

THE DEVELOPMENT OF CRYOMODULE FOR C-ERL AT MHI

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Abstract

Mitsubishi Heavy Industries, Ltd. (MHI) manufactured the Superconducting Accelerator Cavity Module of the Injector and the Main Linac of the c-ERL facility being constructed by the High Energy Accelerator Research Organization (KEK). This report provides status of the development.

INTRODUCTION

For the realization of next generation synchrotron radiation light source ERL (Energy Recovery Linac), a small size ERL "Compact ERL" is under development at KEK (Fig. 1).

MHI manufactured Superconducting Cavities and Cryomodule for mounting Cavities as a high frequency acceleration device to accelerate electrons in the high electric field required as its nucleus technology, and completed installation and delivery of one (1) Injector Cryomodule and one (1) Main linac cryomodule [1].

At present, the beam acceleration test of the Injector Cryomodule is underway at KEK after having been through the High power test.

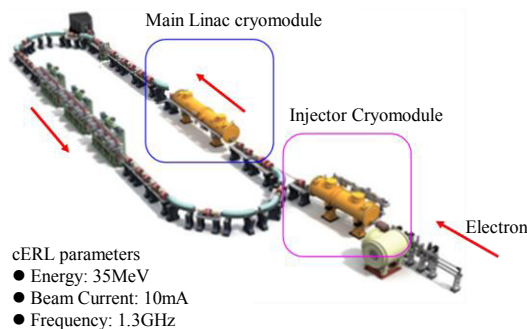


Fig. 1: Outline of the Compact ERL

INJECTOR CRYOMODULE

Configuration of the Cryomodule

The Container enclosing the whole assembly is made of stainless steel, inside of which Aluminum Shield cooled down to 80K is lined to shield radiant heat. Inside of the 80K Shield, the Helium Panels which can store helium of 5K are contained. The thermal anchor is led from the piping connecting two panels to the Input Coupler. Three (3) Cavities welded to the Jacket made of titanium are arranged in the middle of these components (See Fig. 2) [2]. Further, the Magnetic Shield is installed inside the Jacket to cover the Cell. Helium Panels and Piping to supply and recover liquid helium and liquid nitrogen are made of stainless steel,

and they passed inspection of High Pressure Gas Safety Inst. of Japan.

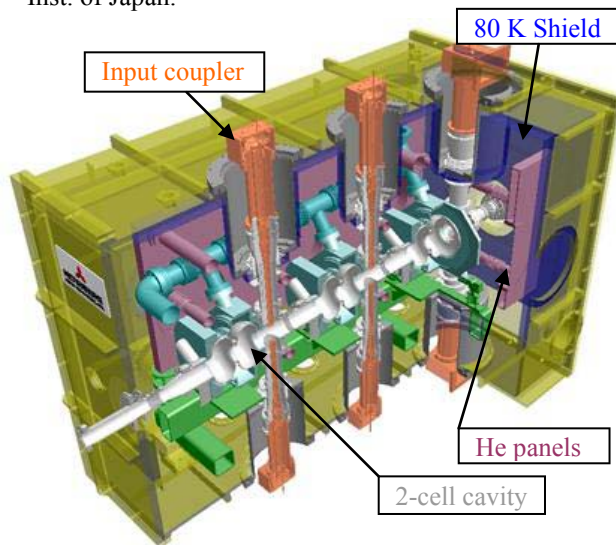


Fig. 2: Overall configuration of Injector Cryomodule



Fig. 3: Examples of component parts, (a) Thermal Shield and piping, (b) Helium Panel.

Superconducting Cavities

The construction is such that the Jacket made of titanium is installed outside of the 2 cells type Superconducting Cavities made of niobium so that the Cavities are held under the superconducting condition by storing liquid helium between the Jacket and the Cavities. The Jacket is designed to be compact so that the Slide Jack Tuner for frequency adjustment can be installed. The design specifications of the Cavities are as shown below, and they passed inspection of the High Pressure Gas Safety Inst. of Japan. The performance of subject three (3) Cavities are confirmed individually at KEK [3].

Table 1: High pressure gas design conditions of the Cavities

Design temp.	-271.4 to +30°C
Design press.	0.031+0.1013 MPa
Capacity	0.006 m ³
PV Value	0.0008 (<0.004) General rule



Fig. 4: Witness test by the High Pressure Gas Safety Institute of Japan

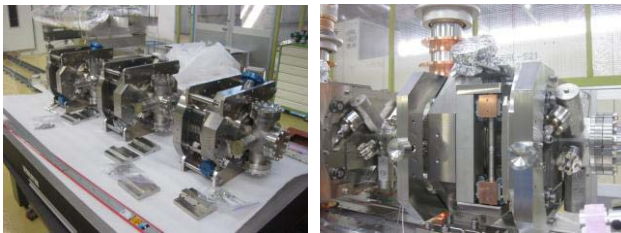


Fig. 5: Superconducting Cavities (left) and Frequency Tuner (right)

Assembly and installation of the Injector Cryomodule

In April of 2012, coupling of Cavities and Coupler installation work were performed in the clean room. Then, containing the Cavities in the Cryomodule was performed spending approximately a month and installation in the beam line was completed in June.



Fig. 6: Assembly and installation of the Injector Cryomodule (@ KEK-ERL Development Bldg.)

High power test of the Injector Cryomodule

In February of 2013, high power RF test was performed at KEK. Achievement of accelerating electric field of 8MV/m at CW operation and 15MV/m at pulse operation were confirmed.

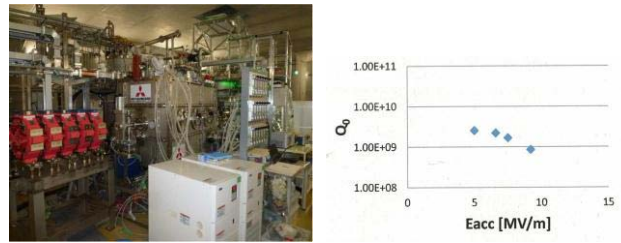


Fig. 7: High power test of the Injector Cryomodule

MAIN LINAC CRYOMODULE

Configuration of the Cryomodule

The Vacuum vessel enclosing the whole assembly is made of stainless steel, inside of which Aluminum Shield cooled down to 80K is lined to shield radiant heat. The main component called as Back Bone is contained in the vacuum vessel. The Cavities weld to the Jacket is fixed to the Frame cooled down to 5K and then covered by the Thermal Insulation and Magnetic Shield, and installed on the Back Bone (See Fig. 7) [4]. Piping to supply and recover liquid helium and liquid nitrogen are made of stainless steel, and they passed inspection of the High Pressure Gas Safety Inst. Japan.

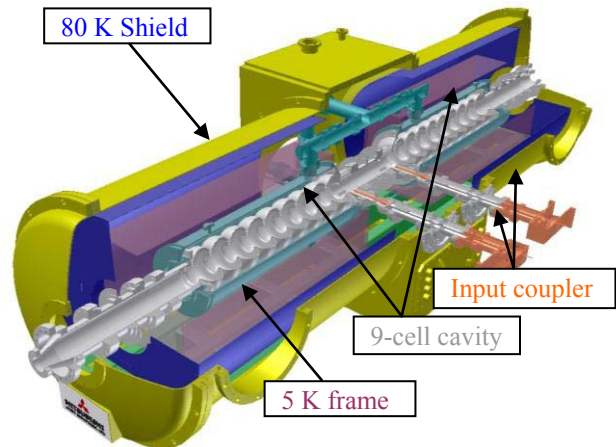


Fig. 8: Overall configuration of the Main Linac Cryomodule

Superconducting Cavities

The construction is such that the Jacket made of titanium is installed outside of the 9 cells type Superconducting Cavities made of niobium so that the Cavities are held under the superconducting condition by storing liquid helium between the Jacket and the Cavities. The design specifications of the Cavities are as shown below, and they passed the Designated Equipment Inspection. The performance of subject two (2) Cavities are confirmed individually at KEK [5].

Table 2: High pressure gas design conditions of the Cavities

Design temp.	-271.4 to +30°C	
Design Press.	0.031+0.1013 MPa	
Capacity	0.046 m ³	
PV Value	0.0061 (>0.004)	Particular rule

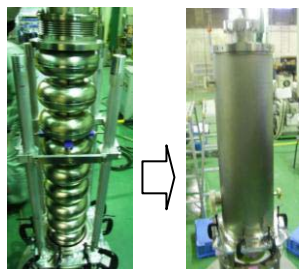


Fig. 9: Jacking of the Cavities (Before jacking of the 9 cells Superconducting Cavities and after jacking of the Cavities)



Fig. 10: Witness test by the High Pressure Gas Safety Institute of Japan

Assembly and installation of the Main Linac Cryomodule

In August of 2012, coupling of Cavities and coupler installation work were performed in the clean room. Then, containing the Cavities in the Cryomodule was performed spending approximately a month and installation in the beam line was completed in October.

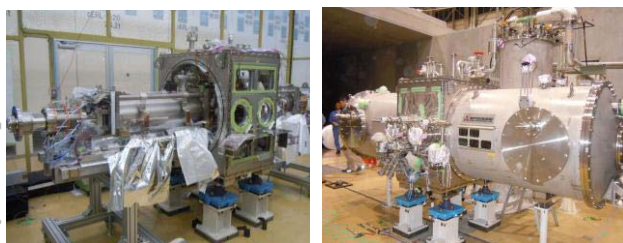


Fig.11: Assembly and installation of the Main Accelerator Module (@ KEK-ERL Development Bldg.)

High power test of the Main Linac Cryomodule

In February of 2013, high power RF test was performed at KEK. Achievement of acceleration electric field of 14MV/m at CW operation was confirmed.

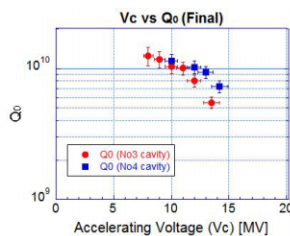


Fig. 12: Quenching test of the Main Accelerator Module

SUMMARY

MHI performed following for the construction of the cERL at KEK.

- Developed 2 cells type Superconducting Cavities for the Injector and manufactured three (3) real units conforming to the General High Pressure Gas Safety Act.
- Developed 9 cells type Superconducting Cavities for the Main Accelerator and manufactured 2 real units conforming to the High Pressure Gas safety Act.
- Manufactured one (1) Injector Module containing 3 units of the 2 cells type Superconducting Cavities for the Injector, and completed assembly, installation and delivery.
- Manufactured one (1) Main Accelerator Module containing 9 cells type Superconducting Cavities for the Main Accelerator, and completed assembly, installation and delivery.

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