

Statement of Work (SOW)

Fabrication of 9-Cell 1.3 GHz Conduction Cooled SRF Cavities

1. Introduction and Background

This Statement of Work (SOW) outlines the requirements for the fabrication and delivery of two (2) 9-cell 1.3 GHz conduction cooled superconducting radiofrequency (SRF) cavities. This procurement supports the ERDC project, in which FNAL is designing an industrial SRF accelerator for pavement treatment. All relevant fabrication, inspection, testing, and delivery requirements are detailed herein.

2. Scope of Work

2.1 Objectives

The objective is to procure two (2) high-quality 9-cell 1.3 GHz conduction cooled SRF cavities fabricated in accordance with FNAL-provided drawings and specifications, using materials furnished by FNAL. The vendor shall ensure the cavities are completed, inspected, packaged, and delivered in accordance with all requirements specified in this SOW.

2.2 Requirements

- Fabrication must adhere to the design and tolerances provided by FNAL, accounting for material removal, weld shrinkage, and RF tuning.
- **All niobium and Nb55Ti materials required for cavity fabrication will be supplied by FNAL.**
- The vendor shall develop fabrication drawings and manufacturing documentation based on FNAL-supplied drawings and a 3D STEP model.
- The vendor shall design and fabricate all required dies, tooling, welding fixtures, and other items as required for fabrication.
- The vendor shall provide information related to previous conduction cooled cavities that they have fabricated as part of the bid package.

3. Tasks

The Vendor shall:

1. Develop their own fabrication drawings from the provided FNAL drawings and STEP model
2. Review the FNAL design for manufacturability and provide a list of any issues (engineering, materials, fabrication, assembly, shipping, etc.).
3. Submit a set of fabrication drawings and the proposed fabrication plan to FNAL for approval prior to the start of work.
4. Participate in a pre-fabrication review meeting with FNAL representatives to discuss design features and processes.
5. Establish and submit a detailed Quality Assurance (QA) Plan for FNAL review and approval prior to fabrication start.
6. Design and fabricate all required dies, tooling, and welding fixtures.
7. Develop the required electron beam (EB) welding parameters.

8. Conduct all required inspections of government-furnished niobium and Nb55Ti materials and notify FNAL of any nonconformance.
9. Fabricate two (2) 9-cell 1.3GHz conduction cooled cavities.
10. Perform optical, dimensional, and leak checks on completed cavities according to specifications.
11. Prepare all required as-built documentation.
12. Package and ship completed cavities to FNAL in accordance with requirements specified in this document.

4. Deliverables

The Vendor shall provide the following deliverables:

1. **Two (2) completed 9-cell 1.3 GHz conduction cooled SRF cavities** fabricated to specification.
2. **Fabrication drawings and manufacturing documentation** generated by the vendor, approved by FNAL prior to start of fabrication.
3. **Quality Assurance Plan** describing traceability, traveler layout, equipment and inspection procedures, EB welding equipment and procedures, weld integrity verification, and final inspection process (to be approved by FNAL prior to fabrication).
4. **Inspection and test documentation** including weld logs, material certifications, reports of equipment calibration, dimensional inspection records, optical inspection records, and leak check data for each cavity.
5. **Documented record** of each cavity before and after any polishing or defect removal, if performed.
6. **Drawings for shipping crate** and packaging details, to be approved by FNAL prior to shipping.
7. All documentation and drawings shall be submitted in electronic (PDF) format unless otherwise specified.
8. Each crated shipment must include a GP1 Accelerometer by SENSIR; FNAL will supply program values prior to shipment.

5. Quality Assurance

- The vendor shall submit a Quality Assurance Plan for FNAL acceptance prior to fabrication.
- The QA Plan shall ensure traceability, proper control of fabrication processes, and conformance to this SOW.
- The plan must cover traceability, inspection, EB welding, weld integrity checks, and final inspection.
- FNAL approval of the QA Plan is mandatory before the start of fabrication.
- Half-cells, beam tubes, dumbbells, end assemblies, and finished cavities must be measured and documented per the vendor's QA plan; documentation must be supplied to FNAL.
- Each cavity must pass a helium leak check (no leakage detectable on the most sensitive scale of a helium leak detector with sensitivity minimum 10^{-10} atmosphere cc/sec).
- Upon receipt, FNAL will perform an optical inspection and verify compliance with all RF and mechanical parameters. Cavities may be rejected for defects $>50 \mu\text{m}$ or for nonconformance with drawings/specifications.

6. Government-Furnished Property

- FNAL will provide all required niobium and Nb55Ti materials, as well as a complete drawing package and 3D STEP model.
- Upon receipt of materials, the vendor shall inspect for inclusions or defects and notify FNAL if defects are found.
- FNAL will also supply serial numbers for cavity identification after contract award.

7. Security

No specific security requirements apply. However, FNAL may choose to visit the vendor's facility to observe processes or assess capability, with prior notification.

8. Place of Performance

- All fabrication, inspection, testing, and preparation for delivery shall be performed at the contractor's facility.
- Receipt inspection and final acceptance will be performed at FNAL.

9. Period of Performance

- The vendor shall submit a proposed schedule for fabrication, inspection, and delivery in their fabrication plan.
- Key milestones—including QA plan submission/approval, drawing submission/approval, and delivery—are subject to schedule review and acceptance by FNAL.

10. Special Requirements

- All polishing, cleaning, handling, and storage requirements must be performed as outlined in this SOW. Documentation of procedures and verification of outcomes shall be supplied as required.
- Niobium and Nb55Ti surfaces must be protected from contamination at all times; no contact with substances that may not be removed by etching/cleaning is permitted.
- Cleaned and etched parts must be protected during storage and transport in appropriately sealed vessels under vacuum or inert gas.
- Each completed cavity must be ultrasonically cleaned, degreased, sealed in a clean polyethylene bag, protected with plastic caps, and shipped in a padded box per vendor-approved drawings.
- Weld fixtures must be properly cleaned and handled before use.
- Cavities shall be marked with FNAL-provided serial numbers.
- No vacuum grease shall be used in leak testing.
- A pre-fabrication review meeting between the vendor and FNAL is required prior to manufacturing startup.
- **Field flatness (π -mode)**: $\geq 98\%$ (after warm tuning)
- It is required that the vendor has produced conduction cooled cavities in the past and the vendor shall provide documentation of previous conduction cooled cavity fabrication.

11. Options

1. **CMM Measurements:** Vendor shall provide option on proposal detailing cost and lead time for performing CMM measurements of the two cavities after fabrication.

2. **Eddy Current Scanning of Raw Niobium Material:** Vendor shall provide option for Eddy Current Scanning of Niobium sheets and provide documentation stating the procedures they will use.