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## 1.0 SCOPE

**1.1 PURPOSE** This Statement of Work (SOW) describes the requirements necessary to produce NEW END CAN ASSEMBLIES. Even though the design reflects a built-to-print product, additional requirements are imposed on manufacturer -- herein stated as “manufacturer”. Additional (aside from fabrication) responsibilities include:

1.1.1 Manufacturing details such as cut sheets and travelers

1.1.2 Sequencing and Parts Control

1.1.3 Quality Assurance

1.1.4 In this text, and in applicable specifications, references such as vendor, manufacturer, subcontractor, fabricator, manufacturer and the like, mean the same thing. We understand this to be the commercial contractor responsible for making and delivering the End Cans. Furthermore, CEBAF and JLAB are different names for the same entity. Herein references to older documents that denote CEBAF, are still valid and are applicable.

1.1.5 Over 45 pairs of production End Cans are in use at JLab. An additional 12 units will be purchased for our planned accelerator facility and FEL project upgrades. This SOW describes the requirements for these new modified models. Changes from the original design include:

<b>Change</b>	<b>Details</b>
Primary Side Diodes	Placing redundant pairs in the direct flow of the helium fluid for higher accuracy and to eliminate tubing run.
Beam Pipe	Tubing has been increased in size to accommodate the FEL project requirements. Vacuum vessel penetration is larger
Thermal Shield Modifications	Reworked the end plates and added a transition section to accommodate the new cryomodule
Piping	Reworked to accommodate the new piping configuration.

1.1.6 The new design allows for backward compatibility. The use of the new End Cans with the older cryomodule is possible with minimal rework. In addition, the new design allows for the conversion of older End Cans to the new style.

**1.2 DELIVERABLES TO JLAB** Manufacturer shall offer for acceptance fully fabricated NEW END CAN ASSEMBLIES according to this text, associated drawings, and relevant JLab quality control specifications.

1.2.1 Completely fabricated and tested End Can Assemblies in quantities as described with JLab procurement documents. Specifically:

1.2.1.1 Supply End Can Assembly #115310-1001E

1.2.1.2 Return End Can Assembly #115300-1001E

1.2.2 Documentation providing evidence of quality control surveillance and compliance to manufacturer's and JLab's quality control procedures. Said evidence will be offered to JLab for acceptance prior to delivering hardware. In addition, signed copies of material Certified Mill Test Reports (CMTR's) as specified by this text will be included, at this time.

### 1.3 **MANUFACTURER FURNISHED MATERIALS, EQUIPMENT, AND SERVICES**

Manufacturer shall provide manufacturing engineering services required to generate final shop drawings and all documentation needed to manage and support their suppliers. This will include all technical and commercial supervision such that JLab receives complete and specification compliant assemblies.

1.3.1 Manufacturer shall provide all labor to assemble, test, and supervise the manufacture of all components regarding where these are made: within the manufacturer's plant or in a second facility or sub-contractor.

1.3.2 All material will be provided by the manufacturer. This shall include consumables and raw materials. It is important to note CMTR's may be required for some materials, at the discretion of the JLab technical representative. There will be no Government Furnished Material (GFM) provided by JLab.

1.3.3 Manufacturer will provide all facilities, tools, and fixtures necessary to fabricate and test the END CAN ASSEMBLIES. At the end of the contract, JLab may ask manufacturer to provide all fixtures and jigs that were specifically used for fabricating END CANS, as deliverables.

## 2.0 **APPLICABLE DOCUMENTS**

2.1 Listed at the end of this text (see Appendix A and B) are document lists describing the Supply and Return End Can. Note that several sub-components and hardware items are used in common for both the supply and return assemblies.

2.2 Appendix C is a complete and sorted list with duplicate components and hardware removed for clarity. These lists are available in MS Excel file form.

2.3 The following Baseline Design Specifications and Procedures are required technical documents and shall be used by vendor to manufacture and test End Can Assemblies.

No	Title	Document No.	Rev	Pages	Author	Issue Date
2.3.1	Vacuum Leak Test Internal Evacuation Small Items	11141S0029	A	5	J. Van Dyke	8/26/88
2.3.2	GTAW Specifications for Stainless Steel	11141S0030	---	3	G. Biallas	8/26/88
2.3.3	Stainless Steel Cleaning and Handling Specification	11141S0034	---	3	G. Biallas	8/26/88
2.3.4	General Cleaning and Handling Specification	11141S0035	---	2	G. Biallas	8/26/88
2.3.5	Application of Super Insulation	11141S0037	---	4	G. Biallas	8/26/88
2.3.6	Aluminized Mylar Film for use in Cryogenic or Superinsulation Systems	11141S0038	---	4	W. Schneider	8/26/88
2.3.7	Spunbonded Polyester	11141S0039	---	2	W. Schneider	3/22/88

### 3.0 REQUIREMENTS

**3.1 DIMENSIONAL CONFORMANCE** The JLab Drawing numbers 115300-1001E and 115310-1001E (which respectively control the Return and Supply End Can Assemblies) shall be used by manufacturer to control configuration and dimensional conformance.

Dimensional variances of interfaces (inlet and outlet) and overall envelope configuration shall be maintained to specified tolerances. Additionally, type, quantity, and material of controlled parts shall be monitored by manufacturer such that no substitutions are effected on the assembly or its subcomponents.

**3.2 LEAK CHECKING REQUIREMENTS** All pressure and vacuum barriers shall be leak checked by using a MSLD or RGA detectors, with appropriate sensitivity and calibration. Fabricator shall use the CEBAF (JLab) specification #11141S0029 to perform said testing.

3.2.1 It is required that manufacturer “cold shock” welds and brazed joints prior to leak checking as stated in part 3.3 of this text. In addition, it is the responsibility of the manufacturer that repairs are properly effected and re-tested. The use of Glyptol or similar products to repair leaks is not acceptable.

3.2.2 Leak tight boundary shall include vacuum jacket, all piping (both internal and external) and valves. Closure plates and plugs will be necessary to close the atmospheric side of relief valve and bayonet ball valves in order to test the integrity of the system. Leak checking the valve seats will not be necessary, for this application.

3.2.3 Manufacturer shall provide recorded evidence in the form of independent reports or line items in the manufacturing travelers that clearly state the date, time, and conditions of these tests.

**3.3 COLD SHOCK REQUIREMENTS** All piping welds shall be subjected to liquid nitrogen temperatures such that these components reach 80 K before or during leak checking process of section 3.2 of this text.

### **3.4 WELDING REQUIREMENTS**

3.4.1 Stainless steel welding shall be performed in accordance with JLab specification 11141S0030. Manufacturer shall offer and receive approval for any alternative methods prior to award.

3.4.2 Copper thermal shield welding shall be performed using the Inert Gas Shielding method. Manufacturer shall ensure that no entrapped gases, fluxes, pits, cracks, or like imperfections are left in the heat effected zones. The use of temporary Polyethylene glove boxes is acceptable method for shielding welds.

3.4.2.1 Thermal shield pieces shall be fixtured and welded in such a way as to have intimate and continuous contact. This in order to achieve the best possible heat transfer between these components.

3.4.3 Specific welding requirements for the vacuum jacket include the preparation of the weld surfaces such that future repairs may be performed without reworking the parent material. The rectangular section (valve box) of the vacuum jacket must be prepared such that in-the-field repairs are possible. It is important that fillet weld does not entirely fill the cavity and wash over the corners. Examples of how this is presently done are available for further clarification.

3.4.3.1 Manufacturer shall sequence the closure welds such that the final and hermetic pass is on the vacuum side on the enclosure and the structural stitches are on the atmospheric side. Exceptions are granted to circumstances where both sides of the weld joint may not be accessible or will pose difficulties in leak checking.

3.4.3.2 Rectangular section shall have an external fillet for possible and future parting of this wrap around section. Manufacturer shall ensure that no virtual leaks are created when making this final closure.

### **3.5 INSULATION MATERIAL REQUIREMENTS**

All cold surfaces shall be thermally (radiation) protected with Multi Layer Insulation (MLI) throughout. This application consists of alternating single layers of spacer and radiation reflectors. Specifically 0.001” thick doubly aluminized mylar with spun-bonded polyester insulation.

3.5.1 Aluminized mylar shall conform to CEBAF specification 11141-S-0038

3.5.2 Polyester spacing shall be made from Reemay Corporation product number 2250.

3.5.3 Fabrication of the MLI blankets shall be performed in a clean area free of dust, oil, and moisture contamination. JLab technical representatives reserve the right to approve the location and method of assembly for these blanket components. Failure to satisfy this requirement will be considered technically unacceptable.

3.5.4 Application of these blankets shall be effected on clean surfaces only. It is the responsibility of the manufacturer to clean and protect the piping and thermal shield surfaces prior to this installation. Said metal surfaces shall be dust and oil free.

3.5.5 MLI blanket joints shall consist of interspersing adjoining layers (15 at a time) with sufficient overlap to accommodate for thermal movements. It is recommended that a 2" overlap is used in order to avoid light gaps.

3.5.5.1 Where interspersing of edges is not practical (say, around thermal shield corners) the following alternative method may be used: Using of quarter thickness (specified coverage) of pre-made blankets in a butt joint application is acceptable. That is, if joints are staggered by a 2" separation and overlap leaving blanket ends open, Do not tape ends, as this may tend to thermally short inside to outside layers.

3.5.5.2 Monofilament nylon thread, nets, or tag binders may be used to keep MLI blankets from sagging and shifting during transit to JLab. In addition, contact preventing spacers shall be used where surfaces may be subject to thermal shorts after contraction. A fabricator with experience in valve box design will be able to avoid these potential problems.

### **3.6 INSULATION COVERAGE REQUIREMENTS**

Process piping and thermal heat stations shall be barber pole wrapped with MLI. As previously stated, all other surfaces to be blanket covered. Coverage for each type of surface shall conform to the following coverage schedule:

<b>Location</b>	<b>Coverage</b>
Thermal shield proper -- surface	45 to 60 layers on warm side (outside)
Shield Piping --- 50 K	Bare within shield boundary and 15 layers where exposed to 300 K surfaces
Primary Piping --- 2 K	24 layers throughout. Reduced coverage is allowed next to heat stations.
Heat Station Straps --- 50 to 2 K	15 layers

### **3.7 HEAT STATIONING REQUIREMENTS**

Conductive heat intercepts shall be installed between all 300 K to 2 K connections at the 50 K nominal gradient point. Specifically, process relief vents, bayonets, and diode wires shall be mechanically connected to the thermal shield as located on the main assembly drawings for both types of End Cans. Manufacturer shall provide FINAL manufacturing drawings and assembly directions to install these features.

3.7.1 Material for these conductors shall be 3/32" thick high purity annealed copper strip (or plate) in the form of Oxygen Free High Conductivity (OFHC) per UNS C10200. Alternatively, braided material of the same material type and of 110% cross section can be used to increase flexibility and ease of manufacturing. Alternative materials and methods must be approved by the JLab technical representatives.

3.7.2 Brazing and inert gas welding are acceptable methods of attaching straps to thermal shields and intercept points. If brazing is used, fluxes shall be removed completely with organic acids. JLab technical representatives reserve the right to approve material types and procedures for this application.

3.7.3 Primary (2 K) instrumentation wires shall be heat stationed by taping these down directly onto the shield with aluminized mylar tape. Approximately 36" of wire shall be wrapped, or laid in serpentine fashion onto the bare shield surfaces. The JLab technical representative will provide further instructions during the assembly First Articles.

3.7.3.1 Manufacturer shall inspect and ensure conductors do not (ground) short to the thermal shield surface or to each other. Manufacturer shall perform non-destructive testing to ensure wire insulation integrity is maintained.

### **3.8 MANUFACTURING ENGINEERING REQUIREMENTS**

3.8.1 Manufacturer shall fabricate jigs and simple fixtures to ensure bayonets and other important interfaces are maintained to specified tolerances. In particular to the bayonets, perpendicularity and location to theoretical centerline (beam line) is of great importance.

3.8.2 JLab component parts are detailed to the nominal and assembled material conditions. It is the responsibility of manufacturer to allow for fitting and welding tolerances by adjusting said drawings to their manufacturing style.

3.8.3 Manufacturer is required to generate shop travelers and sequencing documentation to assemble the End Cans. JLab can provide historical data (previous revision) as a reference. However, it is the ultimate responsibility of the manufacturer to deliver completed and tested End Can Assemblies.

### **3.9 TEMPERATURE SENSOR REQUIREMENTS**

3.9.1 In-process (primary) temperature diode pairs shall be installed and as shown on JLab drawing number 115310-1045C. Location for these sensors are shown on the main assembly drawings. Manufacturer is responsible to fabricate and test these units such as to ensure reliable operation.

3.9.1.2 Sensor tip direction shall point against the on process flow and. Furthermore, wires shall be routed and thermally intercepted according to this specification and using best cryogenic practices.

3.9.2 Secondary (shield) temperature diodes are “donut” types and are specified on JLab drawing number 115310-1073C shall be installed in the following locations of the thermal shield: inside of flat end plate, top of valve box, and beam tube intercept. These locations are shown on each assembly drawing.

3.9.2.1 These sensor assemblies shall be attached by using machine screws directly onto the bare copper plates. Manufacturer shall place thermal epoxy between sensor and plate to ensure good thermal contact. Alternatively, Indium solder (foil) could be used for this function.

### **3.10 DOCUMENTATION REQUIREMENTS**

3.10.1 A Quality Assurance Plan, as stated in section 4.1, must be provided prior to contract award. In addition, said plan shall be maintained during the term of the contract.

3.10.2 Certified mill test reports of all raw materials used to fabricate deliverables shall be provided to TJNAF prior to final acceptance of deliverables by TJNAF. These material certifications shall include all processes and tests with grade and composition being clearly identifiable.

3.10.3 Certifications of all welding personnel and/or equipment that will perform any welding task on the deliverables. All certificates shall be current and up to date with all applicable standards and codes. Provided prior to contract award.

3.10.4 Production timeline for fabrication, starting from time of award running through F.O.B. TJNAF. Following TJNAF approval of timeline and contract award, it is the responsibility of the contractor to comply with and meet dates specified in approved timeline. Provided prior to contract award.

### **3.11 PIPING CODE REQUIREMENTS**

Manufacturer shall fabricate piping and process line components in accordance with the American National Standards Institute (ANSI) B. 31.1.0 power piping codes and regulations. Pneumatic testing shall be performed on each assembly at the prior to sealing the vacuum jacket.

3.11.1 A pneumatic pressure testing nameplate shall be attached (permanently affixed) to outside of EACH End Can vacuum vessel as detailed in section 3.12.1, of this text. This shall display the following information:

Primary Piping Tested to 75 psig  
Secondary Piping Tested to 188 Psig

### 3.12 MARKING AND TRACEABILITY REQUIREMENTS

Manufacturer shall inscribe parts with clear markings such that a visual inspection will provide traceability and fast identification. Sufficient information will be provided on these markings that will allow for immediate recognition of said components and its source, such as subcontracted work, material specification, and part number.

3.12.1 Manufacturer shall permanently affix a metal nameplate to each End Can assembly. Location of this name plate will be provided by JLab technical representative, at a later date. Included on this plate the following information shall be clearly displayed:

1	Manufacturer's Name	
2	Date of Manufacture	
3	Test Data Parameters	Pneumatic Test Pressure Information
4	Fabrication Standards	Piping Code Information
5	JLab Part Number and Name of Component	Per Top Assembly Drawing, Including Revision Level
6	Serial Number	Sequential Number Starting with 101 and Assigned to each PAIR, or set of End Cans
7	Additional Data	Any other markings required by manufacturer such as ISO tracing information

### 3.13 CLEANLINESS REQUIREMENTS

Surfaces shall be cleaned and protected at all stages at stages of fabrication such that dust, oils and other contaminants are removed prior to final assembly and preparation for delivery to JLab.

3.13.1 Manufacturer shall follow JLab cleanliness specification #11171S0034 where it applies to specific material and conditions. Manufacturer is required to exceed these requirements by providing as much protection as practical and possible.

3.13.2 In addition to the above requirement, the copper shield shall be cleaned to a bright metal condition. No solvents, waxes, oils, or protective coatings shall be placed (or left) on this surface. This thermal shield will be used in a moderate to high vacuum service.

3.13.3 MLI shall be protected during assembly. No fingerprints, oils or dust shall be allowed to remain on any surface of the MLI. Loose insulation shall be bagged and protected during storage and shipment.

3.13.4 No anti-seize compounds shall be used on the assemblies which could be easily removed by normal handling procedures. JLab reserves the right of approval on this matter. In addition, no (none) anti-seize compounds shall be used in the vacuum space which would cause out-gassing. Silver plating and the use of dissimilar metals are recommended.

**4.0 QUALITY ASSURANCE**

The manufacturer shall maintain a documented quality assurance program which shall insure that each item offered for acceptance (fully Assembled End Cans) conforms to this Statement of Work and documentation subsets. Documents which briefly describes such plans, shall be submitted at time of formal quotation for review and approval by JLab technical representatives.

**4.1 DOCUMENTATION**

The manufacturer shall maintain records of all inspections and tests. In addition, the following information shall be made available for inspection to any JLab technical representative.

1	Leak Checking Method	Including calibration, rework, and final acceptance procedures
2	Assembly Sequence	Including the logical steps for in-process corrective action and Q/C points
3	Cold Shocking Method	A clear and concise process by which parts are subjected to thermal stresses prior to leak testing
4	Parts/Process/Materials Tracing Method	Including the resolution of non-conformance reports and methods to insure parts and supplies meet required standards
5	Any Other Non Destructive Test (NDT) that may apply	Manufacturer’s Option that fits their Q/C Plan

**4.2 FIRST ARTICLE**

First Article (Prior to Production Run) The first articles (one complete pair) shall be offered to JLab for inspection and testing. These first units shall be used to demonstrate initial compliance with all stated requirements. If needed, adjustments and further clarifications will become evident at that time.

4.2.1 JLab reserves the right to have its technical or procurement representatives witness any or all manufacturing steps, tests, and inspections established under the manufacturers’ quality assurance program to demonstrate compliance with this specification. Any information of a proprietary nature must be identified in the bid response.

4.2.2 JLab representatives shall have unannounced visitation access to the manufacturers plant and personnel during normal operation hours. This for the purpose to conduct Quality Assurance Audits.

4.2.3 Part of, or entire End Can assemblies may be rejected in accordance to this Q/C plan.

## 5.0 PREPARATION FOR SHIPMENT

All deliverables, including documentation shall be cataloged and offered for acceptance to JLab at time of End Can delivery. Clear documentation must accompany the products such that JLab receiving personnel clearly understand the contents and can match delivery to a purchase order.

5.1 Assembly Packaging shall be such that no damage is incurred during transit. This shall include weather protection and the closure of all open pipe with test plugs or removable caps.

5.2 End Can assemblies shall be bagged in clear polyethylene plastic and crated. Crating shall be such that stacking two units on top of each other is possible during transit.

5.2.1 Any internal component that may be subject to dynamic damage (in particular, the shield end plates) shall be blocked or temporarily supported. These shall be easily removed by simple hand tools.

5.2.2 Temporary supports must be clearly and conspicuously labeled: **REMOVE PRIOR TO FURTHER ASSEMBLY**.

## 6.0 NOTES – NARRATIVE OF END CANS

There are at least 45 pairs of supply and return End Cans Assemblies in the JLab accelerator and in the Free Electron Laser (FEL) facilities. These are in daily use providing the interface between the accelerator cryomodules and the cryogenic utility lines. These End Can units work in pairs at each end of a long cavity accelerator train. Each End Can is welded to the cryomodule and becomes part of this major assembly. See Simplified Flow Diagram on the last page of this text.

6.1 **OPERATION PARAMETERS** There are two distinct cryogen coolant systems:

Primary:	4 K or 2 K super-fluid helium
Secondary:	50 K thermal shield, helium gas

6.2.1 Primary helium enters at approximately 2.2 K and at 2.8 atmospheres of pressure during normal operations. After isoenthalpically flashing thru supply cap control (JT) valve, super-fluid helium (2 K/.03 atm) is delivered to cavity bath tanks. This flashing is achieved by vacuum pumping thru the large subatmospheric bayonet, on the return End Can.

6.2.2 The thermal shield is cooled by exchanging 50 (actually, low as 38 K) bulk temperature helium gas through pipe wall to thermal radiation envelope (copper sheath).

## **6.2 INTERFACES**

Thirty-two inch long bayonets are used to receive transfer lines from cryogen headers. Upon withdrawal from Cryomodule End Cans, in-line ball valves are used to hermetically isolate the system, at bayonet glands.

6.2.1 Since system operates at below atmospheric pressure, a guard vacuum header and purge distribution systems is used to manage gas during (male bayonet) transfer line removal or insertion. Furthermore the JT valve is installed in a non-conventional (exit at bottom) way in order to avoid air entering through the valve bonnet.

## **6.3 INSTRUMENTATION**

In-stream redundant temperature elements (4-wire diodes) are used to determine thermodynamic performance of cryomodule. In addition, single element diodes are used on the thermal shield to determine shield temperature and quality of vacuum pressure.

6.3.1 Vacuum jacket consist of two parts:

- Box section which houses bayonets and interface components
- Cylindrical shell section

The latter slides back over the first flange on the cryomodule in order to access beam tube and pipe connections. This cylinder is then slid over end components and seal welded to cryomodule end flanges.

**NEW END CANS -- SOW 115070-1007S  
SIMPLIFIED FLOW DIAGRAM**

