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HFIR GP-SANS V-Cavity Equipment Specification

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1. Introduction

The High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) is a high-flux research reactor that, in addition to isotope production, serves as a steady-state neutron source for a suite of neutron scattering instruments. Among these, the General-Purpose Small-Angle Neutron Scattering (GP-SANS) instrument is being upgraded to incorporate incident beam polarization capabilities. This enhancement will enable spin-resolved SANS measurements, allowing for the separation of nuclear and magnetic scattering components and facilitating studies of magnetic order, spin textures, and correlated spin structures. A critical component of this upgrade is the integration of a polarizing cavity, which utilizes magnetized supermirrors or transmission-based polarizers to produce a beam of neutrons in a well-defined spin state prior to their interaction with the sample. This capability is essential for conducting polarization analysis and advanced techniques such as polarization contrast measurements and vector-magnetic SANS.

2. Scope

Herein, Seller refers to parties responsible for providing the fabricated Polarizer assembly within the scope of this specification. The term “Company” refers to UT-Battelle, LLC and its representatives, including the HFIR.

This specification defines requirements for materials of construction, fabrication, inspection, and delivery to the Company of a complete polarizing cavity and magnetic housing assembly. The polarizing cavity and magnetic housing assembly shall be installed at the GP-SANS instrument.

The polarizing cavity and magnetic housing assembly, hereinafter referred to as the polarizer, is described in the following sections. Any minor part not specifically defined, but required for complete assemblies, shall be considered included herein, unless specifically excluded.

The Seller is responsible for fabrication, inspection, packaging, and shipping a complete polarizer in accordance with the requirements of this specification. Any exceptions to this specification shall be clearly noted as such in the Seller’s proposal documentation. Where exceptions are taken, the Seller shall propose alternatives.

3. Equipment Specification

The polarizer shall accommodate the existing collimated beam profile, accept the full beam size (4 cm x 4 cm) and divergence, and have a super mirror coating (m=1). The system shall be optimized for a broad wavelength band, transmitting neutrons with wavelengths ranging from 4 Å to 10 Å, with the optional capability of going down to 2.8 Å – or longer than 10 Å . To preserve the existing optical alignment and beam conditioning downstream, the polarizer shall operate in transmission geometry and be positioned in collimator box 1 (see figure 1) to ensure compatibility with the instrument's current beamline architecture and scattering geometry. The polarizer will be positioned in Collimator Box 1 to suppress stray scattering, while ensuring that it does not interfere with standard instrument configurations used for non-polarized experiments.

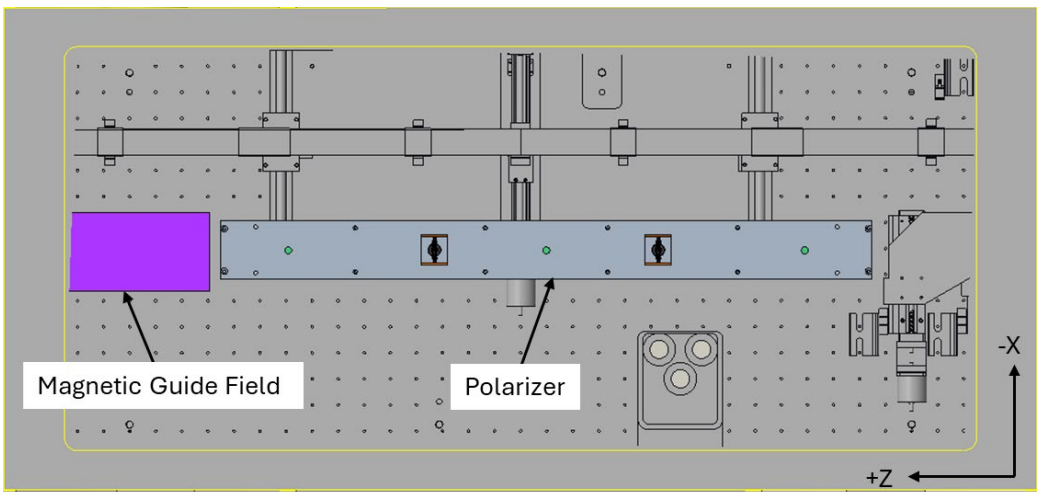

Figure 1: Collimator box 1 with polarizer and magnetic guide field

Requirements

ID	Requirement	Value
3.1	The polarizer guide body shall be a maximum of [z max] long in the z and a minimum of [z min].	[z max]: 1500 mm [z min]: 1300 mm
3.2	Polarizer cross section at the entrance and exit shall be at minimum height [y] and width [x].	[y]: 40 mm [x]: 40 mm
3.3	The magnetic housing will incorporate all magnets necessary to maintain the saturation field. Vendor shall specify saturation magnetic field strength.	Provided by vendor
3.4	The Polarizer shall operate in transmission mode only.	N/A
3.5	The distance from beam center to the bottom of the magnetic casing shall not exceed [y max] long.	[y max]:150 mm
3.6	The polarizer shall provide neutron beam polarization no less than [x] percent in the wavelength band between minimum [min.] and maximum [max.] with [h], and [v] FWHM horizontal and vertical divergences respectively.	[x]: 95% min[x.]: 95% min [min.]: 4 Å [max.]: 10 Å [h]: 0.2°, [v] :0.2°
3.7	Polarizer shall provide minimum neutron beam transmission no less than [Transmission] percent in the wavelength band between [λ]	[Transmission]: 30% min [λ]: 4 Å - 10 Å
3.8	Polarizer magnetic housing shall have reference marks at entrance and exit for alignment along with holes for laser reflectors. Reference Appendix A for hole specifications.	See Appendix A
3.9	The Polarizer shall be compatible for use in a rough vacuum.	1.0×10^{-3} Torr
3.10	The Polarizer shall accommodate lifting fixtures by incorporating a minimum size of M8 holes compatible with the use of swivel hoist rings on the top of the magnetic housing.	N/A
3.11	The Polarizer shall be equipped with four (4) threaded holes on front and back faces to allow for a neutron absorbing mask to reduce reflections.	N/A
3.12	Magnetic stray field shall not exceed maximum [max.] at 300 mm. Vendor shall provide a stray field map specifying magnetic field strength out to 500mm.	[max]15 Gauss
3.13	Vendor shall provide covers for the front and back of the polarizer to protect the super mirror during shipping and storage.	N/A
3.14	Each part shall have the part number indelibly marked on the surface, preferably by metal stamping or etching.	N/A

4. Design Requirements, Documentation, and Approvals

4.1 Electronic Documents

Wherever feasible, all documents shall be submitted in an electronic format acceptable to the HFIR Drawing Database, in addition to any other format. Adobe Portable Document Format (PDF) has been listed as an acceptable format for all documents, including drawings that would normally be printed on paper. Acceptable CAD formats are CREO, STEP, and IGES.

4.2 Design Documentation

The Seller shall submit design drawings and CAD file(s) for the polarizer for review and approval following completion of design phases. The drawing submittal shall include all components and sub-assemblies that make up the polarizing cavity. Written approval of the design documentation is required prior to start of fabrication.

4.3 Design Reviews

A final design review shall be conducted and approved prior to fabrication. Details to be confirmed during the award stage of proposal. Conceptual and preliminary design reviews are optional at the discretion of the Seller; a final design review is mandatory.

4.4 Materials of Construction

The Seller shall provide a list of all materials used in the construction of the Polarizer.

5. Quality Assurance

The Seller shall submit a Quality Assurance (QA) program or "Quality Control System" for evaluation with the quote. The QA Program shall address at a minimum the following elements: A written QA program, training and qualifications, improvement process, documents and record control program, control of procedures, design control, procurement control, and an inspection and test program. The Seller shall ensure that all work is done in accordance with this QA Plan. The Seller is responsible for the administration and performance of all testing, inspections, and examinations, whether performed at the Seller's facilities or at other facilities. The Company reserves the right to witness all tests, inspections, and examinations.

5.1 Access for Source Surveillance Inspections

As part of the Company's quality assurance program, source surveillance activities may be conducted at the Seller's facility or any sub-tier facility that the Company determines necessary to ensure that quality objectives are met. Such surveillance may include auditing and monitoring of production processes, in- process inspection and controls, chemical and physical certifications, final inspection and tests, preparation for shipment, and review of certification data. The Seller shall provide the Company representatives access to all data and operating areas pertinent to the contract. Source surveillance by the Company representative shall not constitute product acceptance by the Company and shall in no way relieve the Seller of the responsibility to furnish acceptable items.

5.2 Calibration Program

All equipment used in tests, inspections, and examinations shall be calibrated in accordance with the equipment manufacturer's recommendations. All equipment shall be tagged in some manner to indicate the date of last calibration and the status of that calibration.

Procedures shall be established for the correction of out-of-tolerance equipment. The procedures shall provide for tagging and removal of such equipment from the work area.

Procedures shall be established for re-testing or re-inspecting when out of tolerance equipment has been used for testing or inspection.

5.3 Control of Non-Conformances

The Seller may use their existing nonconformance program to identify, report, and recommend disposition of all non-conformances, but dispositions that would leave any remaining nonconformity must be submitted to the Company for approval. The request should identify the affected item(s) by name and serial number, citing the drawing/specification number and revision number containing the specific requirement that has not been met. It should state the number of nonconforming items being reported. The request should include a description of the nonconformity, identifying requirement(s) not met. The supplier may attach a description of the cause and a corrective action plan and schedule if pertinent.

Note: The issuance and acceptance of such a request in no way limits or affects the warranty provision of the Agreement. Such a request shall not establish a precedent or obligation to accept existing or future items not conforming to all provisions of the Agreement.

5.4 Manufacturing Plan

The Seller shall include a draft manufacturing plan in their proposal submittal. The Seller shall submit a final Manufacturing Plan for Company approval prior to the start of fabrication. The Manufacturing Plan shall include, but shall not be limited to, the following items:

- A milestone schedule, showing how the Polarizer assembly will be delivered by the contract date. The milestones shall include material procurement, fabrication, assembly, inspection, and shipping.
- Inspections and examinations to be performed (Inspection Plan).
- Identification of hold points.
- Subcontractors to be used, if any, and means of controlling quality at subcontractors.

5.5 Deviations

The Seller may propose deviations from the specifications, drawings or other technical requirements of the procurement. Where time is a consideration, the Seller may communicate the proposed deviation directly to the engineer or technical lead, with a copy to the Company's buyer. The engineer or technical lead will evaluate the technical aspects and make recommendations to the buyer, who will communicate acceptance or disapproval to the Seller. The request should identify the affected items, drawing/specification number and revision number, a description of the proposed deviation, and justification for it. The request for deviation shall be submitted to the Company and approved prior to making any change.

6. Examination, Testing and Inspection

The Seller shall notify the Company in writing of inspection activities at least 30 days prior to the start of such activities. The Company will provide the Seller with a document that contains the requirements for inspections. All inspections, tests, or examination reports shall contain the following information, as a minimum:

- Unique report number
- Job title
- Inspection date
- Equipment identification
- Specific inspection or examination, including procedure designation

- Identification of measuring and test equipment used and their latest calibration dates
- Inspection results
- Actions taken because of any discrepancies noted during the inspection
- Signature or initials of the person performing the inspection or examination and his/her qualifications, and the signature or initials of the person witnessing the test.

6.1 Test Plan

The Seller shall submit a test plan that fully characterizes the polarizer and provides data to support the polarizer meets or exceeds all performance requirements listed in Section 3.

6.2 Magnetic Casing for Polarizer Testing

The seller shall perform stray magnetic field measurements and report stray fields at 300 mm from each face of the polarizer.

6.3 Polarizer Assembly Testing

The following tests shall be performed and documented.

6.4 Magnetic Field Strength

The magnetic field strength along the polarizer assembly shall be in the test documentation. The testing shall include the entire width and length of the polarizer assembly. A minimum of 3 locations along the length of the polarizer assembly shall be measured for magnetic field strength as shown in the figure below.

Figure 2: Side view of polarizer assembly with rough locations for magnetic field strength testing

6.5 Neutron Testing

- Polarized neutron transmission at required operational wavelengths and including entire beam size as stated in requirements 3.2 and 3.6.
- Transmission of up and down polarization states at required operational wavelengths and including entire beam size as stated in requirements 3.2 and 3.6.

- Polarization at required operational wavelengths and including entire beam size as stated in requirements 3.2 and 3.6.

6.6 Inspections

The following information shall be reported regarding the polarizing cavity and polarizer assembly:

- Substrate thickness
- Number and placement of mirrors
- M-value of coatings with reflectivity at critical edge, as applicable

6.7 Dimensional Inspections

Dimensional inspections shall be performed in accordance with the latest revision of CG2-M-20-U-0009, the revision shall be confirmed by the seller the day prior to the planned inspection.

7. Packaging and Shipping

The Seller shall submit a packaging and shipping plan to the Company for approval prior to shipment. The Polarizer assembly shall be packaged and shipped by the Seller to the Spallation Neutron Source site in Oak Ridge, Tennessee, USA. The Company reserves the right to reject any or all items if the Seller deviates from the approved plan. The packaging and shipping plan shall meet or exceed the following requirements:

The packing and shipping plan shall include provisions for sealing, securing, and shipping the Polarizer assembly. Special attention shall be made to protect the delicate blades from shock or impact damage. An appropriate shock timer sensor or similar recording device shall be attached to the middle of the polarizer to indicate possible abusive handling during shipping. A typical sensor is manufactured by Instrumented Sensor Technology Inc., Okemos, Michigan 48864 USA.

The Polarizer assembly shall be totally enclosed and secured in a wooden crate that is adequately designed to protect against possible shipping damage. Internal packaging shall further enhance physical and environmental protection for the Polarizer assembly. The outside of the crate shall be plainly and permanently labeled with the following:

- Gross Package Weight
- Package Identification Number
- Seller identification
- Polarizer assembly serial number (if any)

- Company's specification number
- Company's subcontract number
- Company's shipping address
- Attention: Cassie Scully

The Seller's packaging crates shall be designed and built to accommodate handling by fork trucks. The Company will inspect each shipping crate upon arrival. Any damage will be documented and, if necessary, the Seller will be contacted to establish a plan of resolution. The Seller shall notify the Company of a shipping date not less than thirty (30) working days prior to shipment. The Seller shall transport the Polarizer assembly F.O.B. via a commercial carrier.

If the components are transported or stored near salt water, special consideration shall be given to protection against corrosion.

8. Documentation

The Polarizer assembly shall be fabricated in accordance with all requirements of this specification and drawing CG2-M-20-U-0009-R00. The Seller shall submit a final detailed design for the Polarizer assembly to the Company for review. The final design shall be approved prior to the start of fabrication. Once approved, this design shall constitute the official documentation from which deviation requests and non-conformance reports are required. The final design package shall be in the form of engineering/fabrication drawings and specifications and a three-dimensional CAD model. Any deviations or non-conformances from this specification or from dimensions or tolerances shown on drawing CG2-M-20-U-0009-R00 must be submitted for approval by the Company.

8.1 Submittals

Seller shall submit documentation as referenced previously in this specification and listed again in the following table. All documents listed in this table must be approved by the Company prior to shipping the polarizer assembly. Any approved deviations or non-conformances shall be captured in revised drawings and CAD model(s) as an as-built documentation package that must be submitted to the Company and approved by the Company prior to shipment.

DOCUMENT	WHEN REQUIRED	SECTION
Quality Assurance Program – Unless previously provided	With quote/proposal	5
Draft Manufacturing Plan	With quote/proposal	5.4
Exceptions to Specification and Drawing CG2-M-20-U-0009	With quote/proposal	5.5,5.3
Fabrication Tolerances	With quote/proposal	3
Mirror Specifications	With quote/proposal	3

Materials of Construction	With quote/proposal	3, 4.4
Request for Deviation	Prior to making change	5.5
Non-conformance Reports	At time of occurrence	5.3
Final Manufacturing Plan	Prior to fabrication	5.4
Seller's Final Design Package *	Prior to fabrication	8
Packaging and Shipping Plan	Prior to shipping	7
Testing Results	Prior to shipping	6
Dimensional Inspection Documentation	Prior to shipping	6.
Seller's Certificate of Compliance	Prior to shipping	9

* Fabrication shall not start before the final design package is approved by the Company.

8.2 Language

All supporting documentation shall be in English. Translated versions of the original documents signed by the personnel responsible are acceptable.

8.3 Inspection Reports

Inspection documentation and reports shall be performed in accordance with Specification Section 4.

9. Verification And Acceptance

The following shall be the basis for final acceptance:

1. Receipt and approval of all data as required in this Equipment Specification.
2. Confirmation by a Company representative that the Seller produced the Polarizer assembly in accordance with this Equipment Specification.
3. Receipt of a Certificate of Compliance (COC) signed by a representative of the Seller, verifying that the Polarizer assembly conforms to the engineering drawings, approved deviations, and this specification. The COC shall be submitted to the Company for written approval prior to shipment.

10. Appendix A: Hole Sizes for fiducials

Metric:

Ø6.350-6.372, H8, 18 depth (with a Ø15.5 spot face on anything other than a flat machined plate)

Countersink Ø7.9 x 90°

American Customary:

Ø.2500-.2509, H8, x 0.70 depth (with a Ø.61 spot face on anything other than a flat machined plate)

Countersink Ø.31 x 90°