Cryostat Technical Specifications

FEND-40.03.00.00-002-B-SPE

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Change Record

Version	Date	Affected Section(s)	Change request #	Reason/remarks
A	2003-07-28	All	N/A	First document issue, not released
B	2003-09-02	Section 1.3 Section 1.4 Section 5.1 Section 5.4 Section 7.1.5 Section 7.1.6	N/A	Updated Issue Date and Document ID of [AD8] Updated Issue Date and Document ID of [RD3] Increased mass from 400 kg to 450 kg Redefined specification Clarified specification Clarified specification
B	2003-09-20	Section 1.4 Section 4.2.2 Section 7.1.6 Section 8.1.2	N/A	Updated Issue Date and Document ID of [RD3] Updated specification Updated specification Added He supply line pressure sensor

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1. INTRODUCTION

1.1. Purpose

This document provides the design specifications and requirements for the ALMA cryostat.

1.2. Scope

The information given in this document provides a complete summary of all the requirements that must be met by the ALMA cryostats delivered to the project. This document is accompanied by Interface Control Documents for this cryostat.

The following table shows a partial view of the ALMA product tree [AD1] at "module", "unit", and "item" level for the cryostat components that are covered by this document.
Those products belonging to the cryostat which are not specified by this document are clearly identified in the "remarks" column of this table.

PT level 2 / "module		*PT level 3 / "unit*		*PT level 4 / "item"*		*Remarks*
Product No.	*Product Name*	*Product No.*	*Product Name*	*Product No.*	*Product Name*	
40.02.00.00	Cartridges					
		40.02.01.00	Frequency band 1 cartridge			
				40.02.01.07	Band 1 support structure	
		40.02.02.00	Frequency band 2 cartridge			
				40.02.02.07	Band 2 support structure	
		40.02.03.00	Frequency band 3 cartridge			
				40.02.03.07	Band 3 support structure	
		40.02.04.00	Frequency band 4 cartridge			
				40.02.04.07	Band 4 support structure	
		40.02.05.00	Frequency band 5 cartridge			
				40.02.05.07	Band 5 support structure	
		40.02.06.00	Frequency band 6 cartridge			
				40.02.06.07	Band 6 support structure	
		40.02.07.00	Frequency band 7 cartridge			
				40.02.07.07	Band 7 support structure	
		40.02.08.00	Frequency band 8 cartridge			
				40.02.08.07	Band 8 support structure	
		40.02.09.00	Frequency band 9 cartridge			
				40.02.09.07	Band 9 support structure	
		40.02.10.00	Frequency band 10 cartridge			
				40.02.10.07	Band 10 support structure	

Table 1.1, Partial view ALMA Product Tree for cartridges

PT level 2 / "module		*PT level 3 / "unit*		*PT level 4 / "item"*		*Remarks*
Product No.	*Product Name*	*Product No.*	*Product Name*	*Product No.*	*Product Name*	
40.03.00.00	Cryostat					
		40.03.01.00	Dewar			
				40.03.01.01	Outer vacuum container	
				40.03.01.02	Radiation shields	
				40.03.01.03	Mounting plates	
				40.03.01.04	Windows & IR Filters	Not part of this Technical Specifications document
				40.03.01.05	Evacuation valve	
		40.03.02.00	Cryocooler			
				40.03.02.01	Cold end	
				40.03.02.02	Cryo compressor	
				40.03.02.03	Cryo cooler monitoring & control	
		40.03.03.00	Vacuum pumps			
				40.03.03.01	Roughing pump	
				40.03.03.02	High vacuum pump	
				40.03.03.03	Vacuum meters	
		40.03.04.00	Cryostat electrical infrastructure			
				40.03.04.01	Electrical feed-throughs	
				40.03.04.02	Dewar wiring	
				40.03.04.03	Temperature sensors	
				40.03.04.04	Vacuum transducers	

Table 1.2, Partial view ALMA Product Tree for cryostat

1.3. Applicable Documents List (ADL)

The following documents are part of this document to the extent specified herein. If not explicitly stated differently, the latest issue of the document is valid.

Reference	*Document title*	*Date*	*Document ID*
[AD1]	ALMA Product Tree	2002-11-01	SYSE-80.03.00.00-001-L-LIS
[AD2]	Common optics – Vacuum Vessel ICD	2002-12-12	FEND-40.01.00.00-40.03.01.01-A-ICD
[AD3]	Antenna – Front End ICD	2003-06-03	ALMA-34.00.00.00-40.00.00.00-A-ICD
[AD4]	ALMA System: Electromagnetic Compatibility (EMC) Requirements	2003-04-04	ALMA-80.05.01.00-001-A-SPE
[AD5]	ALMA Power Quality (Compatibility Levels) Specification	2003-02-14	ALMA-80.05.00.00-001-B-SPE
[AD6]	Standard for AC Plugs, Socket-outlets, and Couplers	2003-07-18	ALMA-80.05.00.00-004-B-STD
[AD7]	ALMA Electronic Design Specification and Guidelines	2003-04-25	ALMA-80.05.00.00-005-A-SPE
[AD8]	ALMA Environmental Specification	2003-07-29	ALMA-80.05.02.00-001-B-SPE
[AD9]	Cryostat – Front End M&C unit ICD	2003-04-01	FEND-40.03.00.00-40.04.03.00-A-ICD

In the event of a conflict between one of the before mentioned applicable documents and the contents of this document, the contents of this document shall be considered as a superseding.

1.4. Reference Documents List (RDL)

The following documents contain additional information and are referenced in this document.

Reference	*Document title*	*Date*	*Document ID*
[RD1]	ALMA Project Book	2002-02-20	Version 5.5
[RD2]	ALMA Front End Design Specifications & Requirements	2003-05-28	FEND-40.00.00.00-001-A-SPE
[RD3]	ALMA Cryostats Design, Development and Pre-Production Statement of Work	2003-09-19	FEND-40.03.00.00-003-B-SOW

1.5. Acronyms

A limited set of basic acronyms used in this document is given below.

AD Applicable Document
ALMA Atacama Large Millimeter Array
AOS Array Operation Center
CDR Critical Design Review
FE Front End
ICD Interface Control Document
IPT Integrated Product Team

IR	Infra Red
MTBF	Meantime between Failures
PDR	Preliminary Design Review
OVC	Outer Vacuum Container
RD	Reference Document

1.6. Verb Convention

"Shall" is used whenever a specification expresses a provision that is binding. The verbs "should" and "may" express non-mandatory provisions.
"Will" is used to express a declaration of purpose on the part of the design activity.

1.7. Requirements Numbering

The requirements within the present document are numbered according to the following code:

[FEND-40.03.00.00-XXXXX-YY / Z(ZZ)]

Where:

FEND-40.03.00.00 identifies the 'Front End – Cryostat' as based on [AD1];

XXXXX is a consecutive number 00010, 00020, … (the nine intermediate numbers remaining available for future revisions of this document);

YY describes the requirement revision. It starts with 00 and is incremented by one with every requirement revision;

Z(ZZ) describes the requirement verification method(s). Where T stands for Test, I for Inspection, R for Review of design and A for Analysis. Multiple verification methods are allowed.

2. DESCRIPTION

2.1. Equipment Definition

The cryostat is one of the core components for the ALMA front-end sub-system. It consists of a vacuum vessel of which the inner part is cooled to a temperature of less then 4 Kelvin. This very low physical temperature is necessary for operating millimetre and sub-millimetre mixer circuits using super conducting devices. These super conducting devices, SIS junctions, enable the high sensitivity as is required by the science objectives of the ALMA instrument.
To allow for long term, more then 1-year, unattended operation of the cryostat a closed cycle cryo cooler has been selected.
Those parts cooled to less then 4 Kelvin are protected by two shields that have physical temperatures of approximately 15 Kelvin and 110 Kelvin. These shields minimise the heat load caused by radiation on the 4 Kelvin components. These two shields also allow for cooling of other electronic components that do not use super conducting devices but have improved performance, e.g. in terms of less noise contribution or higher efficiency, compared to normal room temperature operation.

The present preliminary design is able to accommodate ten receiver observational bands operating in the millimetre to sub-millimetre wavelength range. In addition, sufficient room has been allowed for inclusion of a cold load to calibrate the atmospheric water vapour monitor.
The radio frequency and other electronic components that form an individual receiver band are integrated into an autonomous support structure known as a cartridge assembly (ALMA Prod No.: 40.02.01.07 through 40.02.10.07). An example of such a, empty, cartridge assembly is shown in figure 2.1.

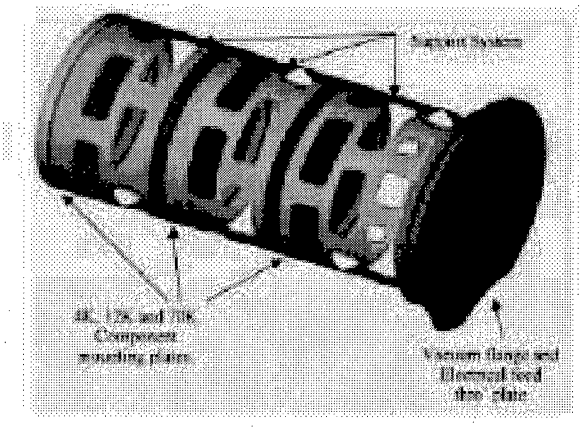

Figure 2.1, Example of an ALMA cartridge

All ten cartridges are inserted into a single large vacuum vessel (see figures 2.2 and 2.3) that provides thermal insulation, radiation shielding and cryogenic heat lift, the latter via a close cycle cooling system.

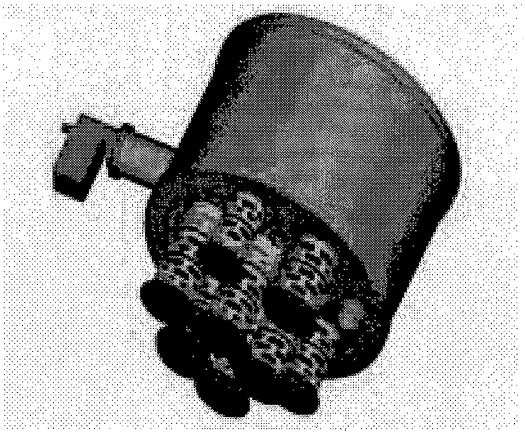

Figure 2.2, Bottom view of cryostat with cartridges extended

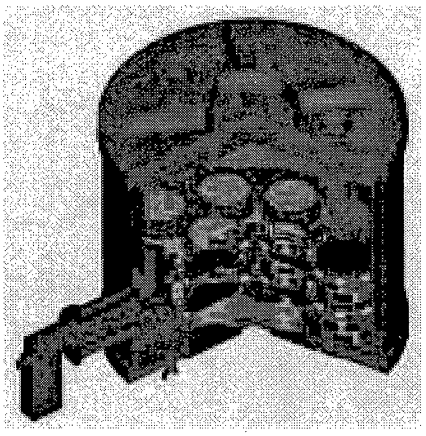

Figure 2.3, Cut-away view of outer vacuum container

Further, the outer vacuum container (ALMA Prod No.: 40.03.01.01) supports external optical components associated with the receiver-antenna optical interface: internal optical components are supported on individual cartridge assemblies.
The top cover plate of the OVC provides an interface for 10 vacuum windows (ALMA Prod No.: 40.03.01.04), one for each frequency band, allowing the incoming RF signal to reach the cold optic components mounted on each cartridge. To limit the heat load on the 4 k plates that might enter through the same access path as the RF signal, the holes in each of the radiation shields are equipped with IR filters. These, cooled, IR filters attenuate the incoming IR radiations but allow the RF signal to enter the cryostat with very low loss.
Thermal connection to each cartridge assembly heat sink stage is provided via a novel low resistance thermally activated link arrangement that requires no permanent mechanical attachment, i.e. it does not need to be physically bolted to a stage. This mechanism provides a significant operational advantage in that withdrawal of a cartridge, and hence a complete receiver band, can be simply performed at room temperature and ambient atmospheric pressure without disturbing the rest of the receiver and cryogenic system. This minimises risk of damage to the remaining receiver bands, reduces maintenance time and avoids a potentially lengthy and difficult readjustment of the external optical assembly since this need not be separated from the vacuum vessel. Furthermore, adoption of the cartridge principle allows construction and test of individual receiver assemblies to be performed at separate development facilities prior to final integration into the main vacuum vessel.

Each cryostat is equipped with temperature (ALMA Prod No.: 40.03.04.03) and vacuum (ALMA Prod No.: 40.03.04.04) sensors to monitor the status and early detection of failures during operation.

Necessary accessories, evacuation valve (ALMA Prod No.: 40.03.01.05), turbo backing pump (ALMA Prod No.: 40.03.03.01) and high vacuum pump (ALMA Prod No.: 40.03.03.02), to allow vacuum pumping of the OVC to prepare for cryogenic cooling are included as well.
Both turbo backing pump (ALMA Prod No.: 40.03.03.01) as well as high vacuum pump (ALMA Prod No.: 40.03.03.02) are permanently attached to the cryostat.

3. GENERAL REQUIREMENTS

3.1. Operation Modes

The cryostat shall be used according to the following modes.

3.1.1. Operational

[FEND-40.03.00.00-00010-00 / I]
This mode is applicable during normal observations with the front end sub-system. For this mode, all specifications and requirements in this document shall apply.

3.1.2. Non-Operational

[FEND-40.03.00.00-00020-00 / I]
This mode is applicable when the Cryostat is switched off. Therefore it is also called the "Off-mode". For this mode, the specifications and requirements in all sections of this document shall apply, with the exception of section 4 and unless otherwise noted.

3.1.3. Transport with the Antenna Transporter

[FEND-40.03.00.00-00030-00 / I]
This mode is applicable, when the Cryostat as part of the front end sub-system is transported with the antenna on the antenna transport vehicle. For this mode, the specifications and requirements in all sections of this document shall apply, with the exception of section 4 and unless otherwise noted.

3.1.4. Transport in the Front End Service Vehicle

[FEND-40.03.00.00-00040-00 / I]
This mode is applicable, when the Cryostat as part of the front end sub-system is transported on the front end service vehicle. For this mode, the specifications and requirements in all sections of this document shall apply, with the exception of section 4 and unless otherwise noted.

3.2. Compatibility with ALMA Front End Sub-System

[FEND-40.03.00.00-00050-00 / I]
The Cryostat design shall be compatible with other products within the ALMA front end sub-system, especially the receiver optics and FE chassis. Details as given in the applicable ICDs.

3.3. Design for Production

3.3.1. Technology

[FEND-40.03.00.00-00060-00 / R]
The Cryostat design should use mature technologies whenever possible.

3.3.2. Series Production

[FEND-40.03.00.00-00070-00 / R]
The Cryostat design should give a high degree of consideration to reduction of production and assembly costs. Complexity of the design and mechanical structures should be simplified wherever possible.

3.3.3. Standard Parts

[FEND-40.03.00.00-00080-00 / R]
Standard, unmodified commercially available components should be used where possible.

3.4. Cables and Connectors

[FEND-40.03.00.00-00090-00 / R]
All cables and connectors shall be in compliance with [AD6].

3.5. Metric Hardware

[FEND-40.03.00.00-00100-00 / R]
All hardware used in the Cryostat, including but not limited to fasteners, tapped holes, etc., shall be metric.

4. PERFORMANCE REQUIREMENTS

4.1. Cold Stage Requirements

The cryostat shall have three temperature stages according to the following specifications. All temperatures are specified at the centre of the appropriate temperature stage for all 10 cartridges contained inside the cryostat.
An exception is made for the Band 1 (ALMA Prod No.: 40.02.01.00) and Band 2 (ALMA Prod No.: 40.02.02.00) cartridges which don't have '4 K' stages.

4.1.1. '4 K' Stage Temperature

[FEND-40.03.00.00-00110-00 / T]
This temperature stage shall have a maximum temperature of 4 K with the maximum heat loads as specified in sections 4.3.1. through 4.3.3.
This specification does not apply to the Band 1 (ALMA Prod No.: 40.02.01.00) and Band 2 (ALMA Prod No.: 40.02.02.00) cartridges.

4.1.2. '15 K' Stage Temperature

[FEND-40.03.00.00-00120-00 / T]
This temperature stage shall have a temperature between 10 K and 18 K with the maximum heat loads as specified in sections 4.3.1. through 4.3.3.

4.1.3. '110 K' Stage Temperature

[FEND-40.03.00.00-00130-00 / T]
This temperature stage shall have a temperature between 80 K and 130 K with the maximum heat loads as specified in sections 4.3.1. through 4.3.3.

4.2. Temperature Stability

The temperature stabilities specified hereafter shall be reached within 15 minutes after the maximum heat loads as stated in section 4.3 are applied to the involved cartridge. The temperature stabilities specified in this section shall be measured at the same location as defined in section 4.1.

4.2.1. '4 K' Stage Temperature Stability

[FEND-40.03.00.00-00140-00 / T]
The temperature change of the '4 K' stage shall be less than 2 mK on timescales of one minute or less.

4.2.2. '15 K' Stage Temperature Stability

[FEND-40.03.00.00-00150-00 / T]
The temperature change of the '15 K' stage shall be less than 50 mK on timescales of one minute or less.

4.2.3. '110 K' Stage Temperature Stability

[FEND-40.03.00.00-00160-00 / T]
The temperature change of the '110 K' stage shall be less than 100 mK on timescales of one minute or less.

4.3. Cooling capacity

4.3.1. '4 K' Stage

[FEND-40.03.00.00-00170-00 / T]
The total maximum instantaneous heat load due to dissipation of electronic components mounted on the '4 K' stages shall be 108 mW. This dissipative heat load being equally distributed among any 3 out of the 8 cartridges.
Heat load on the '4 K' stage due to conduction by wiring is assumed to be 40 mW, 5 mW per cartridge, and is not included in the stated value of 108 mW.

4.3.2. '15 K' Stage

[FEND-40.03.00.00-00180-00 / T]
The total maximum instantaneous heat load due to dissipation of electronic components mounted on the '15 K' stages shall be 200 mW. This dissipative heat load being equally distributed among any 3 out of the 10 cartridges.
Heat load on the '15 K' stage due to conduction by wiring is assumed to be 950 mW, 95 mW per cartridge, and is not included in the stated value of 200 mW.

4.3.3. '110 K' Stage

[FEND-40.03.00.00-00190-00 / T]
The total maximum instantaneous heat load due to dissipation of electronic components mounted on the '110 K' stages shall be 2,5 W. This dissipative heat load being equally distributed among any 3 out of the 10 cartridges.
Heat load on the '110 K' stage due to conduction by wiring is assumed to be 4 W, 400 mW per cartridge, and is not included in the stated value of 2,5 W.

5. MECHANICAL REQUIREMENTS

5.1. Mass

[FEND-40.03.00.00-00200-00 / T]
The total mass of the cryostat shall be less than 450 kg.
This mass being the sum of the contributions of all the items that are listed in the tables 1.1 and 1.2 of this document, but excluding the mass contributions of the Windows & IR Filters (ALMA Prod No.: 40.03.01.04) and Cryo compressor (ALMA Prod No.: 40.03.02.02).

5.2. Centre of Gravity

[FEND-40.03.00.00-00210-00 / T]
The centre of gravity shall be as specified in [AD3].

5.3. Volume

[FEND-40.03.00.00-00220-00 / T]
The cryostat, mounted in the front end must be able to fit though the antenna receiver cabin door. This limits the total receiver package, including external optics, to a maximum envelope size as specified in [AD3].

5.4. Deformation

5.4.1. Angular misalignment

[FEND-40.03.00.00-00230-00 / T]
The tilt of any "4 K" stage relative to the plane of the mechanical interface between FESS and cryostat shall be less than:

- Angular misalignment: < 1 mrad

5.4.2. Linear misalignment

[FEND-40.03.00.00-00235-00 / T]
The position of the actual centre of any "4 K" stage relative to the centre of the cryostat top plate compared to the nominal position shall be less than the following values:

- Linear misalignment in horizontal direction [1]: < 0,8 mm
- Linear misalignment in vertical direction [2]: < 3,0 mm

[1] – Translation of the actual centre of the "4 K" stage versus the nominal centre
[2] – Actual position of a point at the top of the "4 K" stage versus the nominal position of that point

The vertical direction being defined as perpendicular to the plane in which the FESS ring is located.

5.5. Orientation

[FEND-40.03.00.00-00240-00 / T]
The cryostat shall be designed in such a way that its performance is independent of antenna elevation.

5.6. Eigen Frequency

[FEND-40.03.00.00-00250-00 / A]
The lowest Eigen frequency of the cryostat shall be not less than 10 Hz.

6. ELECTRICAL REQUIREMENTS

6.1. Mains-Power Supply

[FEND-40.03.00.00-00260-00 / R]
The cryostat can be powered from both 230 VAC and 400 VAC power supplies. The exact power qualifications of these supplies as described in ALMA Power Quality (Compatibility Levels) Specification [AD5].

6.2. Electrical Power Consumption

[FEND-40.03.00.00-00270-00 / T]
The cryocooler (ALMA Prod No.: 40.03.02.00) shall not consume more than 10 kW of mains-power.

6.3. EMC Requirements

[FEND-40.03.00.00-00280-00 / T]
The cryostat and its components, including EMC filtering of wire feed-throughs, as described in tables 1.1 and 1.2 of this document must comply with requirements as specified in [AD4].

7. ENVIRONMENTAL OPERATING CONDITIONS

7.1. Operational conditions

7.1.1. Altitude

[FEND-40.03.00.00-00300-00 / R]
The operating altitude is 0 - 5200 m.

7.1.2. Operating Temperature

[FEND-40.03.00.00-00310-00 / T]
The operating temperature for equipment within the receiver cabin is 16 ° C – 22° C.
The temperature stability is within +/- 1 ° C.
Cryo compressor (ALMA Prod No.: 40.03.02.02) and cryo cooler monitoring and control (ALMA Prod No.: 40.03.02.03) shall be mounted on the outside of the antenna. Applicable operating conditions as described in [AD8].

7.1.3. External Heat Load

[FEND-40.03.00.00-00315-00 / A]
Specifications defined in chapters 4 and 5 of this document shall be met with a temperature rise of the outside vacuum vessel of not more than 5 degrees Celsius above the normal operating temperature specified in section 7.1.2. This temperature rise caused by dissipation in external electronics mounted on the cryostat.

7.1.4. Relative Humidity

[FEND-40.03.00.00-00320-00 / R]
The operating relative humidity ranges from 20 % to 80 %.

7.1.5. Vibration

[FEND-40.03.00.00-00330-00 / A]
The cryostat shall survive vibration levels as specified in Appendix 1 of [AD8].
The vertical direction being defined as perpendicular to the cryostat top and bottom cover plates.

7.1.6. Acceleration

[FEND-40.03.00.00-00340-00 / A]
The cryostat shall comply with the following survival specification:

- 3 g shock load in the vertical direction
- 2 g shock load in any horizontal direction

The vertical direction being defined as perpendicular to the plane in which the FESS ring is located.

7.1.7. Tilt Angle

[FEND-40.03.00.00-00350-00 / R]
The tilt angle of the cryo compressor shall not exceed 10 degrees from its normal operational position.

7.2. Storage and Shipping Conditions

[FEND-40.03.00.00-00360-00 / R]
The cryostat cartridge shall comply with [AD8].

8. FUNCTIONAL REQUIREMENTS

8.1. Monitoring and Control

8.1.1. Remotely Controlled Functions

[FEND-40.03.00.00-00360-00 / R]
The following components shall be electronically controlled:

- Roughing pump (ALMA Prod No.: 40.03.03.01)
- High vacuum pump (ALMA Prod No.: 40.03.03.02)
- Evacuation valve (ALMA Prod No.: 40.03.01.05)
- Cryo cooler start/stop

8.1.2. Monitoring Points

[FEND-40.03.00.00-00370-00 / R]
The following parameters shall be monitored with appropriate sensors:

- Dewar vacuum
- Temperature of all 3 stages near the cold head
- Temperature of 2 radiation shields at two places. Exact places to be defined and agreed.
- Cryo cooler drive indication
- Compressor over temperature alarm signal according to manufacturers recommendation
- Compressor He line pressure alarm signal according to manufacturers recommendation
- Compressor He supply line pressure

8.1.3. Temperature Sensors

[FEND-40.03.00.00-00375-00 / R]
The temperature sensors mentioned in section 8.1.2. shall have an accuracy of better than 0,5 Kelvin. The type of sensor is specified in the applicable ICD [AD9].

9. RAMS REQUIREMENTS

9.1. Continuous Operation

[FEND-40.03.00.00-00380-00 / R]
The cryostat shall be designed for continuous use.

9.2. Reliability

[FEND-40.03.00.00-00390-00 / R]
Repeated thermal and vacuum cycling of the cryostat structural components; including cartridges, vacuum vessel, windows etc., shall not cause catastrophic system failure.
A limit of not less than 100 thermal and vacuum cycles is specified.

9.3. Lifetime

[FEND-40.03.00.00-00400-00 / R]
The cryostat shall have the same minimum lifetime as the front end sub-system, this being 15 years.

9.4. Availability

[FEND-40.03.00.00-00410-00 / A]
The cryostat shall be able to achieve continuous, unattended and reliable operation for more than 12 months.

9.4.1. Evacuation and Cool Down Time

[FEND-40.03.00.00-00420-00 / T]
The total cryostat evacuation and cool down time from room temperature, nominally 295 K, shall not exceed 48 hours. This time to be met with all 10 cartridges installed and each cartridge equipped with a mass of 2 kg of copper at the '4 K' stage. This mass representing the thermal capacity of the components mounted on each cartridge. The cryostat must have the ability to be evacuated to a suitable pressure to allow cool down consistent within this time frame and to ensure long term operation as specified under 9.2.
An external, high capacity roughing pump may be used to achieve this requirement.

9.4.2. Warm-Up Time

[FEND-40.03.00.00-00430-00 / T]
The warm-up time of the cryostat to ambient temperature shall be performed in maximum 12 hours. Active heating or the introduction of an inert gas into the vacuum space may be used to achieve this requirement.
Precautions shall be taken to assure that the temperature of any part inside the cryostat due to this active heating can not rise above 50 degrees Celsius to avoid damage to components.
The outside temperature of the vacuum vessel shall not drop below 10 degrees Celsius during warm-up.

9.4.3. Cryostat Hold Time

[FEND-40.03.00.00-00440-00 / T]
The cryostat shall be able to allow for a power interruption of 30 minutes maximum duration and after return of power be able to return to the normal operational mode, fulfilling all applicable specifications in this mode, within 6 hours.
This specified cryostat hold time shall be achieved at any time in the nominal 1 year of operation between regular service as mentioned in section 9.5.1.

9.5. Maintainability

9.5.1. Cryostat Service Period

[FEND-40.03.00.00-00450-00 / R]
The cryostat must have a minimum regular service interval of 1 year. The regular scheduled servicing to include examination of cryo cooler components, cold end and compressors, and pump out of vacuum chamber.

9.5.2. Cryo Cooler Service Periods

[FEND-40.03.00.00-00460-00 / R]

The cryo cooler service period shall be not less than:	10.000 hours
The compressor service period shall be not less than:	20.000 hours

9.6. Safety

9.6.1. Vacuum

[FEND-40.03.00.00-00470-00 / R]
The evacuated cryostat shall be designed to safely withstand the atmospheric pressure at altitudes between 0 meters and 5500 meters. This design requirement shall be equivalent to CE safety standards.

9.6.2. Over Pressure

[FEND-40.03.00.00-00480-00 / R]
The cryostat shall be designed to safely cope with over pressure and have appropriate provisions to limit over pressure equivalent to CE safety standards.

9.6.3. Handling

[FEND-40.03.00.00-00490-00 / R]
The cryostat and its components having a mass of over 25 kilograms must have the provision of attaching suitable lifting eyes to enable handling with a hoist.

9.6.4. Electrical

[FEND-40.03.00.00-00500-00 / R]
All electrical parts used in the cryostat shall comply with CE safety standards.

9.6.5. Moving Parts

[FEND-40.03.00.00-00510-00 / R]
All moving and rotating parts of the cryostat shall be properly shielded, equivalent to applicable CE rules, to avoid injury.