

**Government of India
Bhabha Atomic Research Centre
Accelerator Control Division**

Ref: ACnD/EMAS/17/628

Date: 1.9.2017

Detailed Engineering, fabrication, assembly, testing, supply and safe delivery of coil winding and bobbin assemblies for Combined Function Electromagnetic Dipole Correctors confirming to the Technical Specification Number: ACnD/DCCB/17 dated 23.8.2017.


Dear Sir/Madam,

Quotations are invited for "Detailed Engineering, fabrication, assembly, testing, supply and safe delivery of coil winding and bobbin assemblies for Combined Function Electromagnetic Dipole Correctors confirming to the Technical Specification Number: ACnD/DCCB/17 dated 23.8.2017".

Bidder shall quote for deliverables as per technical specifications.

1. No Free Issue material is involved.
2. Taxes shall be quoted separately. Form AF/H whichever is applicable shall be provided, if required.
3. **The quotation must reach The Head, EMAS, ACnD by 15/9/2017 (12:00 Noon) and must be sent in a sealed envelope super scribed with the reference number & the due date given above. Courier are not allowed in BARC premises; the quotation shall be sent by speed post/registered post.**
4. The address on the envelope should read: **The Head,
Electromagnetic Application Section,
Accelerator Control Division,
RCnD Bldg., North Site
BARC, Trombay,
Mumbai - 400 085.
(Kind Attn: Elina Mishra, SO/D)**
5. The bidder shall complete the job within 16 weeks from the date of firm work order issued to the bidder. The finished components shall be delivered by the bidder at **RCZ stores, BARC, Trombay, Mumbai-400 085.**
6. Head, EMAS, Accelerator Control Division reserves the rights to accept/reject any or all quotations without assigning any reason.
7. Delivery charges if any must be clearly mentioned in the offer. Quotation must also indicate the validity of offer. Quotation must also indicate the VAT no and PAN no of the party.
8. Drawings / Sketches must be returned along with the offer.
9. The quotation has to be signed by authorized person with company seal.
10. Payment will be made by cheque only after satisfactory completion of work on production of bill, delivery challan and advance stamped receipt. It may be noted that IT @ 2% and surcharge on tax at 15% shall be deducted from your bills.

Encl.: Technical Specification Sheet no: - ACnD/DCCB/17


19.37
Sanjay Malhotra,
Head, EMAS, ACnD

Specification no.	Revision no.	Total pages	Date
ACnD/DCCB/17	0	7	23.8.2017

Detailed Engineering, fabrication, assembly, testing, supply and safe delivery of coil winding and bobbin assemblies for Combined Function Electromagnetic Dipole Correctors confirming to the Technical Specification Number: ACnD/DCCB/17 dated 23.8.2017.

1.0 Scope

This specification specifies “*Detailed Engineering, fabrication, assembly, testing, supply and safe delivery of coil winding and bobbin assembly for Combined function Electromagnetic Dipole Correctors*” for proton beam orbit correction and optics measurement.

The electromagnetic dipole correctors (DCs) are an integral part of the high energy beam line of high intensity proton accelerators. The primary function of the various kinds of magnets in these lines is to keep the emittance growth of the output beam as low as possible by focusing the proton beam and ensuring proper orbit correction and transverse beam position control. DCs are placed in between two of the focusing elements and take the feedback signal from beam position monitors for beam orbit correction.

The job includes fabrication of layered coil winding assembly with bobbins for Dipole Correctors. This requires precise fabrication of electromagnetic coils and their assembly. Supplier shall also be responsible for testing of the fabricated products including geometrical and electrical qualification of the electromagnetic coils and thermal qualification of the assembly. Assembly and safe packaging of the magnets and other components is also in the supplier’s scope.

This document is organized as follows:

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2.0 Statement of purpose

The Beam Transport line of high intensity proton accelerators is required to match the optical functions between the SRF cavities/DTL cavities. The primary function of the lines is to keep the emittance growth of the output beam as low as possible. The transverse focusing of the beam is achieved by strong focusing quadrupoles. The Dipole correctors serve the function of a control element to achieve the desired transverse beam position and beam orbit correction. To minimize the emittance growth high magnetic field gradient is required in a highly constrained longitudinal space. Magnet construction and installation errors lead to differences between the actual beam orbit and intended beam orbit of the machine known as design orbit and reference orbit. Orbit correction is a fundamental requirement in the alignment and tuning

process of an accelerator. This document specifies all the technological specifications and requirements for manufacturing such items, assembly procedures, their qualifications and testing.

3.0 Details of deliverables and scope of supply

The list of the items to be fabricated, assembled, inspected, packed and safely delivered to the purchaser includes (reference documents and drawings attached):

Item no.	Description	Quantity
1.	Graded coil assemblies along with metallic bobbins and test certificate	12 sets.

The scope of the supplier includes:

- Preparation of manufacturing drawings on the basis of engineering drawings provided by the purchaser. Approval shall be taken from the purchaser on the prepared manufacturing drawings before the start of fabrication.
- Purchase of raw material as per technical specifications and produce test certificates for approval from purchaser before procuring.
- Manufacturing of coil winding as per Para 6.1 of this technical document.
- Inspection of the fabricated components as per Annexures.
- Packing of the magnet assemblies as per Para 6.2 in wooden suitcases and shipment of the same.

4.0 Vendor Qualification

Suppliers will be qualified based on technical evaluation. As this is a multi-disciplinary work hence supplier must have technically qualified and trained staff for both mechanical and magnetics jobs. Supplier must have required infrastructure and past experience of similar jobs. Supplier will be evaluated based on the information provided by the supplier as requested below. Purchaser's specialists may visit the supplier facilities for evaluation and for detailed technical discussions.

SN	Type of job	Outsourcing permissible (Yes/No)
1.	Preparation of manufacturing drawings on the basis of engineering drawings provided by the purchaser.	No
2.	Coil fabrication including bobbin fabrication, winding, varnish and epoxy hand lapping	No
3.	Coil Electrical and thermal tests	Yes

Purchaser's specialists may visit the supplier facilities for evaluation and for detailed technical discussions. Details to be furnished by the vendor related to facilities and expertise:

Particulars	To be filled by the vendor
Human resource (The supplier must give the complete detail of human resources including Engineers, Consultants (if any), Draftsmen, Technicians, Welder, Assembly Mechanic, quality control inspector, machinist etc.)	

Infrastructure:

The supplier must give the detail of infrastructure suitable for this jobs such as 3D Drafting software, Manufacturing machines, coil winding machines, electrical testing equipment, Assembly room, other tools and tackles, Inspection and Metrology facilities, building head room, overhead crane facility.

5.0 Details of Free Issue Material to be provided by the purchaser

No free issue material will be provided to the supplier. The physical, chemical, geometrical inspection reports of the raw materials should be provided to the purchaser by the supplier and the raw material shall be purchased only after approval from the purchaser.

6.0 Technical description of the job

This technical specification document includes fabrication, assembly, testing and supply of coil winding and bobbin assembly for Combined Function Electromagnetic Dipole Correctors. Precise fabrication and accurate qualification of the electromagnetic coils are very critical. The end use of these components demands fabrication within the tolerances and assembly of components which are covered in this document.

The dipole corrector is a window framed magnet with four legs made of soft iron. This forms the magnet yoke. Each of the four legs of the magnet is wound by electromagnetic coils. In each leg there are three sets of winding, one above the other giving a pyramidal look. This has been done to accommodate the required no of turns of the coil to generate the specified integral field strength within a small aperture and thus prevent the contact of the EM coils in the adjacent legs as well as minimizing the Magneto Motive Force (MMF) wastage. These coils provide the required to the magnets for generating MMF magnetic field in the aperture. These coils are wound using annealed copper wires having H-modified enameling wound on molded bobbins. The bobbins are fabricated out of copper metal sheets. The entire magnet assembly is placed upon an aluminium base platform which has groves and clamps to ensure that the magnet assembly has sufficient repeatability even after multiple assembling and disassembling procedures.

6.1 Coil Windings:

- Each leg of the window magnet is equipped with 3 racetrack coil windings (one above the other) of different no of turns and are connected in series as shown in the drawing no: A3-A02EMCA06. The size of the copper coils to be used and no of turns per coil winding is given in the table below.

Winding No.	Total Dimension (length x thickness)	Wire Gauge	No of turns
W-1 (Inner)	190 mm x 15 mm	4 mm x 2 mm	276
W-2 (Middle)	160 mm x 15 mm	4 mm x 2 mm	240
W-3 (Outer)	130 mm x 15 mm	4 mm x 2 mm	186
Total			702

- The current passing through these coils generate a MMF which in turn generates magnetic field needed for beam steering. The MMF depends on the no. of turns of the coil and thus the total no. of turns should be exactly what is specified for the required MMF to be achieved.
- The coils of each leg should be identical and interchangeable with the coils of other legs.

- The coils are made of rectangular cross section (4 mm x 2 mm) annealed copper conductor and vacuum pressure impregnated with vacuum compatible varnish. The finished coils shall behave in all respects as rigid units so that relative movements between turns due to the action of magnetic forces and thermal strains inside the windings are excluded.
- The insulation to be used in the coil windings is H-modified class of insulation which has a temperature range of 180°C.
- The inner coil (with the largest length) shall be wound on copper bobbin. The bobbin shall be formed by metal sheets. Sufficient electrical insulation shall be provided on the inner surface of the bobbin (winding side), leakage current between coil terminals and bobbin shall be less than 5 μ A at 1000 V. This is a critical requirement. The thickness of bobbin shall be 2 mm.
- The coil ends of each leg shall be connected to electrically insulated flexible copper connecting wires through terminal blocks. These blocks should be direct mounting type on the yoke of the DC. Recommended terminal blocks is Part number ATK10-4P of Toyogiken make.
- The technical specifications of the coil windings are listed below:

Sr. No	Parameter	Value	Unit
1.	Nominal current	10	A
2.	Maximum current	12	A
3.	Maximum stabilized voltage	25	V
4.	Resistance	0.6 \pm 5 %	Ω
5.	Conductor size	4 mm x 2 mm	
6.	Number of turns	702	Turns
7.	Number of Layers per leg	18	Layers
8.	Nominal current density	1.5	A/mm ²
9.	Maximum current density	1.7	A/mm ²
10.	Maximum power dissipation	50	watts
11.	Temperature rise	32	°C
12.	Weight of coil on each leg	27.5	kgs (approx.)
13.	Weight of yoke	25	kgs
14.	Insulation class	H modified	-

- The environment in which insulation and winding operations are to be done should be air conditioned.
- The coil winding should be done using a single continuous length of cable without any joints or overlaps.
- Appropriate mandrel must be used on which winding should be done and the conductor should be kept under proper mechanical conditions.
- To fill in all the pores in the coil winding, it shall be vacuum impregnated.
- A layer of thermally conductive epoxy shall be applied for protection.
- No epoxy shall be applied on leads.

6.2 Assembly of the magnets, packing and shipment:

- The coil assemblies shall be properly packed inside wooden boxes with proper lining and covering.
- Then they will be shipped to the purchaser with all the geometric, thermal and electrical qualification test certificates.

7 Acceptance criteria

Following are the acceptance criteria of the components and coils and other relevant parameters:

S.N.	Particulars	Acceptance criteria
1.	Visual	Any signs of damage, deterioration and oxidation shall not be present on any component. Loose terminal connection or wiring shall not be present.
2.	Qualification Assembled magnets	<ol style="list-style-type: none">1. Hi-pot Test between coil terminals and magnet yoke: Leakage current less than 5 micro Ampere at 1000 V DC.2. Ring test: Compared with reference coil. (G_o, No G_o test)3. Resistance: $0.60 \Omega \pm 5 \%$4. Turns: 702 (No deviation permitted)5. No. of layers per leg: 18
3.	Thermal Qualification	<ol style="list-style-type: none">1. After 12 hours of continuous operation, voltage across coils for fixed DC current shall be noted. (For each coil)2. Combined thermal heat run test with voltage tapping on individual magnet. (Applicable to magnet assembled in frames).

8 Price

The supplier shall give overall price and its break-up for all the deliverables mentioned. The overall price will be compared. The supplier shall offer prices in following format.

Item no.	Description	Quantity	Price per unit	Total price
1.	Copper coil winding on bobbins	12 nos.		

9 List of concept drawings attached

SN	Drawing title	Drawing Number
1.	Dipole Coil and Bobbin Assembly	A3-A02EMCA06

10 List of Appendix

SN	Appendix Name	Particular	Page No
1.	Appendix A	Qualification tests on coil assembly	7

11 General conditions

- All intellectual property rights belong to purchaser for work done under this technical specification/PO.
- Supplier shall maintain the authenticity of drawings or any related drawings/document provided by the purchaser.
- All activities would normally be carried with due professional care. However, purchaser shall not be responsible for any loss or personnel accident during execution of the work pertaining to the technical specifications under this PO.
- Supplier shall agree to hold in confidence all information provided by the purchaser.
- Supplier shall collaborate and coordinate all the work sub-contracted to any vendor.

- f. Publication if any pertaining to work of related to work under this purchase order can be done only after prior mutual consent of purchaser.
- g. All the raw materials required for deliverables except the Free Issue Material mentioned is in scope of supplier and the supplier should quote accordingly.
- h. Overall cost of all the items in the deliverables will be compared including packaging, forwarding and safe delivery to BARC RCZ stores and shall be quoted separately.
- i. Suppliers shall give complete details of their product & list of users for technical evaluation.
- j. Supplier shall submit along with the quotation, compliance certificate adhering to the specifications.

ANNEXURE A

(QUALIFICATIONS TESTS ON COIL ASSEMBLIES)

- The following electrical qualification tests need to be carried out with the coil assembly before assembly.

1. Winding Material Specifications

Sr. No	Parameter	Value
a)	Wire Gauge	
b)	Grade of conductor	
c)	ISO standard for winding material	
d)	Class of insulation	
e)	Thermal class	
f)	Chemical Base of insulation: (Modified polyester/Polyamide)	

2. Coil Specifications

Sr. No	Parameter	Value
a)	Total no of turns	
b)	Total no of windings	
c)	No of turns per layer	

3. Electrical Parameters

Coil No.	Dimensional Check					Remarks
	Resistance	Inductance @ 100 Hz	Q @ 100 Hz	Inductance @ 1 kHz	Q @ 1 kHz	Pass/fail

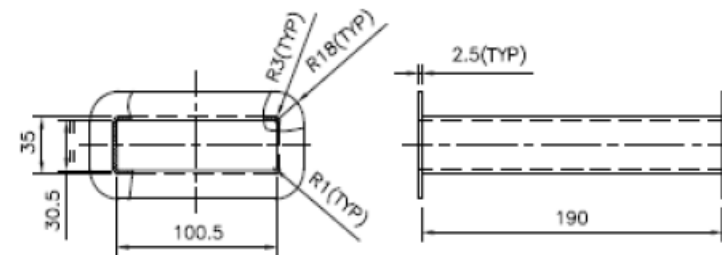
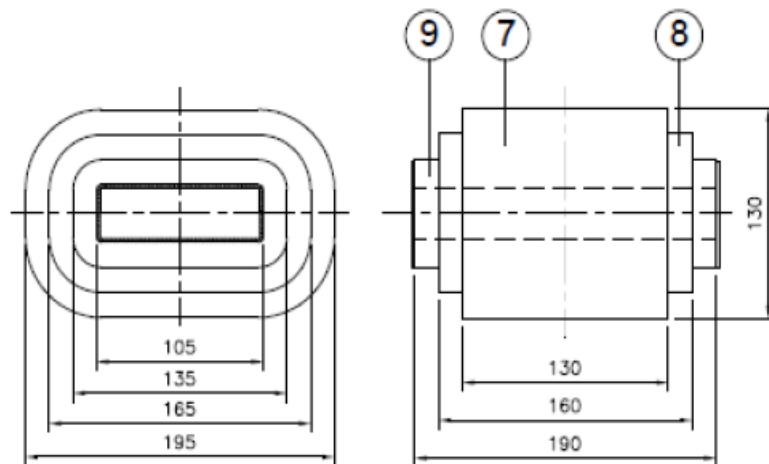
4. Ring Test

Coil No.	Pass/Fail

5. Hipot Test

Coil No.	Leakage Current Between Coil and Dummy Core

A maximum leakage current of 5 μ A is allowed at a coil to core voltage of 1000 V DC.



11 BOBBIN

Mat: ETP Copper
Qty: 12 nos.

COIL :

- COIL WINDING BIG : 190 LENGTH x 15 WIDTH
TURNS : 276
- COIL WINDING MEDIUM : 160 LENGTH x 15 WIDTH
TURNS : 246
- COIL WINDING SMALL : 130 LENGTH x 15 WIDTH
TURNS : 186

COPPER STRIP : 4 mm X 2 mm COPPER STRIPS
MATERIAL : ETP COPPER

7 8 9 11 DETAILS OF BOBBIN & COIL

APP'D.
SCALE 1:1
ALL DIMENSIONS ARE IN mm

DR'N	R.B.C. 28.04.17	PROJECT	M E B T
DRG. CHK'D.		GOVERNMENT OF INDIA BHABHA ATOMIC RESEARCH CENTRE ACCELERATOR CONTROL DIVISION	
DES'D.			
DES'N CHKD.			

REV.	DATE
DRG. No.	A3-A02EMCA06
SH	OF DATE