Collider Accelerator Department / Vacuum Systems
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Brookhaven Science Associates
Upton, New York 11973

SPEC. CAD-1211
Revision B
March 4, 2010

Specification
For
Collider-Accelerator Beam Line Vacuum Component Heating Jackets

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This Specification consists of 10 pages, including this cover sheet.

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1.0 SCOPE

This specification, in conjunction with the current drawing package, defines the Configuration, Construction, Materials, Performance, Quality Assurance, and Workmanship required for Heating Jackets used for bakeout of the Collider-Accelerator Beamline Vacuum components.

The seller is encouraged to make recommendations for changes in the construction and materials specified that might lead to improvements in the performance or reliability of these Jackets or a reduction in their cost. However, changes in the Jacket specifications may be made by the seller only with the written approval of a representative of BNL Procurement, in consultation with the cognizant Engineer or designee of the BNL, Collider-Accelerator Vacuum Group.

2.0 APPLICABLE DOCUMENTS

The following documents comprise part of this specification:

- BNL QA-101, Seller Quality Assurance Requirements, April, 2006.
- The BNL drawing package, containing as a minimum, working drawings defining the geometry of the vacuum components to be heated and/or BNL generated drawings of the heating jacket configuration with seam locations. The drawing package will be specified and contained in the Purchase Order and/or Statement of Work (SOW) accompanying this Specification.

It is the responsibility of the seller to determine that all buyer drawings and other referenced documents used in the preparation of quotations by the seller and in the execution of the contract, on the award of a Purchase Order, are the most current drawing revisions. This is emphasized here, in the interest of the seller.

3.0 REQUIREMENTS

3.1 Standard Laboratory Heater Jacket Applications

Requirements specified herein apply to all Collider Accelerator heater jacket applications including standard laboratory and special applications unless specifically stated otherwise. Standard Collider Accelerator heater jacket requirements specified herein apply unless the related purchase order, relevant SOW or drawing, specify a special application.

3.2 Special Heater Jacket Applications

3.2.1 Special applications include, but are not limited to clean room and restricted clearance applications.

3.2.2 In the event a special application is specified, the special requirements shall be provided in supporting documentation such as the purchase order, Statement of Work or relevant drawing(s).

3.2.3 Standard laboratory application requirements specified herein apply in all applications except where there is a conflict resulting from the special application requirements specified.

3.2.4 In the event a conflict in requirements arises due to the design approach to address special application requirements, the vendor shall submit a list of the exceptions to the specifications herein. Written approval of a representative of BNL proposal Procurement, in consultation with the cognizant Engineer or designee of the BNL, Collider-Accelerator Vacuum Group is required to accept any exception(s).

3.2.5 Certain provisions for special applications are specified herein. These provisions may be applicable to comply with the special application requirements provided the remaining specifications for the special application as specified herein and other referenced documentation are met. Other documentation refers to the associated SOW and/or relevant drawing(s).

3.2.6 The vendor shall submit in writing with their quotation, a detailed description of the specific design features required to meet the special application specifications and provisions. Written approval of a representative of BNL proposal Procurement, in consultation with the cognizant Engineer or designee of the BNL, Collider-Accelerator Vacuum Group is required to accept any of these allowance(s).

3.3 Materials, Construction and Performance

3.3.1 Materials

3.3.1.1 All materials used in the construction of the heating jackets shall be capable of withstanding repeated exposure to temperatures of at least 400°C without degradation.

3.3.1.2 Standard Jackets shall be designed to be compatible for operation in high, ionizing radiation fields of up to 10^7 Rad. This generally precludes the use of organic materials such as plastics with the exception of Kapton. Use of PTFE (e.g.,Teflon® [1]), or Teflon® type materials for any component is prohibited.

3.3.1.3 Materials other than Teflon® may be permitted for Special Application Jackets, provided all non-conflicting Standard Requirements and remaining specifications for the Special Application Jacket as specified herein and other referenced documentation are met.

3.3.1.4 Asbestos: Use of asbestos or asbestos containing materials is prohibited.

3.3.1.5 Jackets shall not release any potential contaminant under any circumstance, including heating from room temperature up to maximum specified operating temperature.

3.3.1.6 An MSDS and/or manufacturers specification for all materials proposed in the construction of the Heater blankets shall be submitted to the buyer for review and approval in writing by BNL prior to acceptance as a material of heater jacket construction.

3.3.2 Construction

3.3.2.1 Jackets shall be designed and constructed such that intimate contact is made with the heated vacuum component wherever possible. Where intimate contact cannot be made due to component design, the Jacket design and construction shall be such that the temperature and temperature gradient as specified herein is maintained without resulting in jacket damage.

3.3.2.2 Jackets shall be designed and constructed to be safe to handle when electrically energized to the voltage specified herein.

3.3.3 Liner

3.3.3.1 The innermost layer of the heater jacket shall be constructed from a densely woven glass fiber cloth.

3.3.3.2 The liner shall be able to withstand prolonged exposure at the maximum operating temperature of the heating elements without damage or degradation in performance.

3.3.3.3 The liner shall provide electrical insulation sufficient to prevent shorting of 500 VAC applied between the heating elements and the heated vacuum component that is grounded.

3.3.3.4 The liner shall be capable of withstanding typical and repeated handling for installation,

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1 Teflon® is a registered trademark of E.I. duPont deNemours and Company.

removal and storage without suffering damage that prevents the jacket from meeting any other applicable specification herein.

3.3.3.5 Special Application Liner: Other materials may be permitted in the construction of the Special Application Jacket liner to achieve a special application requirement provided the remaining Standard and Special Application specifications are met.

3.3.4 Heating Elements

3.3.4.1 Each jacket shall be designed with a single heating zone, whereby the performance of this specification is achieved through the input of power to a single set of cold power leads.

3.3.4.2 Each jacket shall be provided with two (2) complete and redundant heating element circuits with separate cold power leads. Each circuit shall be independently capable of producing the thermal performance characteristics as required by this specification.

3.3.4.3 Heating elements for jackets shall be made from continuous multi-stranded resistance wire. No splicing of the heater element circuit is permitted inside the jacket.

3.3.4.4 Heating elements shall be dielectrically strengthened with fiberglass.

3.3.4.5 Heating elements shall be non-magnetic with a maximum magnetic permeability of 1.02.

3.3.4.6 Elements shall be secured in place within the jacket such that the elements do not displace from their original mounting position within the blanket structure. Elements must not touch or cross each other at any time.

3.3.4.7 Where possible, elements shall run parallel to the long axis of the vacuum component and be arranged such that the bending of heater elements is minimized when the jackets are installed.

3.3.4.8 Where possible, elements shall be less than one inch apart and shall be configured to cover the maximum possible surface area. Gaps between elements at lacing edges and ends of jackets shall be minimized and shall be less than one inch where possible.

3.3.4.9 Special Application Heater Element: Other heater element construction methods may be permitted for Special Applications, provided the remaining Standard and Special Application specifications are met.

3.3.5 Insulation

3.3.5.1 Insulation for all jackets shall be 100% E fiberglass mat.

3.3.5.2 The insulating material shall be attached to the cloth carriers to preclude displacement, bunching, etc., in order to maintain a constant thickness.

3.3.5.3 Insulation thickness shall be specified in the drawing package, SOW and/or PO.

3.3.5.4 The vendor shall provide insulation thickness and thermal performance data on vendor supplied drawings for those heating jackets with jacket thickness limitations as specified on BNL supplied drawings, SOW, or PO.

3.3.5.5 Compliance with performance specifications specified herein for reduced insulation thickness heater jackets is required unless an exception is made by the vendor in writing at the time of vendor quotation and is subsequently accepted by BNL in writing.

3.3.6 Outer Facing

3.3.6.1 The outermost layer of the heater jacket shall be constructed from a densely woven glass fiber cloth.

3.3.6.2 The outer facing shall be able to withstand prolonged exposure at the maximum operating temperature of the heating elements without loss of structural integrity or electrical insulating properties.

3.3.6.3 The outer facing shall provide electrical insulation sufficient to protect personnel in contact with the outer surface from electrical shock due to contact between a compromised heater element dielectric and the inside surface of the outer facing. No electrically conductive materials shall be used in the outer facing construction.

3.3.6.4 The outer facing shall be capable of withstanding typical and repeated handling for installation, removal and storage without suffering damage that prohibits the jacket from meeting any other requirements specified herein.

3.3.6.5 Special Application Outer Facing: Other materials may be permitted in the construction of the Special Application Jacket Facing to achieve the special application requirement provided the remaining Standard and Special Application specifications are met.

3.3.7 Fasteners

3.3.7.1 Securing the heating jackets to the components shall be with non-magnetic materials only. Fastening shall be accomplished by non-magnetic corrosion resistant lacing hooks located on the jacket seams. Hooks shall be placed such that air pockets and bunching are minimized.

3.3.7.2 The fasteners shall be placed to assure good contact between the jacket component and complete closure of the jacket. Fasteners may be staggered if required, however, no overlapping of lacing patterns is permitted.

3.3.7.3 Fasteners shall be installed on the Jacket such that the forces applied to repeatedly fit and

secure the Jacket do not cause the fastener to detach from the blanket.

3.3.7.4 Special Application Fasteners: Fastening methods such as Velcro may be permitted in the construction of the Special Application Jacket Facing to achieve the special application requirement provided the remaining Standard and Special Application specifications are met.

3.3.8 Cold Leads / Strain Reliefs

3.3.8.1 The cold lead wire shall be made from continuous multi-stranded, corrosion resistant electrical wire suitable for continuous duty at 100 % rated power. The cold lead wire shall be 14 gauge for ≤ 15 amps and 12 gauge for use up to 18 amps in accordance with National Electric Code. No splice except for the connection of the cold lead wire to the heater element is permitted.

3.3.8.2 The primary insulation for the cold leads shall be non-porous and suitable for the environment. An outer sleeve of fiberglass shall protect the primary cold lead insulation. This combined insulation shall withstand 500 VAC without breakdown.

3.3.8.3 Cold leads shall extend 20 feet from the jacket. Connectors are not required on the supply ends of the cold leads.

3.3.8.4 A mechanically crimped splice joint shall connect the heating elements and cold leads. Cold leads shall overlap the heating elements within the splice prior to crimping. The splice connector shall be non-magnetic and corrosion resistant.

3.3.8.5 Each cold lead shall incorporate a strain relief to isolate the heater elements from any force applied to the cold leads.

3.3.9 Assembly

3.3.9.1 Jackets shall be designed such that complete coverage of the component is achieved with the minimum number of sections. However, jackets may be designed in halves, parts, etc., if a significant advantage or economy is realized. If jackets are made in multiple sections, each jacket section shall provide the appropriate power to maintain the covered area at the specified operating temperature, such that the entire component is heated evenly to meet the gradient requirement specified herein. Each jacket of a multiple jacket assembly shall be designed to perform as specified when combined in a series circuit with all other jacket sections of the heater jacket assembly. In the event of a heater element failure of one jacket section, current flow through all jacket sections of the assembly is eliminated. Jacket sections of a multiple jacket assembly shall be electrically interconnected in series with cold lead wire terminated with locking connectors. Connecting and disconnecting shall not require tools.

3.3.9.2 The complete jacket shall not have any exposed unfinished or raw edges. Inside seams shall be used wherever possible. The final closing seam shall be folded over and sewn or sealed to eliminate raw edges.

3.3.9.3 The complete jacket shall be assembled and sewn such that the insulation thickness and the shape of the jacket are maintained prior to installation. Particular attention must be focused on areas around cutouts, lacing and mating surfaces.

3.3.9.4 All jacket seams shall close fully with reasonable ease and the jacket shall closely conform, with good surface contact, to the component shape upon installation.

3.3.9.5 No gaps shall exist in the seams of installed jackets. Jackets may incorporate an overlap or sealing flap on one side of the sealing edge to ensure that no gaps exist. Fasteners used to secure the jacket must also secure this flap.

3.3.9.6 It shall be possible to install and remove the heating jacket without disturbing the assembly to which it is attached, unless specific relief of this requirement is specified in the PO, SOW or associated drawing.

3.3.9.7 The overall thickness of the jacket in an uncompressed state shall not exceed the dimension specified on the associated BNL provided drawing SOW or PO.

3.3.9.8 Special Application Assembly: Other assembly methods may be permitted in the assembly of the Special Application Jackets to achieve a special application requirement provided the remaining Standard and Special Application specifications are met.

3.3.10 Performance

3.3.10.1 The normal operating bakeout temperature of the component is 300°C unless specified otherwise in the PO, SOW or associated drawing.

3.3.10.2 The heater jacket shall provide the power necessary to achieve a temperature of 100°C greater than the normal operating temperature.

3.3.10.3 The operating voltage of the jackets shall be 115 VAC, 60 Hz.

3.3.10.4 The allowable current for a blanket shall not exceed 18 amps at the operating voltage.

3.3.10.5 Jackets shall be designed such that components to which they are attached attain the operating temperature at less than full power in still air at 20°C.

3.3.10.6 Jackets shall be capable of delivering an average ramp rate of 50°C hr^{-1} up to 90% of the operating temperature.

3.3.10.7 The heating element configuration (power density) shall be designed such that a maximum temperature difference between any two parts of the component while at operating temperature is ≤ 50°C. Particular attention must be paid to high heat loss areas such as flanges.

3.3.10.8 The surface temperature for special application jackets shall be noted by the seller in the submitted bid and will be permitted only with the written approval of a BNL purchasing representative, in consultation with the cognizant engineer of the C-AD Vacuum Group. The surface temperature shall also be noted on the jacket marking tag.

3.3.10.9 Jackets shall withstand a minimum of 100 heating cycles. A cycle consists of raising the components temperature from 20°C to its operating temperature, soaking for forty-eight (48) hours, and returning to 20°C.

3.3.10.10 The design of the jackets shall compensate for shrinkage over the life of the jacket so that complete closure of the jacket is always achieved.

3.4 Environment

Between bakeouts, the jacket will be exposed to a temperature of ≤ 20°C, while at a relative humidity of ≤ 90%. The jacket shall be designed to withstand this environment without degradation of performance and thermal or electrical insulating properties.

3.5 Dimensions and Physical Features

Each jacket shall be clearly marked with the following information: *a*) drawing name, *b*) drawing number, *c*) serial number traceable to the test report for that particular jacket, *d*) BNL purchase order number, *e*)power (watts), *f*) operating voltage of 115 VAC, *g)* outer face surface temperature with the component at normal maximum bakeout temperature. This marking shall be on an aluminum tag attached to the outside of the jacket, at or near the electrical leads.

4.0 QUALITY ASSURANCE

The following Quality assurance clauses of BNL QA-101, Seller Quality Assurance Requirements, are applicable to the execution of this contract: 1.0, 2.0, 3.0, 3.1, 3.1.3, 4.10, 4.10.1, 4.10.4, 4.16, 4.19, 4.26, 4.40.

The seller shall be responsible for providing jackets to the buyer that are in total compliance with this specification. A certificate of compliance must be provided with each jacket. Implicit in this certification is that the seller has performed all such tests as may be necessary to assure full compliance.

4.1 Warranty

The jackets shall be covered by a warranty against material and manufacturing faults. The seller shall specify in detail the warranty provisions. The warranty shall be for a period of at least one year from the date of receipt at BNL. Replacement parts shall be available for a minimum period of seven (7) years from the date of receipt at BNL.

4.2 Documentation

The following documentation must be submitted to BNL:

- The vendor shall provide working drawings of the jackets if BNL generated heating jacket drawings are not provided or changes in configuration to BNL jacket drawings are made. Vendor supplied drawings shall include as a minimum, overall dimensions and layout of heating elements with circuit identification and the location of seams, slits and cold leads. This shall be submitted to BNL for approval prior to fabrication.

- Test reports traceable to the individual jackets showing:
  i) written confirmation of bake test
  ii) results of electrical voltage breakdown tests
  iii) electrical current draw of each circuit at nominal voltage
  iv) written confirmation of fitting test.

4.3 BNL Tests

BNL reserves the right to perform any test on the jackets, at BNL's expense, and at BNL facilities, for the purpose of verifying full compliance with any aspect of this specification. Failure of the jackets to meet any requirement of this specification shall be cause for rejection.

5.0 PREPARATION FOR SHIPMENT

5.1 The vendor shall bake the finished jacket at a temperature of 50°C greater than the operating temperature specified herein for two (2) hours with proper ventilation to remove any sizing, finishes or volatile components remaining from the manufacturing process. This process may be done in an oven. Electrical testing of the insulating properties described in this specification shall be performed both at room temperature and at the specified temperature.

5.2 Each jacket shall be test fitted to insure proper fit with the component prior to shipping.

5.3 Standard Jackets shall be bagged in clear plastic bags and sealed.

5.4 Jackets for Special Clean Room Applications shall be blown down with clean filtered dry nitrogen, double bagged and sealed in clean filtered dry nitrogen back-filled clear plastic bags.

6.0 JACKET IMPROVEMENTS

The seller is encouraged to bring to the attention of BNL any improvement in performance or

reliability that would result from the use of materials, parts and processes other than those specified. A request for approval for any such improvement must be submitted to BNL for consideration at least fourteen (14) days prior to bid submittal date. Changes of this specification may be made only with written approval of a representative of BNL Division of PPM.