PROCEDURE	OBJET
AOO_21.2026	ACQUISITION DE REFRIGERATEURS A DILUTION

Pulse-Tube Dilution Refrigerator

Procurement Specification /

Cahier des Clauses Techniques Particulières

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1. APPLICABLE AND REFERENCE DOCUMENTS

N°	Reference	Title	Issue
RD1	D1505-CM-1	Compliance Matrix	1

2. ACRONYMS AND ABBREVIATIONS

DR	Dilution Refrigerator
LoS	Line of Sight
MXC	Mixing chamber
NA	Not Applicable
PSE	“Prestations Supplémentaires Eventuelles” (= Options)
MA	Mandatory requirement
EV	Evaluation requirement

3. INTRODUCTION / PURPOSE OF THE DOCUMENT

Institut Néel QuNES group is enquiring for a dilution unit as standard as possible, this means optimised cost, and with a short delivery time.

The technical requirements for this apparatus are listed in the next sections of the document. A summary of these requirements can be found in the compliance matrix.

Req. 3.1: The supplier shall fill the compliance matrix with as much detail as possible in order for the customer to undergo a fair and documented comparison between the different technical proposals.

Req. 3.2: The compliance matrix shall include details on the way the performances are guaranteed by the supplier. The validation of the performances is preferably performed by tests. Validation by design, by calculation or by analogy can also be envisaged.

Note: In the following sections and in the compliance matrix, we give, for each requirement:

- The reference number (**Ref.**)
- The **designation**
- The **requirement**, which corresponds to the requirement the system shall provide. Deviations may or may not be accepted, depending on the criterion parameter (see below). If accepted, such deviations will have an impact on the evaluation of the associated requirement.
- The criterion (**Crit.**) applicable on the requirement (see above):
  - **MA. Mandatory**
  - **EV. Evaluated**

The criterion (**Crit.**) is specified for each requirement and will be used in the evaluation of the proposals. “MA” denotes a **mandatory requirement** (failure to meet it is a **killing factor**, and the proposal can no longer be considered), while “EV” denotes an **evaluation criterion** that will be assigned a weighting factor when assessing the proposal.

4. DR PERFORMANCE REQUIREMENTS

The dilution refrigerator must be designed to host a superconducting solenoid as described in the mandatory option §14.2 and §14.3. The required performances of the dilution refrigerator are detailed in the table below:

Ref	Designation	Required value	Crit.	Comment
4.1	Minimum temperature with wiring described in section 11 mounted.	≤ 10 mK	**MA**	As measured on the MXC plate and with compressor bypassed.
4.2	Minimum temperature with the maximum current (~100Amps) in the magnet current leads	≤ 10 mK	**MA**	As measured on the MXC plate and with compressor bypassed.
4.3	Cooling power at 20mK	≥ 12 µW	**MA**	For the same flowrate as above. Higher values (at higher flowrate) can be documented (e.g. associated Tmin).
4.4	Cooling power at 100mK	≥ 350 µW	**MA**	With no impact on Tmin perf. Combined with current leads at max. current.
4.5	Available cooling power at 4K stage	≥ 2 W	EV	
4.6	Leaktightness at DR level (mixture inlet and outlet lines)	$< 10^{-8}$ mb.l/s	EV	
4.7	No indium seal used except for the DR unit mixture circuit		**MA**	
4.8	Cooling time from 300K to base temperature with 14T magnet (without bottom loading mechanism)	≤ 45 hours	EV	
4.9	Galvanic isolation from the GHS and the pulse tube compressor	Complete ground isolation between the DR and the GHS, and between the DR and the pulse tube compressor (isolation resistance >1GOhm)	**MA**	Use Swagelok or equivalent electrical isolator for the condensing lines and standard Teflon/plastic centring rings with plastic clamps for the still line.
4.10	Fastening of the fridge	All thermal screens, except those at 4 kelvin and below, as well as the OVC should be installed with their screw heads facing downward to facilitate fastening.	EV	

5. PULSE TUBE COOLER / VIBRATION DAMPING

The Pulse Tube cooler shall be adapted to fulfil the above requirements.

Req. 5.1 (EV): As our laboratory is equipped with maintenance tools and auxiliary equipment (connectors, flexible lines, etc) for Cryomech type cryocoolers, a Cryomech type of cryocooler or equivalent shall be preferred. Model PT425-RM or equivalent would be recommended.

Req. 5.2 (EV): The cryocooler should be able to operate in a power-saving mode during circulation. **This requirement is an ecological criterium**.

6. GAS HANDLING SYSTEM

Specific requirements for the Gas Handling System (GHS) are:

Ref.	Designation	Required value	Crit.	Comment
6.1	No membrane compressor running in circulation mode (steady state), even with maximum current (100Amps) in the current leads	Membrane compressor bypassed during normal operation	**MA**	If membrane compressor is present for condensation, it must be equipped with a bypass circuit
6.2	Mixture contamination - molecular	Oil free pumps / compressors	**MA**	
6.3	Mixture contamination - molecular	As a minimum: LN2 trap with a LN2 tank	**MA**	Other standard means (e.g. charcoal trap), if any, shall be detailed
6.4	Pumping system of the DR outer vacuum can	Oil free pumps including a turbomolecular pump. Controlled via the GHS	**MA**	
6.5	Safety	The GHS, together with monitoring system, shall ensure automatic recovery of the mixture in case of trouble	**MA**	List of potential issues to be detailed and way they are handled, e.g. : - Power shut down - Inlet line clogging - Air into vacuum jacket - etc
6.6	Dimension	The height must be ≤ 170 cm. Otherwise, the GHS must be designed so that it can be tilted onto its side.	**MA**	Lowest height in the basement corridor is 171 cm due to utilities pipe
6.7	Automatization and manual control	The GHS must include both a manual panel to control all valves and software interface for remote control	**MA**	

6.8	Automatized valves	All valves necessary to operate the DR in normal operation must be controlled and interfaced by the GHS, except the mixture dump security valve and the overpressure safety valve for returning mixture in the dump.	EV	Provide the schematics of the GHS.
6.9	Circulation pump	The circulation pump shall require no maintenance for a period of 5 years.	EV	

7. ^{3}HE - MIXTURE

Req. 7.1 (MA) CNRS has some stock of ^{3}He in house. The system must be delivered without mixture or ^{3}He. It can be delivered either empty of helium or with the correct amount of ^{4}He in the dump of the GHS but without ^{3}He. ^{3}He (and ^{4}He, if empty) will be added to the GHS to adjust the ^{3}He/^{4}He mixture at CNRS during installation.

8. MONITORING SYSTEM

The monitoring system main requirements are:

Req. 8.1 (**MA**): Elapsed time for each of the components requiring maintenance (Pulse tube cooler, pumps, compressor, etc) shall be recorded and easily accessible.

Req. 8.2 (EV): The system shall provide automatic cool down of the DR from room temperature to Tmin.

Req. 8.3 (EV): The system shall provide automatic warm up procedure, including mixture recovery.

Req. 8.4 (EV)**:** The DR shall be equipped with a pressure gauge so as to control the vacuum jacket. The type of gauge shall be indicated.

9. TEMPERATURE MEASUREMENT

The system shall include a temperature controller. The temperature control main requirements are:

Req. 9.1 (MA): The system shall comprise at least one thermometer at the following levels: MXC, cold plate, still plate, 4K plate, and 60K plate.

Req. 9.2 (MA): All thermometers shall be calibrated.

Req. 9.3 (MA): The temperature controller must be able to monitor a temperature as low as 10mK.

Req. 9.4 (MA): The system shall comprise at least 1 heater at MXC level and 1 heater at still plate.

Req. 9.5 (EV): The system shall comprise an extra temperature measurement wiring (2 twisted pairs) down to the baseplate to enable the user to install and monitor its own thermometer. This thermometer wiring must be connected and monitored by the temperature controller provided by the supplier. The type of connector at baseplate level will be determined in the early phase of the project.

Req. 9.6 (EV): The system shall comprise wiring (1 twisted pairs) down to the baseplate to enable the user to connect an extra heater on the sample holder. This wiring must be connected and the user heater should be controllable by the temperature controller provided by the supplier. The type of connector at baseplate level will be determined in the early phase of the project.

10. INTERFACE REQUIREMENTS

10.1 IMPLEMENTATION IN THE EXPERIMENTAL ROOM

Two months after purchase order reception, the supplier shall provide an implementation drawing of the system in the experimental room. Drawings of the available space and constraints of the experimental room will be transmitted to the supplier **within one month after the start of the project**.

Req. 10.1.1 (MA): According to the validated drawings, all service lines from the GHS and pulse tube must be long enough to enable the installation of the system in the two

rooms and should be provided by the supplier. The still and pumping lines extension will be discussed with the CNRS Néel Institute staff.

Req. 10.1.2 (MA): The supplier shall provide the main dimensions (including height) and weight of the major components: at least DR, GHS, Control cabinet, LN2 dewar and pulse tube compressor.

Note that the PT compressor will be located in the basement, beneath the experiment room The distance between the PT remote valve and the compressor is estimated to be about 6 meters.

Req. 10.1.3 (MA): The cryostat + support structure should fit in a 2.5m x 2.5m surface on ground, in a room of **ceiling height of 3.5m**.

Req. 10.1.4 (MA): The GHS must be installed in a room beneath the experimental room of the cryostat. The **ceiling height of this service room is 2.3m but access to it is limited to 1.71m (see Mandatory requirement 6.6)**.

10.2 MECHANICAL SUPPORT OF THE DR

The system shall include a suitable support frame for the DR (see section 13.3).

10.3 MECHANICAL INTERFACES OF THE DR

Concerning mechanical interfaces of the DR, main requirements are as follow:

Ref.	Designation	Required value	Crit.	Comment
10.3.1	Experimental space below the baseplate	$\phi \geq 230$ mm $H \geq 100$ mm	EV	Actual dimensions to be provided. STEP files would be helpful.
10.3.3	Ports	$\geq 3 * DN \geq 25$ $\geq 3 * DN \geq 50$	EV	
10.3.4	Number of LoS	≥ 2	EV	Among the ports of 10.3.3
10.3.5	Interface drawings	Drawings with mechanical interfaces shall be provided	EV	The drawings shall at least include: - Main dimensions at each stage (e.g. side and cut views) - View of available space at each stage (e.g. top view of each plate except baseplate: bottom view) - List of ports at 300K together with their use, e.g. temperature readout, vacuum jacket pumping port, customer LoS, etc

11. DC WIRING

The supplier must quote the installation of the following DC wiring with the following specification:

Ref.	Designation	Required value	Crit.	Comment
11.1	48 shielded dc lines from 300K to 4K plate	2 sets of shielded 12-twisted pairs woven-looms. Resistance per line must be < 30 Ohms to ensure Johnson noise < 0.7nV/√Hz	**MA**	Each 12-twisted pairs woven-loom must be shielded with a stainless steel (or CuNi) braid connected to the connector ground on both extremity.
11.2	2 break-out of the 48 dc lines thermalized at the 4K plate.	Use of 25 pins-micro-D connectors	**MA**	Include a grounded metallic backshell for the connector
11.3	48 shielded dc lines from 4K to MXC plate	2 sets of 12-twisted pairs woven-looms. Resistance per line must be as high as possible	**MA**	Use constantan or manganin wires, or if available enamelled stainless steel wires. Each 12-twisted pairs woven-loom must be shielded with a stainless steel (or CuNi) braid connected to the connector ground on both extremity.
11.4	2 connectors for the 48 dc lines thermalized at the MXC plate.	Use of 25 pins-micro-D connectors	**MA**	Include a grounded metallic backshell for the connector
11.5	Room temperature connectors for DC wiring	Use Jaeger (https://www.hummel.com/en/) hermetic panel connectors 52 contacts ref 536 252 006 or hermetic pneurop (DN50) 52 contacts ref 250 052 006	**MA**	Possibility to split into two hermetic Jaeger connectors of 25 contacts. We exclude here Fischer connectors. **Connectors will be supplied by CNRS staff.**

12. COAXIAL WIRING

The supplier must quote the installation of the following coaxial cables with the following specification:

Ref.	Designation	Required value	Crit.	Comment
12.1	4 coaxial lines from 300K to MXC plate	Use SCuNi-CuNi cables or any other low thermal	**MA**	The cables should not affect the base temperature of the MXC flange. See performance Ref. 4.2.

		conductivity semi-rigid coaxial cables Bandwidth <18GHz Use cryogenic compatible attenuators Include break-out at each flange of the fridge for thermalization via cryogenic attenuators installed on each break-out connectors. Use SMA connectors and feedthroughs at each flange (including 300K and MXC flange)		The values of the different attenuators will be defined by the CNRS staff during the drawing approval phase.
12.2	2 none-attenuated coaxial line to serve for a low-temperature microwave amplifier.	Use SCuNi-CuNi coaxial cable or any other low thermal conductivity semi-rigid coaxial cables from 300K to 4K flange Use NbTi-NbTi coaxial cable from 4K flange to MXC flange. Bandwidth <18GHz Use cryogenic compatible 0dB attenuators for thermalization, if needed. Include break-out each flange with SMA connectors Use SMA connectors and feedthroughs at each flange (including 300K and MXC flange)	**MA**	The cables must not affect the base temperature of the MXC flange. See performance Ref. 4.2. Other coaxial cables with lower attenuation can be proposed or defined with the CNRS staff during the drawing approval phase. 0dB Attenuators can serve for thermalization

13. MISCELLANEOUS

13.1 RESOURCES

The system will need power supply as well as compressed air or water and other potential resources.

Req. 13.1 (EV): The supplier shall indicate, within the technical proposal, the necessary resources: number and type (mono-phase, 3-phase, type of plug) of power supplies, number of lines for compressed air and associated technical specifications (e.g. nominal pressure), number and type of water lines and associated technical specifications (e.g. flowrate), any other resources needed to operate the system: LN2 for nitrogen trap, etc.

13.2 DOCUMENTATION

The supplier shall provide, in the course of the project, all necessary documentation to operate the system and ensure proper maintenance. This includes at least:

- User Manual with detailed operation instructions, troubleshooting, software description
- Maintenance plan
- Calibration data for thermometers, flowmeter, etc
- Interface drawings updated according to the "as built" system
- Factory test report (at supplier's premises).
- Test protocol (for the test at customer's premises)
- Acceptance test report (after successful tests at customer's premises)
- All EN required documentation: certificates of conformity, calibration certificates, etc

14. MANDATORY OPTIONS ("PSE OBLIGATOIRE")

14.1 INTRODUCTION

This section, we define a list of mandatory options. These options will be taken into account during the evaluation process and must be included in the supplier's proposal. **Failure to propose any of these mandatory options will result in exclusion from the tender.**

14.2 12-TESLAS SUPERCONDUCTING SOLENOID

This option is mandatory for the present call.

The supplier shall provide a quotation for a 12 T magnet, including current leads, a persistent switch, diode-based quench protection, electrical feedthroughs, and installation in the dilution refrigerator. The supplier shall provide additional thermal screens to operate the fridge without the magnet. The supplier shall also provide a quotation for a four-quadrant power supply.

If the DR is installed before delivery of the magnet, the magnet can subsequently be installed by CNRS and cooled down by CNRS prior to the supplier's on-site testing.

The specifications are as follows:

Ref.	Designation	Required value	Crit.	Comment
14.2.1	Superconducting solenoid equipped with persistent switch, diode quench protection, current leads and electrical feedthrough	≥12T at 4.2K Bore ≥ 76mm	**MA**	
14.2.2	4 quadrant magnet power supply	±120 A, ±5V, 16-bit control	**MA**	
14.2.3	Additional thermal screens to operate the fridge without magnet		**MA**	

14.3 14-TESLAS SUPERCONDUCTING SOLENOID

This option is mandatory for the present call.

The supplier shall provide a quotation for a 14 T magnet, including current leads, a persistent switch, diode-based quench protection, electrical feedthroughs, and installation in the dilution refrigerator. The supplier shall provide additional thermal screens to operate the fridge without the magnet. The supplier shall also provide a quotation for a four-quadrant power supply.

If the DR is installed before delivery of the magnet, the magnet can subsequently be installed by CNRS and cooled down by CNRS prior to the supplier's on-site testing.

The specifications are as follows:

Ref.	Designation	Required value	Crit.	Comment
14.3.1	Superconducting solenoid equipped with persistent switch, diode quench protection, current leads and electrical feedthrough	≥14T at 4.2K Bore ≥ 76mm	**MA**	
14.3.2	4 quadrant magnet power supply	±120 A, ±5V, 16-bit control	**MA**	
14.3.3	Additional thermal screens to operate the fridge without magnet		**MA**	

15. NON-MANDATORY OPTIONS (“PSE FACULTATIVE”)

15.1 INTRODUCTION

In this section, we define a list of non-mandatory options. **These options will not be taken into account in the evaluation and comparison of the offers. The supplier may choose whether or not to include them in the quotation.**

15.2 SUPPORT FRAME FOR THE DR

The supplier may provide a quotation for a heavy-duty support frame designed to support the dilution refrigerator. The support frame may be anchored either to the floor or to the ceiling of the experimental room. The final configuration shall be determined in consultation with CNRS staff, taking into account the room constraints and the need to minimize the transmission of mechanical vibrations to the dilution refrigerator.

15.3 ADVANCED ANTI-VIBRATION SYSTEM

CNRS may want to minimise the level of exported vibrations. Systems such as a very low vibration support structure might be proposed as a heavy-duty support frame designed to support the dilution refrigerator.

The supplier shall provide the basic list of components / features comprised in the option.

The supplier shall provide all technical details relative to this option e.g:

- Performance
- Drawings
- Update of mass budget

15.4 20-BIT UPGRADE OF THE MAGNET POWER SUPPLY

This option quotes the upgrade of the magnet power supply for a 20-bits control. Notice that this option does not quote a standalone 20-bit magnet power supply but only the price difference between the 16-bit and the 20-bit magnet power supply. This option, if taken, will be complementary to the mandatory option 11.4 or 11.5 that already include a magnet power supply.

15.5 AUXILIARY PUMPING UNIT

The auxiliary pumping unit is used to pump out air from the mixture lines (inlet and outlet lines) and also to pump the vacuum jacket.

END OF THE DOCUMENT