THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY
12000 Jefferson Avenue
Newport News, VA 23606

SPECIFICATION NUMBER:

MAG0000000S0051

TITLE:	Statement of Work: Generic Corrector Magnet Assemblies	DATE:	May 6, 2014
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REV.	ECO#	DESCRIPTION	BY	CHK.	APP.	APP.	DATE
SUMMARY OF CHANGES FROM PREVIOUS REVISION:							

STATEMENT OF WORK:

GENERIC CORRECTOR MAGNET ASSEMBLIES

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1 Scope

1.1 *Purpose*

This Statement of Work denotes the specific requirements, fabrication processes and geometric parameters necessary to produce Corrector Magnet Assemblies. Corrector Magnet Assemblies include the corrector core assembly, the coil assemblies and all of the subassemblies and parts necessary to produce a functional corrector magnet. This document has been published in such a way as to explicitly document the specific requirements of producing acceptable Corrector Magnet Assemblies.

1.2 Deliverables to Jefferson Lab

The following items shall be delivered to Jefferson Lab or to a subcontractor representing Jefferson Lab's interest at the Vendor's expense.

1.2.1 Corrector Magnet Assemblies fabricated in accordance with the documents specified in Section 2 of this statement of work, and in quantity as specified in the contract.

1.2.2 Quality control documentation as specified in Sections 3 and 4 of this text shall be published in Adobe (.pdf) format and submitted with each completed Corrector Magnet Assembly. In addition to electronic format, this documentation may also be provided hard copy inside the shipping container.

1.2.3 Significant excess materials such as: steel, conductor, parts, etc. purchased for but not used during manufacture of the Corrector Magnet Assemblies.

1.2.4 All component level tooling and fixturing required to fabricate the assemblies and subassemblies.

1.3 *Vendor Furnished Equipment, Material, and Services*

1.3.1 The Vendor shall submit a Manufacturing Plan for Jefferson Lab approval. The Vendor shall not begin fabrication of special tooling or components before Jefferson Lab has approved the Manufacturing Plan in writing. As a minimum, this plan shall include:

1. a time schedule for vendor's receipt of materials and or subassemblies
2. a schedule estimating delivery dates of first article and production corrector magnets
3. a description of the work flow sequence and processes, including quality control (QC) inspection hold points. The JLab Subcontracting Officer's Technical Representative (SOTR) will work with the vendor to determine which inspection hold points require SOTR validation prior to process continuation
4. the brand, model, and specification of QC inspection equipment (ie. Baker Hipot Surge Tester)
5. a detailed procedure for the inspection process
6. a quality plan that ensures conformance to the requirements of this document

1.3.2 Vendor shall provide all materials and material certifications to produce Corrector Magnet Assemblies.

1.3.3 Vendor shall provide facilities and equipment required for fabrication, assembly, testing, and inspection of subcomponents and complete assemblies.

1.3.4 Vendor shall provide, or subcontract, all labor to complete assemblies.

1.3.5 Any lower tier component, labor, services, or material shall be monitored by Vendor. Vendor is responsible for repairs, rework, or delays caused by their subcontractor or material suppliers.

1.4 *Jefferson Lab Furnished Equipment and Specifications*

Jefferson Lab will furnish a raw steel billet that shall be used to manufacture magnet core pieces.

2 Fabrication Documents

The following documents define materials, processes and dimensional requirements. It shall be the Vendor's responsibility to make sure all documents are of the "revision number" as specified in the contract.

2.1 *Statement of Work: MAG0000000S0051 – Generic Corrector Magnet Assemblies (this text)*

2.2 *Corrector Magnet Assembly Drawings – as specified in contract*

3 Requirements

3.1 *Dimensional Control Requirements*

Corrector Magnet Assemblies shall conform to geometry and tolerances as stated on the Jefferson Lab manufacturing drawings denoted in the contract.

3.2 *Material Requirements*

Corrector Magnet Assemblies shall only be fabricated of materials and components as stated on the manufacturing drawing bill of materials and this statement of work. No alternate sources, types, or count changes are allowed without prior written permission from JLab.

3.3 *Parts and Materials Control Requirements*

No magnetic chuck, magnetic lifting devices, or degaussing coils shall be used in the handling, machining and processing of steel pieces at any point in the manufacturing, transportation or assembly processes.

3.4 *Coil Fabrication Requirements*

3.4.1 Coil Fabrication

3.4.1.1 Individual coil assemblies shall be fabricated without any conductor joints or splices.

3.4.1.2 Terminal wire lugs shall be soldered to bare conductor after crimping.

3.4.1.3 Coil start and finish leads shall be anchored to the coil body as detailed on the Coil Assembly Drawing.

3.4.1.4 All coil lead wires shall be protected against shorts by applying heat shrink tubing, from the coil to the terminal lug ends.

3.4.1.5 When ground wrap is required, heat shrink polyester material, used for the ground wrap, shall be thoroughly saturated with epoxy and the wrapped assembly baked following the epoxy manufacturer's recommendations. Fixturing is recommended to assure no bulging of the material occurs or that excess epoxy is not allowed to build up on critical surfaces.

3.4.2 Coil Encapsulation

3.4.2.1 Wire turn-to-turn bonding and coil to cooling plate bonding shall be done by a vacuum pressure impregnation (VPI) process, or by a wet-layup method, as long as the wet-layup performance is consistent with VPI performance in the following areas:

- Equivalent dielectric properties
- Ability to maintain dimensional stability
- Provides a high degree of structural integrity
- Fully wetted matrix construction – for wet layup, this means generously applying epoxy between turns and layers to maximize wetting and encapsulation

3.4.2.2 Vendor shall use a degassed clear epoxy capable of withstanding a 180 C continuous duty operating temperature.

3.4.2.3 Excess epoxy shall be removed/cleaned so dimensional tolerances are maintained.

3.4.2.4 Vendor shall ensure that no lint, dirt or any other inclusion is encapsulated during the winding and curing process.

3.4.2.5 Coil surfaces shall be cleaned at stages of fabrication so that dusts, oils, and other contaminants are removed prior to final assembly and preparation for delivery to Jefferson Lab.

3.4.3 Cooling Tube and Plate (where required)

3.4.3.1 Where cooling tubes are required, they shall be capped during fabrication in order to exclude epoxy and other particulates. In addition, tubes shall be verified to be free of obstructions, internally cleaned, rinsed, dried/purged, and recapped prior to preparation for shipment.

3.4.3.2 Coil cooling plates shall be insulated, positioned, and secured to the coil body as called out on the Coil Assembly Drawing.

3.4.3.3 Insulating paper shall be cut to provide a slight overlap at the plate edge and thus assure complete electrical isolation between plate and coil body.

3.4.3.4 Cooling plates and insulating paper shall be bonded to the coil body with the same epoxy used in the coil potting. Fixturing is recommended to assure plates are properly positioned and that excess epoxy is not allowed to build up on the critical surface specified on the Coil Assembly Drawing.

3.5 *Core Assembly Fabrication Requirements*

3.5.1 The core shall be fabricated and inspected for geometric compliance according the appropriate manufacturing drawing. This shall be done prior to painting and application of bare metal protection.

3.5.2 Contact surfaces and QC inspection surfaces shall remain unpainted and coated with rust inhibitor.

3.5.3 If the steel is not provided by JLab, the steel shall be annealed after any cold work and/or prior to final machining according to the following prescription.

- Annealing temperature: 9300 -10000 Celsius
- Holding (Soaking) Time at Temp.: 3.5 hours minimum
- Maximum Cooling Rate: 270 Celsius/hour until 4000 Celsius
- Atmosphere: vacuum or Jefferson Lab approved equivalent

3.5.4 Steel shall not be handled or chucked by magnets at any time following the annealing process or receipt of steel from JLab.

3.6 *Total Magnet Assembly Fabrication Requirements*

3.6.1 Vendor shall measure and document the gap dimension of each assembly according to Section 3.8.2 and the manufacturing drawing. Any nonconformance found in this dimension warrants rejection of the assembly. Vendor shall notify Jefferson Lab of any discrepancy found.

3.6.2 Assembly and disassembly of magnet core pieces shall be performed in a clean environment to assure no foreign particulates are trapped between mating surfaces.

3.6.3 Core assembly hardware shall be torqued to the values specified on the appropriate manufacturing drawing.

3.6.4 Coil leads shall be routed along the core as shown on the assembly drawing. Wires may be bundled together using cables ties to improve structural integrity and appearance.

3.6.5 Routing and bundling of wires and cooling tubes, as applicable, should permit easy splitting of the assembled magnet into top and bottom pieces for installation around the vacuum chamber at Jefferson Lab.

3.6.6 Routing and bundling of coil leads and cooling tubes, as applicable, shall be developed on the First Article Magnets and approved by Jefferson Lab (see Section 4.3.3 of this text) before remaining magnets' coil leads are terminated.

3.7 *Coil Testing Requirements*

In addition to dimensional inspections, electrical testing shall be performed on all coils. These testing parameters, and subsequent results, shall be recorded on a Quality Control Data Sheet (Attachment #1) for each coil.

3.7.1 Hi-Pot Test

Vendor shall test for insulation integrity by performing a Hi-Pot Test. This to be done, if possible (depending on fabrication sequence), while coil is in the curing fixture.

3.7.1.1 Specific test parameters:

- schematic: as shown on the Coil Hi-Pot Test Schematic (Attachment #2)
- duration of test: one minute after coil saturation
- ground plane: aluminum foil, cooling plates, and curing fixture
- dielectric potential: 1,500 Volts DC

3.7.1.2 Acceptance criteria: a recorded leakage current of less than 10 micro Amperes.

3.7.2 Surge Comparison (Turn-to-Turn) Test

Vendor shall objectively prove and document that any delivered coil has the appropriate number of turns and that no turn-to-turn shorts exist. This shall be done by performing a Surge Comparison Test (Attachment #3) between a "Standard Coil" and each production coil.

3.7.2.1 The "Standard Coil" shall be a coil randomly selected from the production line and singly tested for shorted turns.

3.7.2.2 Individual Coil Specific Testing Parameters:

- Peak Voltage: 2000 Volts
- Induction mode: no core
- Frequency: 60 to 400 Hz
- Schematic: as shown on Attachment #3
- Equipment: Baker model # ST112E, or Jefferson Lab approved equal

- Data: a surge test oscilloscope trace comparing a given test coil to the "Standard Coil"

3.7.2.3 An "unacceptable variation" shall then be defined and witnessed by the Jefferson Lab SOTR. This test shall be performed according to the parameters in section 3.7.2.2 and consist of three steps:

3.7.2.3.1 Vendor shall demonstrate that the "standard" coil and others test and measure identically. This sets the zero baseline and tester calibration.

3.7.2.3.2 Vendor shall demonstrate that the addition of one extra turn (in series) to one of the coils produces a discernable variation in the baseline oscilloscope trace.

3.7.2.3.3 Vendor shall demonstrate that the addition of one shorted turn (in parallel) produces a discernable variation in the baseline oscilloscope trace.

3.7.2.4 All other production coils shall then be tested (ie compare each coil to the "Standard Coil".)

3.7.2.5 Acceptance criteria: any coil that does not exceed the "unacceptable variation" will be accepted.

3.8 *Core Assembly Quality Control Inspections*

3.8.1 Vendor shall perform detailed dimensional inspections on core assemblies during the manufacturing process to provide proof of compliance to the specified dimensional tolerances.

3.8.2 Vendor shall measure and document the gap distance between pole plates. This shall be done in five places: geometric center and 0.5 inches in from each corner. As well as measure and document the alignment of the core halves and parallelism of the assembled pole faces as specified in the manufacturing drawing.

3.8.3 Vendor shall verify that no gap exists between core pieces and that all surfaces are aligned according to the assembly drawing.

3.9 *Total Magnet Assembly Quality Control Inspections*

3.9.1 Vendor shall maintain a documentation package for each magnet assembly. This package shall:

3.9.1.1 Provide manufacturing and QC documentation for all coil assemblies as specified in Section 3.7 of this text.

3.9.1.2 Provide manufacturing and QC documentation for the core assembly as specified in Section 3.8 of this text.

3.9.1.3 Provide manufacturing and QC inspection records for the completed magnet assembly as specified in Section 3.9.2 thru 3.9.4 of this text.

3.9.2 **Hi-Pot Test** – Each assembly shall be tested for ground shorts by testing with a Hi-Pot tester according to the following parameters:

- Potential: 1500 VDC
- High Side: All coil leads
- Ground Plane: Cooling tubes and core
- Duration: One minute after saturation
- Acceptance criteria: A recorded leakage current of less than 10 microamps.
- Test results are to be documented for each assembly.

3.9.3 **Pressure Test** – When applicable, Corrector cooling systems shall be leak tight tested and documented to internal pressure of 225 psi for thirty minutes and visually verify that no water leaks exist.

3.9.4 **Flow Test** – When applicable, Cooling system shall be water flow tested to ensure no restriction exists in tubing. The flow rate shall be recorded at a differential pressure of 50 psi. The required flow rate of 0.3 gpm or greater should be obtained at 50 psi differential pressure.

3.10 *Corrector Magnet Assembly Unit Identification*

3.10.1 Identification Tag

Vendor shall supply and attach durable identification tags at the locations specified on the Magnet Assembly Drawing. Tags shall contain the following information in a clearly visible and legible form:

- Five character magnet assembly serial number. The first two characters shall be the magnet design (*ie.*. 'BD'). The last three characters shall be the three digit serial number associated with the magnet. Serial numbers shall run sequentially beginning with 000 as the prototype serial number.
- Magnet assembly weight
- Vendor's corporate name (or logo)
- Magnet assembly name and Magnet Assembly Drawing number including the latest revision. (*ie.* BD Corrector – MAG-002-0003-0001, Rev. -)
- Date of manufacture in the format "mm/dd/yyyy".

4 Quality Assurance

4.1 *QA Program*

The Vendor shall maintain a documented quality assurance program that shall ensure each item offered for acceptance conforms to this Statement of Work and its documentation subsets. This QA program shall contain the mechanism for:

4.1.1 Inspection of all materials received from Vendor's suppliers and subcontractors and the form of record keeping.

4.1.2 Obtaining and recording of all material certifications, annealing certifications, and chemical or mechanical analyses for the core plates, cooling tube, conductor and cooling plates as applicable.

4.1.3 The calibration of instruments and personnel training for the testing requirements of this effort (if applicable).

4.1.4 Genealogy of data records such that each assembly may be traced back to purchased components.

4.1.5 Final inspection and review of documentation packages.

4.2 *Visitation by Jefferson Lab*

Jefferson Lab reserves the right to have its QA representative and/or Subcontracting Officer witness any or all manufacturing steps, tests, and inspections established under the vendor's Quality Assurance program. This may be necessary to demonstrate compliance with this specification.

4.3 *First Article Approval*

4.3.1 The first article magnet assembly shall be qualified by the inspection criteria and documentation described in this document. The magnet assembly and the inspection data set shall be presented to Jefferson Lab for evaluation.

4.3.2 Jefferson Lab will accept or reject each first article Corrector Magnet Assembly within thirty calendar days of its receipt or of its inspection at the Vendor’s site.

4.3.3 Termination of coil wire leads or coil copper tubing shall not occur on the remaining population until the First Article is accepted by the Jefferson Lab SOTR in writing.

4.4 *Criteria for Acceptance*

4.4.1 Acceptance criteria: full compliance with this text and its documentation subsets.

4.4.2 Upon receipt, Jefferson Lab will inspect each magnet assembly. Any unit failing to meet the criteria set out herein will be considered to have failed incoming inspection and will be returned to the Vendor for repair or replacement. In such instances the Vendor shall incur all expenses including shipping costs.

5 Preparation for Shipment

All deliverables, including documentation, shall be cataloged and offered for acceptance to Jefferson Lab, or to a subcontractor representing Jefferson Lab's interest.

5.1 Vendor shall protect all magnet assemblies and documentation packages from damage by appropriate packing or crating. Crates or pallets shall be built for handling with slings from overhead cranes and for forklift transport. Packaging shall protect the assemblies from damage in transit and from weather during transit and outdoor storage.

5.2 Each magnet assembly shall be bagged in clear polyethylene plastic and with desiccant salt packets added for moisture protection.

5.3 Each crate or pallet shall be marked with the addressee, shipper, contract number, contents, and shipping weight.

5.4 A complete copy of manufacturing records (quality control and test results) shall accompany each completed magnet assembly.

5.5 Vendor shall arrange shipping.

Attachment 1
Corrector Coil Quality Control Inspection Form

Serial Number: _____ Manufacturer: _____

Wire Spool Data

- Conductor Manufacturer: _____
- Lot or Batch Number: _____
- Inspector Name and Date: _____

Winding Data

- Fixture Number: _____
- Free Diameter in Inches: (including insulation)
  Start of Coil Wind: _____
  End of Coil Wind: _____
- Number of Turns: _____
- Comments or Observations: _____
  _____
- Assembler Name and Date: _____

Potting Data

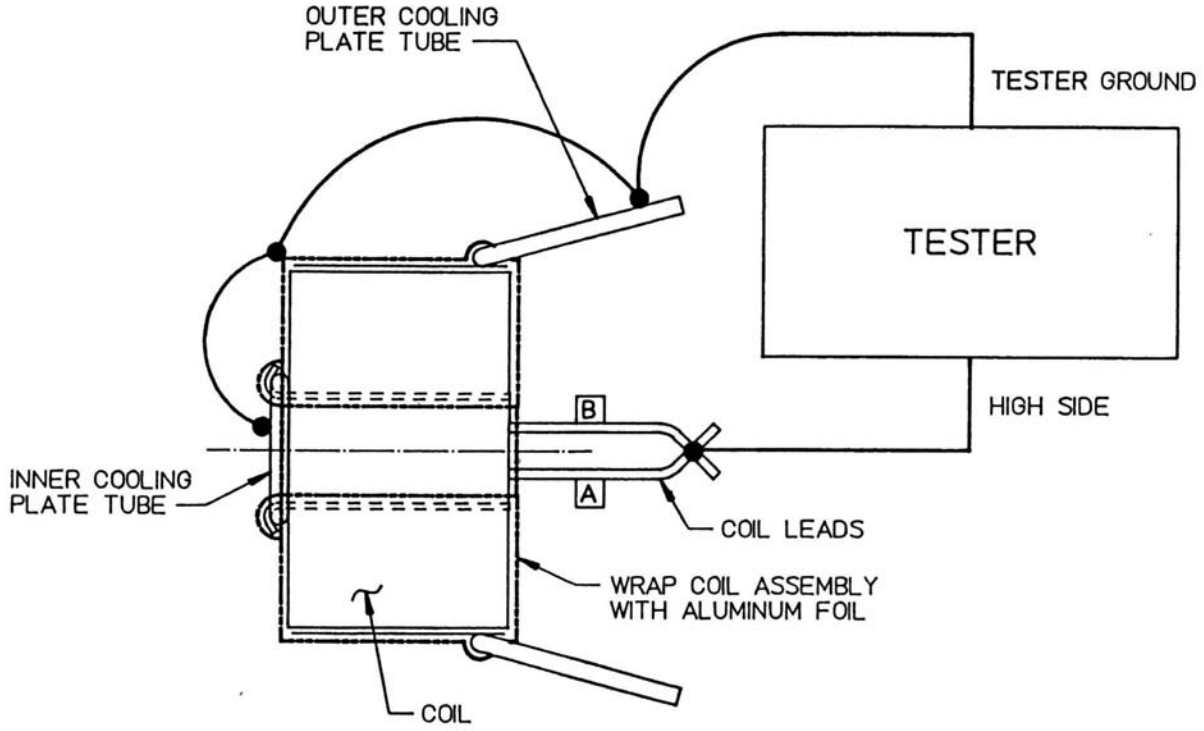
- Epoxy Manuf. and Type: _____
- Epoxy Batch Number: _____
- Cure Temperature: _____
- Cure Time: _____
- Assembler Name and Date: _____

Test Data

- Hi-Pot Testing Results: _____
- Surge Testing Results _____
- Tester Name and Date _____

Attach any additional data sheets or comments to this QC document.

Attachment 2
Coil Hi-Pot Test Schematic



Attachment 3
Coil Surge Test Schematic