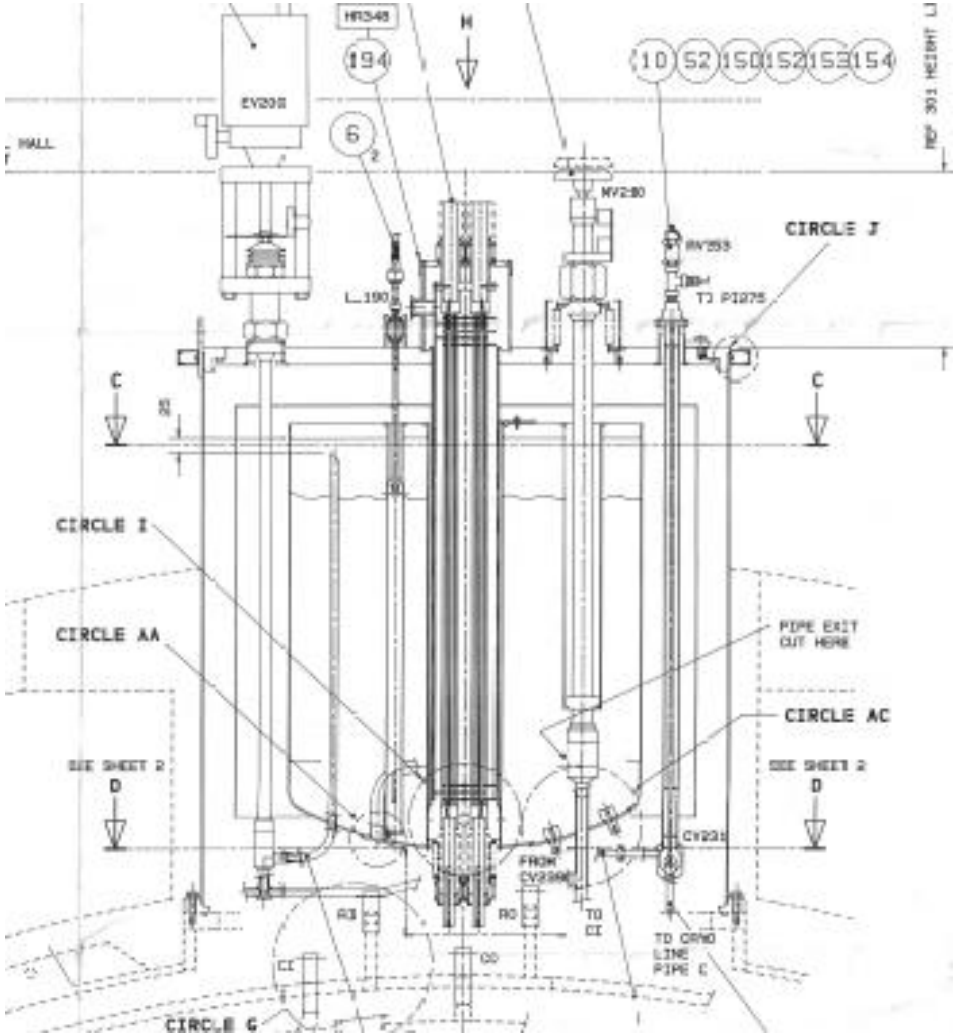
KLOE Magnet handling: Service Turret Removal



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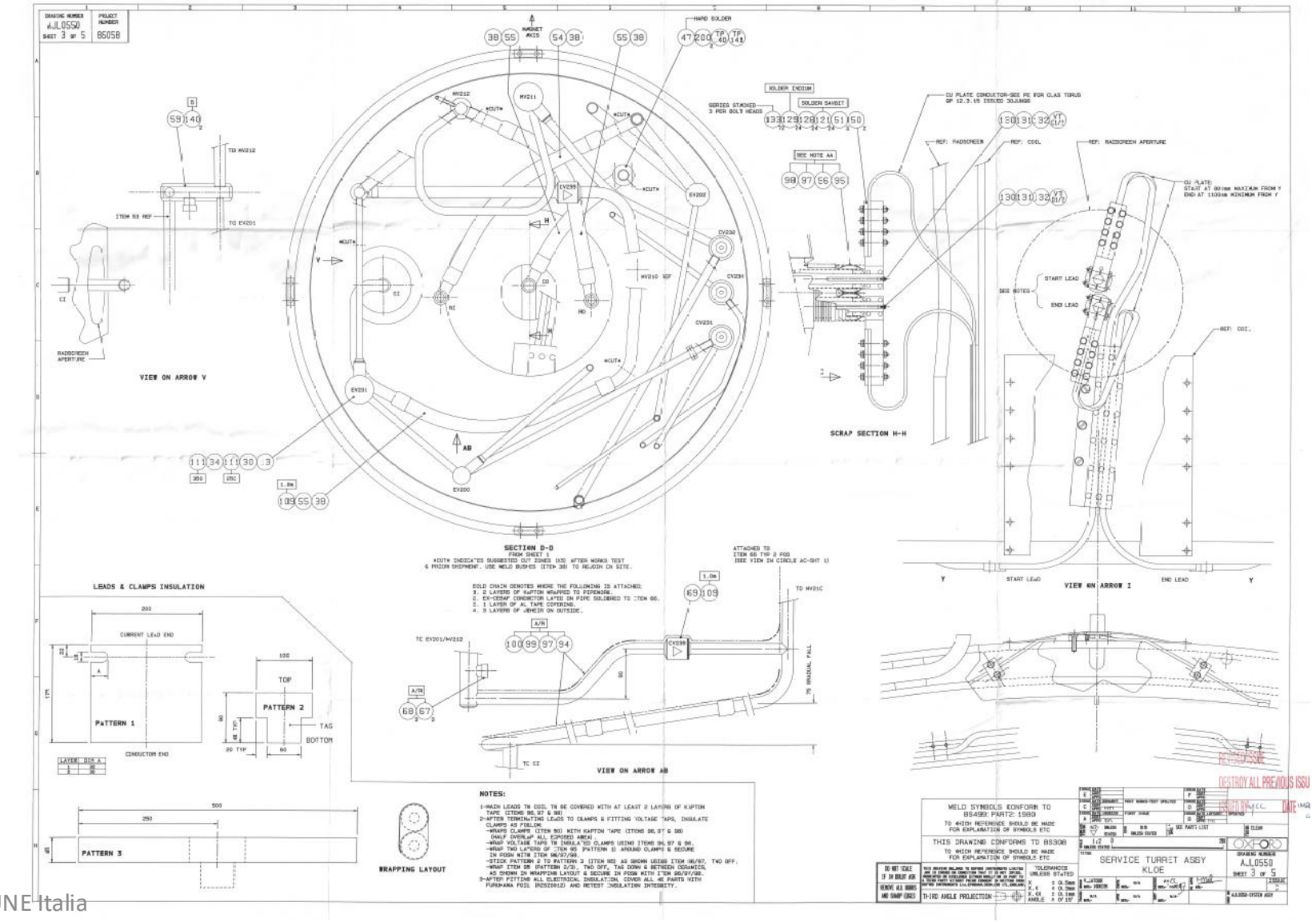
KLOE Magnet handling: Service Turret Removal



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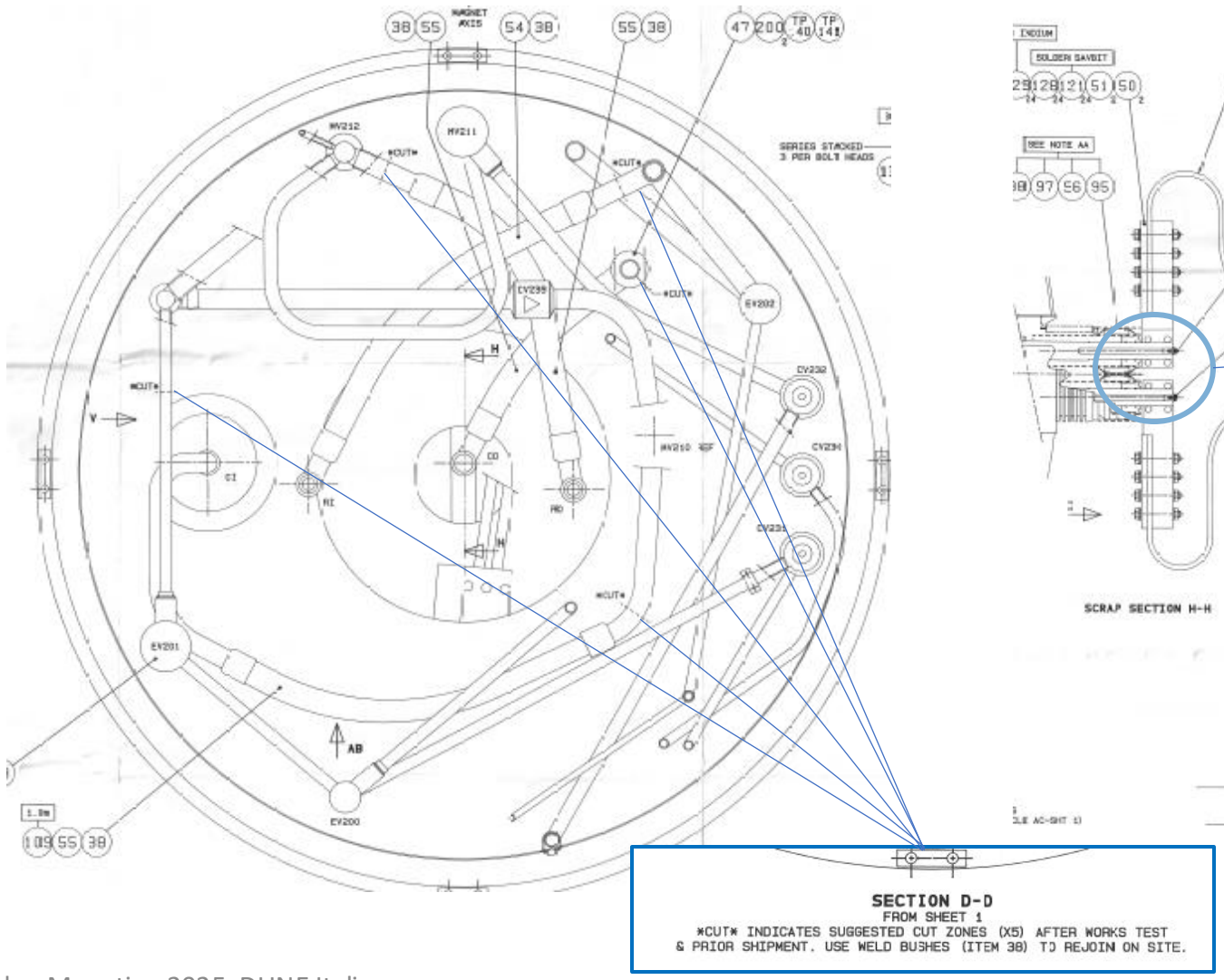
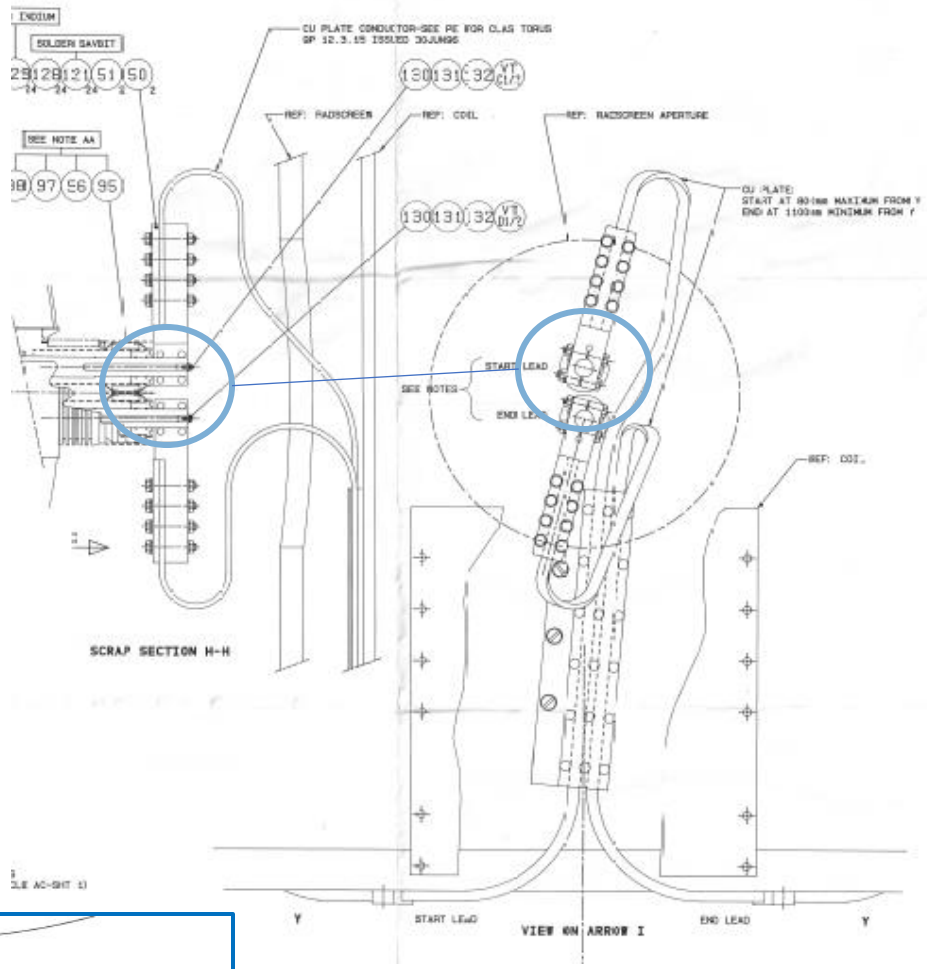
KLOE Magnet handling: Service Turret Removal





SECTION D-D
FROM SHEET 1
CUT INDICATES SUGGESTED CUT ZONES (X5) AFTER WORKS TEST
& PRIOR SHIPMENT. USE WELD BUSHES (ITEM 38) TO REJOIN ON SITE.

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DAFNE Cryo Plant Linde TCF 50

LINDE KRYOTECHNIK AG

2. PLANT & PROCESS DESCRIPTION

2.1. Plant performance

2.1.1 Normal operation mode

The total performance supplied to the 6 magnets is:

Liquefaction rate:	1.14	g/s
Refrigeration capacity at 4.45 K, 1.22 bar	99	W
Shield cooling capacity below 80 K	800	W

2.1.2 Refilling the compensator magnets

The four compensator magnets are refilled periodically with a fixed time interval of 24 hours, all 6 hours an other magnet. The quantity of liquid helium which is used to cool down the transfer line and to fill the compensators is produced continuously and stored in the phase separator of the refrigerator. This quantity is included in the liquefaction rate above.

2.1.3 Cool down of the refrigerator

The time to establish liquid Helium level from turbine start will be 3 hours (or less), with LN2.

2.1.4 Cool down mode for Kloe

During this operating mode the refrigerator is supplied with LN2. Finuda is out of operation, but it is kept cold. The compensators are not refilled. The total cool down time takes less than 10 days.

Capacity available for Finuda:		
Liquefaction rate:	0.2	g/s
Refrigeration at 4.45,1.22 bar	44	W
Shield cooling capacity below 80 K	270	W

Capacity for Kloe while warmer than 80 K.

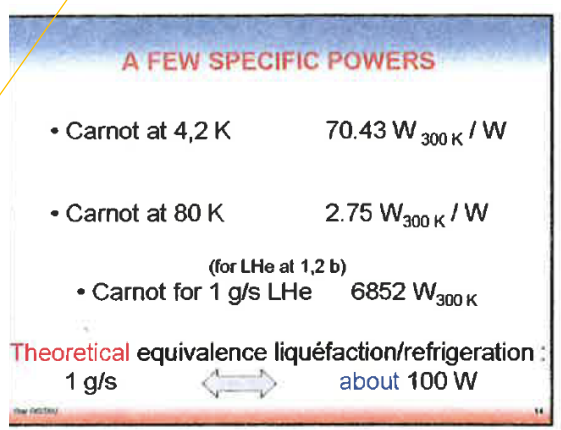
Cold gas (3bar,4.5 K)	4.6	g/s
Shield cooling capacity below 80 K	530	W

2.1.5 Cool down mode for Finuda

During this operating mode the refrigerator is supplied with LN2. Kloe is out of operation, but it is kept cold. The compensators are not refilled. The total cool down time takes less than 10 days.

Capacity available for Kloe:		
Liquefaction rate:	0.3	g/s
Refrigeration at 4.45,1.22 bar	55	W
Shield cooling capacity below 80 K	530	W

Source	Nominal HL (guarantee)	Measured HL @ 1000 A
Current Leads	0.6 g/s	0.12 g/s
coil	55 W	27.6 W
Radiation screen	530 W	62.6 W



Guy Gistau Bauger

Istituto Nazionale di Fisica Nucleare

Cryo plant Linde LR 140 vs TCF 50

Linde Kryotechnik AG

5 INDICATIVE PRICE

132 kW

Main Scope

Pos No	Description	Price
1.	LR140 Helium Refrigeration System including scope of supply as per item 3	EUR 6.5 Mio
2.	Technical assistance during Instal Practical instructions – Including travel, overnight allowances	

Note:

[1] May be subject of separate order.

The prices referred to herein include delivery standard packing for sea transport. The prices not include any Value Added Tax (VAT), sales Any additional taxes and/or duties have to be b

If any taxes/duties become applicable, then th submission of documentary proof by the Selle USA as well as any Tax Deducted at Source (T

The prices are indicative prices and an estimate factors change, we reserve the right to adjust t based on Seller's standard Terms & Conditions or contract conditions are excluded.

Linde Kryotechnik AG

2 REFRIGERATION CAPACITY

The following refrigeration capacities can be provided with the proposed LR140, without LN2 pre-cooling:

Expected Performance Data [1,2,3]	Cooling Power	Pressure supply-return	Temperature supply-return	Mass Flow
	W	bar(a)	K	g/s
Refrigeration at 4.5K [4]	55	3.0 – 1.2	4.45 – 4.45	(4.5)
Shield capacity at 70K	530	5.0 – 1.2	40 – 80	(3.3)
Liquefaction LHe [5]	-	1.25 – 1.05	4.45 – 300	0.73

Notes:

[1] Cooling water supply < 21°C; He gas temperature at Coldbox inlet < 303K

[2] for pure, dry He gas (99.999%)

[3] Expected refrigeration/liquefaction rates, measured in the distribution/test box with the installed equipment.

[4] Pressure in phase separator

[5] Return purity to compressor inlet >99.999%

LINDE KRYOTECHNIK AG

250 kW

The price break down below is indicative only and shall not be used for separated line item procurement: [2]

		with recovery system		without recovery system
Refrigeration System	CHF	1'234'000.--	CHF	1'234'000.--
Cryogenic Distribution System	CHF	831'000.--	CHF	831'000.--
Recovery System	CHF	509'000.--	CHF	--.--
Process control system	CHF	176'000.--	CHF	166'000.--
Installation and Start Up	CHF	316'000.--	CHF	306'000.--
Acceptance tests without and with magnets	CHF	363'000.--	CHF	343'000.--
Total	CHF	3'429'000.--	CHF	2'870'000.--

According to INFN's request, Linde Kryotechnik AG is ready to grant on the above mentioned prices a maximum discount of 3 (three) %, arriving to the following net final totals:

Price for the system and services with recovery system	CHF	3'326'000.--
Price for the system and services without recovery system	CHF	2'783'000.--

3.850.000.000 di Lire in 1995

for a double power plant

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Cryo plant Linde LR 140