DE LA RECHERCHE À L'INDUSTRIE

LB650 cryomodule: Functional Requirements Specification (FRS) & Technical Requirements Specification (TRS)

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Reference documents

	Version	Date	TeamCenter Reference
PIP-II Global Requirements Document	C	27 Jan 20	ED0001222
PIP-II LB650 Cryomodule Technical Requirements Specification (TRS)	A	7 Nov 2019	ED0009658
PIP-II 650 MHz β=0.61 Cryomodule Functional Requirements Specification (FRS)	B	27 Sep 2018	ED0001830
LB650 FRS Metadata Sheet			ED0001830
PIP-II Cryogenic Heat Load Analysis	B	17 Apr 2020	ED0008200
PIP-II SRF Cavity Parameters PRD	A	07 Aug 2020	ED0010221
FESHM Chapter 5031: PRESSURE VESSELS		Jan - 2016	
FESHM Chapter 2110: Ensuring Equivalent Safety Performance when Using International Codes and Standards		Jan - 2017	

Functional Requirements Specification (highlights) (1)

	Units	LB650
Functional Requirements Specification		*ED0001830*
Energy for section	MeV	177 to 516
β_g		0.61
Cavities per cryomodule		4
Cavity operating temperature	K	2.0
Beamline vacuum at room temperature	Pa (mbar)	1×10^{-5} (1.10^{-7})
Beamline vacuum at 2K	Pa (mbar)	1×10^{-8} (1.10^{-10})
Thermal intercept circuits	K	5 & 50
2 K circuit warm MAWP	bar	2.05
2 K circuit cold MAWP	bar	4.10
MAWP for all other circuits	bar	20

Functional Requirements Specification (highlights) (2)

	Units	LB650
Lifetime thermal cycles		50
Cryogenic connection to Cryo distribution		Bayonets

- **The LB650 cryomodule shall have:**
  - the ability for in-situ maintenance of frequency tuners' electromechanical components.
  - A heat exchanger which precools helium from approximately 4.5 K to 2 K.
  - 5 K thermal intercepts available for support structures, input couplers, and to any other components if needed.
  - 50 K thermal intercepts available for support structures, input couplers, instrument wires, RF cables, and to any other components if needed.
  - Instrumentation (pressure, vacuum, magnetic, cavity, coupler diagnostics, etc....) for monitoring and control under all expected operational scenarios.
  - a support structure with required adjustability which will allow for positioning and alignment of accelerating structures, including alignment fiducials referenced to these structures.

Certification

- **All vacuum vessels, pressure vessels, and piping systems will be designed, documented, and tested in accordance with the appropriate Fermilab ES&H Manual (FESHM).**

  - Details can be found in Chapter 5031 - But new revision is being written to allow the use of these dual MAWP.
  - Discussions are needed in order to find a way to qualify the Piping systems with a dual MAWP according to PED.

Technical Requirements Specification (highlights)

	Units	LB650
Technical Requirements Specification		*ED0009658*
Cryomodule weight	tons	<12
Cryomodule flange-to-flange length	m	5.5
Cryomodule width	m	2.1
Cryomodule height (from floor)	m	2.82
2 K heat load	W	80
5 K heat load	W	25
50 K heat load	W	125
Environmental magnetic field	mG	≤ 5
Transverse cavity alignment error, RMS	mm	0.5
Angular cavity alignment error, RMS	mrad	1

Transportation requirements

- **Process for LB650 cryomodule similar to HB650 cryomodule**
  - Requirements for shipping system
    - Lifting and handling
    - Vibration/shock isolation and instrumentation
    - Environmental protection
  - Requirements for outgoing inspection and incoming acceptance

Requirements	Units	LB650
Cryomodule design to handle maximum shocks during transport – Vertical	g	3
Cryomodule design to handle maximum shocks during transport – Longitudinal/axial	g	5
Cryomodule design to handle maximum shocks during transport – Transverse	g	1.5
Frame design to limit shock during transport – Vertical	g	2.5
Frame design to limit shock during transport – Longitudinal/axial	g	3.5
Frame design to limit shock during transport – Transverse	g	1.5

Thank you for your attention