Individual Quality Control Plan for WBS 6.10.07 (Solenoid Magnet)

Prepared by:

{{Sig_es_:signer1:signature}} Date: **{{Dte_es_:signer1:date}}**
Name, Role
Electron-Ion Collider
Institution

Reviewed by:

{{Sig_es_:signer2:signature}} Date: **{{Dte_es_:signer2:date}}**
Name, Role
Electron-Ion Collider
Institution

{{Sig_es_:signer3:signature}} Date: **{{Dte_es_:signer3:date}}**
Name, Role
Electron-Ion Collider
Institution

{{Sig_es_:signer4:signature}} Date: **{{Dte_es_:signer4:date}}**
Name, Role
Electron-Ion Collider
Institution

Approved by:

{{Sig_es_:signer5:signature}} Date: **{{Dte_es_:signer5:date}}**
Name, Role
Electron-Ion Collider
Institution

CC List:

Name or Group
Name or Group
Name or Group
Name or Group

REVISION HISTORY

Revision #	Effective Date	Additional Reviewers	Summary of Change
00			Initial release.

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LIST OF ACRONYMS

BNL	Brookhaven National Laboratory
EIC	Electron-Ion Collider
FRD	Functional Requirements Document
GRD	General Requirements Document
JLAB	Thomas Jefferson National Accelerator Facility
MIP	Manufacturing Inspection Plan
PRD	Performance Requirements Document
QC	Quality Control

Individual Quality Control Plan for WBS 6.10.07 (Solenoid Magnet)

1. BACKGROUND & PURPOSE

Individual product Quality Control Plans are an extension of the overall Detector Systems Product Quality Control Plan and provide detailed descriptions of the quality control factors that are relevant to a specific product. Like all Quality Control Plans, they are required by the EIC Requirements Management Plan and are used to ensure that a system or deliverable will satisfy all pertinent requirements and specifications.

The plan should be developed in accordance with the requirements of the EIC Project Plans and Documents referenced in Table 1.

Table 1. EIC Project Plans and Documents

Document Name	Document Number
Integrated Safety Management Plan (ISMP)	EIC-ESH-PLN-007
Global Requirements Document (GLRD)	add document number
Requirements Management Plan (RMP)	EIC-SEG-PLN-016
General, Functional, and Performance Requirements for the EIC Detector Systems	EIC-SEG-RSI-007
Interface Requirements for the EIC Detector Systems	EIC-SEG-RSI-064
Interface Management Plan (IMP)	add document number
EIC Code of Record	EIC-ORG-RSI-026
Configuration Management Plan	EIC-ORG-PLN-025
EIC Quality Assurance Plan	EIC-QAG-PLN-002
Detector Systems Product Quality Control Plan	
Pressure Systems Design Authority	JLAB ES&H Manual 6151
JLAB Conduct of Engineering Manual	ENG-AD-01-001

1.1. Responsibilities

Per the Quality Assurance Plan, L3 Managers are responsible for developing Quality Control (QC) Plans for their areas of responsibility and are to ensure that:

- the plans are available and controlled,
- teams are working in accordance with the plans, and
- plans are review at an adequate frequency to identify need for change, or to support advance planning of acquisitions and procurements (whether tangible or services, like designs) from other providers (Vendors, In-Kind Contributors, Partners)

1.2. Categories of Producers

In general, all sub-systems and components in the Detector System will be obtained from one of three possible sources: vendor contract, institutional partner, or in-house construction. These sources are described in detail in the Detector Systems Product Quality Control Plan.

2. SCOPE OF QUALITY CONTROL PLAN

This Individual Quality Control Plan addresses the components within WBS 6.10.07 (Solenoid Magnet) that require supplemental documentation beyond what is provided in the Detector Systems Product Quality Control Plan. This section will identify the pertinent components or assemblies within the WBS that are covered by this plan, and will identify the category of provider (vendor contract, institutional partner, or in-house construction), and the approach for quality assurance that will be used for that product.

2.1. Conductor (Strand)

This component is composed of multiple sub-components, each of which has their own quality assurance requirements which are detailed in this document. These include:

- Material Purchase

The following quality control measures are required:

- In-Process Inspection and Test — Section 4/5
- Travelers, Procedures, and Checklists — Section 7
- Deliverable Documentation and Records — Section 9
- Planned Partner and Vendor Communication & Visits — Section 13
- Control of Nonconformances — Section 14

2.2. Conductor (Cable)

This component is composed of multiple sub-components, each of which has their own quality assurance requirements which are detailed in this document. These include:

- Material Purchase

The following quality control measures are required:

- In-Process Inspection and Test — Section 4/5
- Travelers, Procedures, and Checklists — Section 7
- Deliverable Documentation and Records — Section 9
- Planned Partner and Vendor Communication & Visits — Section 13
- Control of Nonconformances — Section 14

2.3. Conductor (Channel)

This component is composed of multiple sub-components, each of which has their own quality assurance requirements which are detailed in this document. These include:

- Material Purchase

The following quality control measures are required:

- In-Process Inspection and Test — Section 4/5
- Travelers, Procedures, and Checklists — Section 7
- Deliverable Documentation and Records — Section 9
- Planned Partner and Vendor Communication & Visits — Section 13
- Control of Nonconformances — Section 14

2.4. Conductor (Soldered)

This component is composed of multiple sub-components, each of which has their own quality assurance requirements which are detailed in this document. These include:

- Material Purchase

The following quality control measures are required:

- In-Process Inspection and Test — Section 4/5
- Incoming Inspection and Acceptance Test — Section 6
- Travelers, Procedures, and Checklists — Section 7
- Verification Plans, Methods, and Activities — Section 8
- Deliverable Documentation and Records — Section 9
- Planned Partner and Vendor Communication & Visits — Section 13
- Control of Nonconformances — Section 14
- Packaging/Transportation/Shipping — Section 15

2.5. Magnet Power Supply

This component is composed of multiple sub-components, each of which has their own quality assurance requirements which are detailed in this document. These include:

- Material Purchase

The following quality control measures are required:

- In-Process Inspection and Test — Section 4/5
- Incoming Inspection and Acceptance Test — Section 6
- Travelers, Procedures, and Checklists — Section 7
- Deliverable Documentation and Records — Section 9
- Calibration Plans — Section 11
- Serialization and Material Traceability Requirements — Section 12
- Planned Partner and Vendor Communication & Visits — Section 13
- Control of Nonconformances — Section 14
- Packaging/Transportation/Shipping — Section 15

2.6. Magnet

This component is composed of multiple sub-components, each of which has their own quality assurance requirements which are detailed in this document. These include:

- Material Purchase

The following quality control measures are required:

3. REQUIREMENTS TRACEABILITY

Requirement traceability will be accomplished as described in Section 3 of Detector Systems Product Quality Control Plan.

SPECIFIC QUALITY CONTROL MEASURES

4. IN-PROCESS INSPECTION AND TEST

In-process inspections and tests for components **built in-house** provide a mechanism for detecting non-conformances in materials, components, or assemblies during fabrication and assembly. This allows problems to be identified and corrected as early as possible, minimizing the impact of manufacturing deficiencies.

Test plans, technical reports, test results, and other documentation resulting from these inspections and tests will be compiled into a report and placed in the central data repository. The document will be referenced through the document index on the EIC Systems Engineering portal.

This section is not applicable.

5. OUTSOURCING: VENDOR/PARTNER/CONTRIBUTORS IN-PROCESS

In-process inspections and tests for outsourced components will be addressed differently for each category of providers. In all cases that tests and inspections are required, a test plan will be developed and approved by the project.

Test plans, technical reports, test results, and other documentation resulting from these inspections and tests will be compiled into a report and provided to the project as part of the deliverable. This report will be reviewed, validated, and then placed in the central data repository. The document will be referenced through the document index on the EIC Systems Engineering portal.

5.1. Conductor (Strand)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

5.1.1. Material Purchase

This component will be produced as part of a vendor contract and the inspections and tests are identified in the Statement of Work. Additional information is provided in the reference: Magnet Conductor Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/ConductorITP.pdf

5.2. Conductor (Cable)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

5.2.1. Material Purchase

This component will be produced as part of a vendor contract and the inspections and tests are identified in the Statement of Work. Additional information is provided in the reference: Magnet Conductor Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/ConductorITP.pdf

5.3. Conductor (Channel)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

5.3.1. Material Purchase

This component will be produced as part of a vendor contract and the inspections and tests are identified in the Statement of Work. Additional information is provided in the reference: Magnet Conductor Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/ConductorITP.pdf

5.4. Conductor (Soldered)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

5.4.1. Material Purchase

This component will be produced as part of a vendor contract and the inspections and tests are identified in the Statement of Work. Additional information is provided in the reference: Magnet Conductor Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/ConductorITP.pdf

5.5. Magnet Power Supply

This component is composed of multiple sub-components/activities which have independent quality control parameters.

5.5.1. Material Purchase

This component will be produced as part of a vendor contract and the inspections and tests are identified in the Statement of Work. Additional information is provided in the reference: MPS Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/MPSITP.pdf

5.6. Magnet

This component is composed of multiple sub-components/activities which have independent quality control parameters.

5.6.1. Material Purchase

This component will be produced by an industry partner as an in-kind contribution and the inspections and tests are identified in the Project Planning Document. Additional information is provided in the reference: Magnet Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/MagnetITP.pdf

6. INCOMING INSPECTION AND ACCEPTANCE TESTS

Incoming inspections and acceptance tests are used to confirm that materials or products provided by a vendor or partner institution have been produced in accordance with the plans and specifications, and meet all system requirements. These plans should be developed in conjunction with the transportation and shipping plans to account for potential impacts of moving items between locations.

Incoming inspections and acceptance tests will be addressed differently for each category of providers. These documents identify the schedule and frequency of such tests, how the results will be reported, and which material and documentation should be supplied to the project with the deliverable.

Test plans, technical reports, test results, and other documentation resulting from these inspections and tests will be compiled into a report and placed in the central data repository. The document will be referenced through the document index on the EIC Systems Engineering portal.

6.1. Conductor (Soldered)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

6.1.1. Material Purchase

This component will be produced as part of a vendor contract and the inspections and tests are identified in the Statement of Work. Additional information is provided in the reference: Magnet Conductor Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/ConductorITP.pdf

6.2. Magnet Power Supply

This component will be produced as part of a vendor contract and the inspections and tests are identified in the Statement of Work. Additional information is provided in the reference: MPS Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/MPSITP.pdf

6.3. Magnet

This component will be produced by an industry partner as an in-kind contribution and the inspections and tests are identified in the Project Planning Document. Additional information is provided in the reference: Magnet Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/MagnetITP.pdf

7. TRAVELERS, PROCEDURES, AND CHECKLISTS

For every item that is manufactured, the manufacturer will be responsible for maintaining records (travelers) of all raw material that are used in the fabrication process, and document the processes and procedures that were used for production. The resultant documentation will be compiled into a report and will be provided to the project as part of the deliverable. This report will be reviewed, validated, and then placed in the central data repository. The document will be referenced through the document index on the EIC Systems Engineering portal.

7.1. Conductor (Strand)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

7.1.1. Material Purchase

- In Process Inspections

  The vendor will provide the material certification, critical measurement at 3, 4 and 5 Tesla field, and RRR (Residual Resistivity Ratio). These measurements will be repeated after sharply bending the strand as well. The vendor will also perform the eddy current test during manufacturing to detect inclusions, voids, cracks and filament defects. This data will be provided for the strands from all the billets used for the complete production of the conductor.

- In Process Inspections

  Technical representative will witness some of these tests at the vendor site.

7.2. Conductor (Cable)

- In Process Inspections

  The cable current will be estimated based on 3 extracted strands after making the cable, critical current will be measured at 3, 4 and 5 T on these extracted strands. The degradation will be checked against the

specification. RRR will also be measured for these 3 extracted strands. The cable will be bend on 20 mm diameter rod and then the same measurement will be repeated for the bend samples.

- In Process Inspections

  Technical representative will witness some of these tests at the vendor site.

7.3. Conductor (Channel)

- In Process Inspections

  The vendor should provide JLab the chemical properties, the copper resistivity at room temperature (293 K), the RRR and the 0.2% yield stress of the copper incorporated in the copper channel before manufacturing of the copper channel begins. The vendor should define the exact internal channel dimensions and corner radius. The vendor should also measure the RRR and the 0.2% yield stress of the final copper channel before cable insertion. The value of the residual resistance ratio should satisfy the final specification. The copper channel stabilizer will have a corner radius adapted to the cladding process. No cold weld is allowed in a unit length.

  The external aspect of the copper channel must not present surface defects, scratches, burrs, etc. It must not include voids, metallic inclusions, and cracks nor rupture spots. The stabilizer external dimension of the reference design (after calibration) is 11.4 mm x 4.6 mm. The vendor will define the exact internal channel dimension of the stabilizer to allow the cable insertion and clamping. In case of tin alloy solder tinning of the copper channel stabilizer, the bath temperature and soldering speed shall be controlled.

  The dimensions of the channel do not directly concern the dimension of the final conductor, but its tolerances can make variation on the final tolerances. Especially, the groove dimensions variations can reduce the crimping quality of the cable in the final conductor. No cold welds are allowed for the channel unit lengths.

- In Process Inspections

  Not applicable.

7.4. Conductor (Soldered)

- In Process Inspections

  The soldered conductor critical current will be estimated based on 3 extracted strands after making the soldering, critical current will be measured at 3, 4 and 5 T on these extracted strands. The degradation will be checked against the specification. RRR will also be measured for these 3 extracted strands. The conductor will be bend on 40 mm diameter rod and then the same measurement will be repeated for the bend samples. The minimum acceptance criterion for critical current is 13,800 A and 3T field. The details of all the tests are given in the conductor specification document.

- In Process Inspections

  Not applicable.

7.5. Magnet Power Supply

- In Process Inspections

The factory acceptance and the site acceptance are detailed in the magnet power supply specifications document.

7.6. Magnet

- In Process Inspections

  The magnet vendor will include the material traceability in their design, this will include coils, mandrel, tie rods and all the vessels. The Vendor is to create a master tracking spreadsheet which lists all vender-performed activities and required deliverables, which includes documents and records.

- Production/Fabrication Process Records

  The Vendor will provide the complete list of travelers and procedures which are to be submitted to JLAB. The travelers will include all the manufacturing details and associated data. TR and engineering teams will be at the vendor site to witness all the critical and crucial processes.

- In Process Inspections

  JLab will hold regular reviews and periodic meetings with the vendor during manufacturing design and manufacturing phase. There will be well defined hold points and witness points where TR and engineering team will be present at the magnet vendor site. The vendor will provide JLab a documented transportation plan for approval, this plan should include the route, methods of shipping, use of accelerometers, any dedicated material handling equipment or hardware.

8. VERIFICATION PLANS: METHODS AND ACTIVITIES

Verification plans are used to coordinate the orderly scheduling of events by providing equipment specifications and organizational requirements, the test methodology to be employed, a list of the test materials to be delivered, and a schedule for user (tester) orientation and participation. Finally, it provides a written record of the required inputs, execution instructions, and expected results of the system test.

The resultant documentation will be compiled into a report and will be provided to the project as part of the deliverable. This report will be reviewed, validated, and then placed in the central data repository. The document will be referenced through the document index on the EIC Systems Engineering portal.

8.1. Conductor (Soldered)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

8.1.1. Material Purchase

- External Verification

  This component will be produced as part of a vendor contract and the verification plans are identified in the Statement of Work.

8.2. Magnet

- Verification as Part of Assembly

This component is part of a larger system that will be tested as a complete assembly. Details are provided in the reference: Magnet Inspection and Test Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/MagnetITP.pdf

9. DELIVERABLE DOCUMENTATION AND RECORDS

Documentation and records that must be provided to the project is specified in the Statement of Work, Project Planning Document, work agreement, or work planning documents identified in the preceding sections. All testing and inspection data that is collected as part of the validation, verification and testing plan will be provided to the project as part of the final report.

10. ASSOCIATED EQUIPMENT

Associated equipment describes tools, parts, materials, components, fixtures and assemblies that are independent of the final product. Any associated equipment that must be delivered to the project is identified in the Statement of Work, Project Planning Document, work agreement, or work planning documents identified in the preceding sections. Conditions of acceptance of this material will be described in the validation, verification and testing plan.

Associated equipment that is required for in-house testing is as follows:

10.1. Magnet

This component is composed of multiple sub-components/activities which have independent quality control parameters.

10.1.1. Material Purchase

The magnet will be delivered to BNL. The magnet will go through the receiving inspection check list. After that magnet will be assembled at BNL site and cold tested at lower current and up to operating current. The field mapping will be done with all the detectors in place.

11. CALIBRATION PLANS

Vendors, partners, and employees shall calibrate any measuring and test equipment used in production or testing against certified standards that are traceable to national standards such as the National Institute of Standards and Technology (NIST), or an international standard, or a physical constant. Specific requirements for calibration plans are described in the Detector Systems Product Quality Control Plan.

11.1. Magnet

This component is composed of multiple sub-components/activities which have independent quality control parameters.

11.1.1. Material Purchase

A calibration plan is required for this component. Details are available from reference: Solenoid Magnet Mapping Plan, which is available from the link below:

https://eic.jlab.org/Documents/DET/Quality/ITP/MAG/MagnetMappingPlan.pdf

12. SERIALIZATION AND MATERIAL TRACEABILITY REQUIREMENTS

Requirements for serialization of parts and materials are as described below.

12.1. Conductor (Strand)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

12.1.1. Material Purchase

This component cannot be serialized because it would degrade overall detector performance. No serialization will be performed.

12.2. Conductor (Cable)

This component cannot be serialized because it would degrade overall detector performance. No serialization will be performed.

12.3. Conductor (Channel)

This component cannot be serialized because it would degrade overall detector performance. No serialization will be performed.

12.4. Conductor (Soldered)

This component cannot be serialized because it would degrade overall detector performance. No serialization will be performed.

12.5. Magnet Power Supply

Serialization of this component is required by Statement of Work.

12.6. Magnet

This component cannot be serialized because it would degrade overall detector performance. No serialization will be performed.

13. PLANNED PARTNER AND VENDOR COMMUNICATION & VISITS

Periodic program technical and progress telecommunications and/or meetings between the vendors/partners and project leaders will be conducted to discuss work progress, technical and contractual questions, presentations of analysis or testing results, troubleshooting, material status, tooling status, resources, and manufacturing issues. The schedule and frequency of these communications is described below.

In addition to the information provided here, technical updates and progress reports may also be provided at the regularly scheduled detector collaboration meetings. The schedule is available at https://indico.bnl.gov/category/402/calendar.

13.1. Conductor (Strand)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

13.1.1. Material Purchase

The communication schedule for this component is provided in the Statement of Work.

13.2. Conductor (Cable)

The communication schedule for this component is provided in the Statement of Work.

13.3. Conductor (Channel)

The communication schedule for this component is provided in the Statement of Work.

13.4. Conductor (Soldered)

The communication schedule for this component is provided in the Statement of Work.

13.5. Magnet Power Supply

The communication schedule for this component is provided in the Statement of Work.

13.6. Magnet

The communication schedule for this component is provided in the Project Planning Document.

14. CONTROL OF NONCONFORMANCES

Vendors, partners, and in-house providers are responsible to provide items which conform to the requirements of the contract or work agreement, regardless of any assessments, surveillances, inspections and/or tests that are conducted as part of the validation and verification process. Non-conformances, significant variations in quality, recalls, and alerts will be reported to the project.

15. PACKAGING/TRANSPORTATION/SHIPPING

In preparation for shipping, a packaging plan will be developed that will be reviewed and approved by the project prior to shipment. Preservation, packaging, and packing for shipment or mailing of all work deliverables shall be in accordance with standard commercial practice and adequate to insure acceptance by common carrier and safe transportation at the most economical rates.

Packaging plans must comply with the standards established in the Detector Systems Product Quality Plan.

15.1. Conductor (Soldered)

This component is composed of multiple sub-components/activities which have independent quality control parameters.

15.1.1. Material Purchase

The packaging plan for this component is included in the Statement of Work.

15.2. Magnet Power Supply

The packaging plan for this component is included in the Statement of Work.

15.3. Magnet

The packaging plan for this component is included in the Project Planning Document.