

Specification for Fabrication of Quadrupole magnet coil

SI No.	Detailed Item to be supplied	Quantity
1	Fabrication and supply of Coil for quadrupole magnets of MC18 beam line as per attached detailed specification and drawings listed in Annexure-I.	18 nos

Scope of Supply:

i.	Procurement of all raw materials to be used for fabrication and supply of the coils as per this specification
ii.	Design and preparation of fabrication drawings of jigs and fixtures, fabrication of all jigs, fixtures and any other devices required for fabricating, inspecting, testing, packing, loading/unloading/transportation of the coils as per this specification.
iii.	Fabrication of pancakes, connector for thermal switches, water connectors etc. as per drawings and assembly of coil to meet assembly drawing and this specification.
iv.	Inspection, testing, documentation of all test results and certification complying quality assurance tests during different stages of fabrication of all components.
v.	Packing and shipment the coils to destination as mentioned in the purchase order.

1. General Information

The quadrupole magnets will be used in MC18 cyclotron beam transport line. It will focus the beam that is extracted from the cyclotron along the beam transport line. The quadrupole magnets will be electromagnets. Four coils mounted on four Iron poles will make the quadrupole field. The coils (Fig 01 and Fig 02) will be conduction cooled by water cooled copper plate.

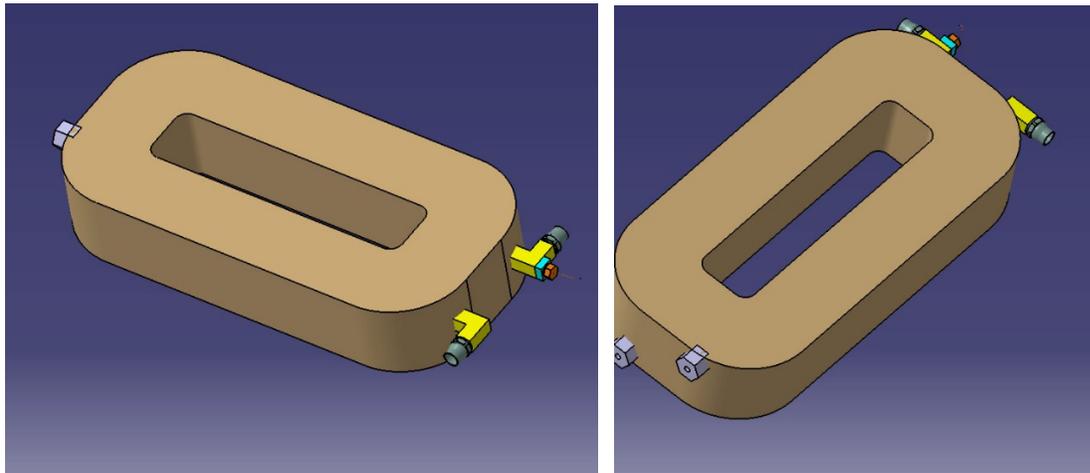


Fig 01 and Fig 02: Solid view of a quadrupole coil

2. Technical Description of the coil

Coil Assembly Details: Drg No: ATDMS-QPOLE-MCP-00-01

No of Turns/per coil: 100 turns

No of layer per pancake: 2

No of double layer pancake per coil: 2

No of turns per pancake layer: 25

Conductor dimension: 12.5mm x 2 mm

Maximum Current: 90 Amp

Resistance at 20 deg C per coil: 47 mOhm (max)

Voltage drop per coil at 20⁰ C : 4.5V (Approx)

Heat sink/Cooling Plate: 8 mm copper as per drawing

Cooling tube: 8 mm OD/Square X6 mm ID copper tube

Flow rate : Minimum 3 lpm @pressure drop 1 bar

Temperature rise (Inlet to outlet measured on cooling tube surface) per coil: Approx. 6.5 deg at 90A when flow rate is 3 lpm

Water connections: Legris Push-ON tube 8mm ODX6 mm ID

Weight of the magnet: 140 Kg (Approx)

Thermal switch(Not in the scope of supply) : Type Thermik 60⁰ C NC

3. Material

All materials used for the coils of the fabrication of coils for quadrupole magnets shall strictly be as per this specification and drawings. They shall be new, first quality, free from defects.

Copper: Good quality copper (UNS C10200 grade with minimum copper wt 99.95%) wire shall be used for fabrication of the coils. Electrical conductivity at 20⁰ C of the copper should not be less than 100% IACS. Original copper manufacturer's (OEM) test certificates for purity of copper and electrical resistivity should be produced before starting of fabrication of the coils.

Glass Fibre Tapes: Unvarnished Glass Fibre tapes, meant for electrical purposes, shall be used as insulation for the coil. The quality of glass fibre tapes shall be as per following:

Comparable Standards: Indian: IS 5352 1999 or International: BS ENG 61067-1 1997

Epoxy for casting coils:

Epoxy resin system shall be used for casting the coils. The epoxy used should have good mechanical and electrical properties. Typical properties of the cured resin should be as per table 2.

Table 2: Typical properties values of Cured resin

SI No.	Properties	Unit	Value
i.	Flexural Strength	MPa	110-130
ii.	Impact Strength	kJ/m ²	10-20
iii.	Tensile Strength @23 ⁰ C	Mpa	65-80
iv.	Dielectric Strength @23 ⁰ C	Kv/mm	16-19
v.	Glass transition temperature	⁰ C	70-90
vi.	Thermal Class	class	Minimum "F"

The coils will work in high ionization radiation area. Total absorbed dose in coil shall be approximately 1 MGy in its lifetime of 40 years of operation. Among others, the resin Araldite F + HY 905+ DY040 + DY061 can satisfy the required properties and dose rate. Epoxy resin, if other brand/grade is used, should be able to sustain the above mentioned radiation dose. Technical data sheet of radiation dose rate for the offered epoxy (if other than Araldite F + HY 905+ DY040 + DY061) should be provided to the purchaser. The vendor must get approval from the purchaser prior to use of the epoxy.

Other material:

Brass if used for fabricating Electrical connectors/thermal switches in the coil side shall be UNS C26000 grade.

Phosphor Bronze if used for water connector shall be UNS 51000 grade.

4. Manufacturing and Process description

4.1 Conductor: Flat copper wire 12.5 mmX2 mm insulated with dual coated enamel, Thermal class index atleast H180 (Insulation Standard IEC 60317-29) shall be used. Conductor dimensions, insulation quality and any defect shall be checked and documented before winding. The uniformity of the conductor shall be such that the variation of resistance of all coils constructed from it shall be within $\pm 1\%$ of mean value of all coils.

4.2 Winding of pancake type coil: The coil pancakes shall be wound on an aluminium/steel mallet. The dimension the mallet shall be checked before winding. No joint is allowed in a single pancake coil. The pancake coil shall be double layer type. Each pancake coil shall be insulated with glass tape.

Controlling parameters (All parameters shall be as per this specification) on each pancake:

- a. Number of turns.
- b. Dimension of each pancake coil.
- c. Resistance (Note: variation of resistance of pancake shall be within 1% of mean value of all pancakes)
- c. Turn to turn insulation at 250V. The Insulation resistance should be better than 50 MOhm
- d. Ground insulation at 250V. The Insulation resistance should be better than 50 MOhm

4.3 Cooling Circuit: The coils shall be cooled with a water cooled copper plate. A round/square hollow copper conductor of dimension 8 mm dia/square with hole 6 mm diameter shall be brazed to copper plates. The water connectors shall be brazed with copper tube. All brazing should be done using silver brazing filler (at least 40% silver). The cooling plate including tube shall be insulated with glass tape.

Controlling parameter(All parameters shall be as per this specification):

- a. Pressure test/leak test of copper tube and connector at 20 bar
- b. Flow rate at 1 bar pressure drop.
- b. Dimensions of copper plate assembly after brazing.
- c. Ground insulation of check at 250 V after insulation with glass tape. The

Insulation resistance should be better than 50 MOhm

4.4 Assembly of pancakes and cooling tube:

Two pancakes and one cooling plate shall be assembled placing the pancakes on both the sides of the cooling plate. The conductor windings shall be drawn to connections on the outside of the coil. The cooling circuit shall be drawn to connections on the outside of the coil. The two pancakes will be made to series connection by brazing the conductor terminals using silver brazing (at least 40% silver) filler. Two terminal of the coil shall be drawn to connection outside the coil. The joints shall be designed and fabricated by the fabricator to carry 200% of the rated current. The complete coil shall be wound half lapped with glass tape.

Controlling parameter (All parameters shall be as per this specification):

- a. The coils shall be tested for inter-turn shortages and insulation between cooling plate and pancakes.
- b. Resistance of the complete coil.
- b. The dimensions of the coil.

4.5 Impregnation:

Material : Araldite F + HY 905+ DY040 + DY061 or equivalent

The coils shall be placed in a mould in vacuum oven and dried and evacuated. After the epoxy is mixed and evacuated it shall be filled in to mould under vacuum. The vacuum oven is raised to atm pr. and temperature is raised to recommended temperature as mentioned in the resin manufacturer's catalogue.

Curing : At 120 Deg C

4.6 Demoulding: After cooling the coil shall be demoulded.

4.7 Final Assembly and test

Fittings for cooling circuit shall be attached. Each coil shall be tested and after successful test and quality control pass, the coils shall be painted.

5. Inspection, Test and Acceptance Criteria

5.1 General

The fabricator shall have all instruments and devices with him to demonstrate compliance of the fabricated components within the required tolerances and quality. **The list of inspection tools, Testing instruments and their capacity available with the fabricator for inspection and testing of the coils as per specification have to be submitted along with the offer.**

Any special tool/jig/fixture, if required for inspection and testing of coils (both mechanical and electrical as mentioned in this specification) shall be designed and fabricated by the fabricator.

Fabricator shall intimate the details of such tools before use for inspection and get approval from the purchaser.

Fabricator shall intimate purchaser the details of all procured items before they are being actually used. Property data sheet of all procured items must be documented.

The purchaser's representatives shall also be permitted free access to the fabricator's works at all reasonable hours for the purpose of inspection of the work (if required) in all stages of progress. The fabricator shall provide all tools, equipment, jigs and fixtures and qualified personnel to facilitate inspection (if required) for the compliance with the specification.

5.2 Coil Inspection and Tests at fabricator's works

The fabricator shall carry out all the tests mentioned in section 4 during the fabrication of the coils and maintain the documents for final submission along with the fabricated coils. In addition the following tests shall be carried out on the final coils after demolding. The coils will pass the tests if all criteria fulfills.

a) Mechanical:

- i) All dimensions including geometrical features as mentioned in the drawing of the coil after demolding shall be measured and documented. All dimensions and features should be within the tolerance limit as mentioned in the drawings.
- ii) Hydraulic test of water connections of the cooling plate of the coils at 20 bar. Drop of pressure larger than 2% in 24 hours is not acceptable.
- iii) Hydraulic test of water connectors of the cooling plate of the coils at 25 bar for 10 minutes. No leakage should be found.
- iv) Water flow test: Water flow measurement through the cooling plate of all coils should be recorded for pressure drop of 1 bar. The flow rate shall be less than 3 lpm.

b) Electrical:

In addition to the tests that should be carried out during fabrication as mentioned in section 4, the following tests shall be performed on the coils after demoulding.

- i) The electrical resistance shall be measured for each coil after demoulding. The electrical resistance in each case shall be measured and corrected to 20°C. The maximum resistance value of the coil should be within the value mentioned in this specification.
- ii) After casting, each coil shall be tested by using it as the secondary winding of a transformer. At least a voltage of 1 kV rms shall be induced across the coil terminations for a period of one minute, the induced voltage and the corresponding primary current shall be recorded. Any indication of short-circuiting between turns shall result in rejection of the coil. The above inter turn insulation test can also be carried out using a suitable winding tester that has features to test short circuit between turn to turn. The details of this tester and testing method to be used must be communicated to the purchaser for approval.
- iii) Each coil shall be immersed in tap water at ambient temperature or shall be completely wrapped with wet cloth but with the terminals exposed above the water level. The following test sequence shall then be carried out:

- a. Record insulation resistance between coil terminals and water bath/wet cloth, using minimum voltage of 1kV for at least 2 minutes. Insulation resistance should be above 100 MOhm.
- b. Apply direct voltage of 2.5 kV between coil terminals and water bath/wet cloth for one minute, and record the insulation resistance. Insulation resistance should be above 100 MOhm.
- iv) Insulation between coil and cooling plate at 1kV. Direct voltage of 1kV should be applied between the cooling plate and coil terminal. Insulation resistance between them should be above 100MOhm.

c) Heat run test

Each coil shall be energized at 90A with cooling water flow rate at 3 lpm for a period of at least two hours. Temperature shall be measured at the inlet and outlet cooling tube. Temperature difference between inlet and outlet shall be within 1 deg C to 4 deg C.

Note:

A copy of the test reports along with method and the achieved value for each parameter shall be submitted to the purchaser.

All electrical insulation tests as mentioned above shall be carried out at least twice consecutively. Any coil exhibiting evidence of breakdown or significant changes of insulation resistance during these tests shall be rejected.

6. Documentation

The fabricator shall provide two sets of paper copies and one soft copy of the following documentation as soon as it becomes available.

- Quality Assurance Plan (QAP) and a detailed time schedule.
- Test certificate/material data sheet for copper material and enamel insulation quality, glass fibre tape, epoxy etc from the OEM of all material/components used.
- Quality control check at each stage of manufacturing as per section 4 and after demoulding as per section 5.

All reports, documents, manuals, and booklets shall be in English language. The fabricator shall provide two full sets of hard copies of fabrication drawings and a soft copy through DVD or e-mail. The soft copy of the drawings shall be in pdf/igs/step/dwg format.

7. Packing and shipment

All components should be stored and packed to prevent any damage for the components. Packing should be seaworthy and ensure no damage to the components and surface of the components during shipment/transportation. The material shall be delivered the address as mentioned in the tender documents/purchase order.

8. Site Acceptance test after delivery

After delivery at site, the coils shall be visually inspected for mechanical damage suffered in transit. Any such damage shall be reported to the manufacturer. Possible repair shall be subject to

agreement with the purchaser. Where the damage has resulted in soundness or shape of coil, insulation or terminals, the coils shall be rejected.

All mechanical and Electrical tests described in section 5 that applies to the coils will be carried out at purchaser premises. The fabricator has the right to be represented during these tests. The acceptance criteria as mentioned in section 5 shall also be applied during these tests.

The coils will be energized at the rated current for a period of at least two hours. Any coil showing evidence of breakdown, local hot spots or other faults during this period shall be rejected.

9. Bidder's qualification Criteria

- i) The bidder must provide the details of the original fabricator of the coils in their offer. Without fabricator's details the offer will not be accepted.
- ii) The fabricator must have prior experience of fabrication of resin cast (by vacuum Impregnation method) coil supplied to any reputed organisations/Labs. Details of past experience on fabricating of coil and customer details (with contact details) has to be attached with the offer.
- iii) Manufacturer must have adequate infrastructure to fabricate and test resin cast magnet coil of tendered specification. Necessary details related to available space, vacuum impregnation plant/facility, services & facilities, machineries, testing instruments etc. have to be provided.
- iv) The bidder/fabricator has to fill and submit the attached **compliance sheet**(Annexure-II) and self certificate for make in India

Annexure-I
List of Drawings

1. ATDMS-QPOLE-MCP-00-01
2. ATDMS-QPOLE-MCP-00-01-001
3. ATDMS-QPOLE-MCP-00-01-002
4. ATDMS-QPOLE-MCP-00-01-003
5. ATDMS-QPOLE-MCP-00-01-004

Annexure -II
Compliance Sheet

SI No	VECC requirement	Bidder's response	
1	Name and address of the original manufacturer of the coil		
2	Whether the fabricator has prior experience of fabrication of resin cast (by vacuum Impregnation method) coil.		
3	If yes to above please provide customer's contact details		
4	Whether infrastructure details (available space, plants, services & facilities, machineries, testing instruments etc) of the fabricator has been attached.	a. Available Space for winding	
		c. VI facility	
		d. Machineries for winding	
		e. Testing Instruments	
5	Whether scope of supply as mentioned in this specification is agreed		
6	Whether the fabricator agreed to meet the parameters of the fabricated coils as per section 2.		
7	Whether the fabricator agreed to use copper conductor, glass fibre tape, epoxy resin and other materials for fabricating coils as per section 3.		
8	Whether the fabricator agreed to use jointless conductor for fabrication of a single pancake coil.		
9	Whether the fabricator agreed to follow the guidelines of fabrication as per section 4		
10	Whether the fabricator agreed to use silver brazing filler (with at least 40% silver) for all brazing.		
11	Whether the fabricator agreed to design and fabricate the series connection joints between pancakes of the coil and terminal		

	joins the coil to carry 200% of the rated current.	
12	Whether the purchaser's representatives will be permitted free access to the fabricator's works at all reasonable hours for the purpose of inspection of the work (if required) in all stages of progress.	
13	Whether the fabricator shall provide all tools, equipment, jigs and fixtures and qualified personnel to facilitate inspection (if required) for the compliance with the specification.	
14	Whether the fabricator agreed to carry out all measurement and tests during fabrication of the coil as per this specification, record all data and supply along with the material	
15	Whether the fabricator agreed to carryout all tests as mentioned in section 5.2, record all data and submit the data before shipment.	
16	Whether the fabricator agreed to test insulation at least twice consecutively as in section 5	
17	Whether the fabricator agreed with the acceptance criteria as mentioned in section 4 and 5	
18	Whether the fabricator agreed to provide all documents as mentioned in section 6	
19	Whether the bidder agreed to pack the coils to prevent any damage during loading/unloading and transportation as mentioned section 7	
20	Whether the bidder agreed with the acceptance test and criteria for acceptance at site as mentioned in section 8	