



TITLE LIGO BEAM TUBE SECTIONS CONSTRUCTION OPTION		IDENTIFICATION C-BT-CO				
		REFERENCE NO. 930212		SHT 1 OF 7		
PRODUCT LIGO BEAM TUBE MODULES CALIFORNIA INSTITUTE OF TECHNOLOGY		OFFICE NOE-C		REVISION 1		
		MADE BY MLT	CHKD BY KHF	MADE BY MLT	CHKD BY SWP	
		DATE 3/22/94	DATE 3/23/94	DATE 5/8/95	DATE 5/12/95	

0.1 SCOPE

This specification gives the technical requirements for spiral welded tube sections to be used in the LIGO Beam Tube Modules for the construction option. The scope of work consists of the fabrication of spiral welded tube sections and the associated documentation and inspection as defined by this specification. The beam tube sections will be incorporated into the LIGO facilities at Hanford, Washington and Livingston, Louisiana by CBI(Purchaser). The LIGO Project is administered by the California Institute of Technology (Caltech) for the National Science Foundation (NSF). Although not subjected to internal pressure, the beam tube modules will be built to the requirements of ASME Section VIII Code, Division 1 as applicable to ultra high vacuum facilities.

1.0 MATERIALS

- 1.1 The material will conform to the requirements of ASME Specification SA-240 Type 304L with the additional supplementary requirements described in the attached material specifications C-240-0186 and C-CMBS1. These supplemental specifications contain special chemical and heat treatment requirements for the material. After material bake, as described in specification C-CMBS1, coupons taken from each coil will be tested by the purchaser to determine the hydrogen outgassing characteristics of the material. Fabrication of the beam tube sections will not be allowed until the hydrogen outgassing rate has been determined and the material has been approved for fabrication by the Purchaser.
- 1.2 No external attachment welds to the tube sections are allowed without the prior approval of the Purchaser.
- 1.3 The Purchaser will provide coil material and weld metal to the beam tube fabricator. The coil material will be fully processed and tested and ready for fabrication. The beam tube fabricator shall state the material properties required for successful beam tube fabrication.
- 1.4 Beam tube fabricators shall state the material dimensional requirements and percentage scrap required in the quotation for the beam tubes. Procurement costs or mark ups, if applicable, shall be listed separately.

2.0 CODES & SPECIFICATIONS

The following codes and specifications shall apply unless revised by this specification. Any conflicts between the requirements given herein and the applicable ASME Specification shall be brought to the attention of the purchaser for resolution.

- 2.1 ASME Boiler & Pressure Vessel Code, Section II, "Materials", 1992 Edition, 1993 Addenda.
- 2.2 ASME Unfired Pressure Vessel Code, Section VIII, Division 1, 1992 Edition, 1993 Addenda as applicable. (Code stamping is not required.)
- 2.3 ASME Section IX Code, Welding and Brazing Qualifications 1992 Edition, 1993 Addenda.
- 2.4 CBI Specification WMS-ER308L
- 2.5 CBI Coil Material Specification C-240-0186
- 2.6 CBI Material Bake Specification C-CMBS1
- 2.7 LIGO Specification 1100004, Rev. E, "Beam Tube Module Specification dated May 17, 1994.



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2.9 LIGO Specification 1100007, Rev. A. "Process Specification for Low Hydrogen, Type 304L Stainless Steel Vacuum Products", dated May 17, 1994.

3.0 PHYSICAL DESCRIPTION

The beam tube modules are composed of a repeating 130' long configuration which consists of two beam tube sections and an expansion joint with fixed and flexible supports. The modules will be composed of equal numbers of 65'-0 and 62'-9 beam tube sections plus shorter make up sections at the ends of each module. Details are shown on the attached drawings which are listed below:

Drawing Title	Dwg #	Rev #
General Module Configuration	1	2
Sub Module Details	2	2
Sub Modules E, F, G, & H	3	2
Sub Modules A, B, & C	4	2

Only the unstiffened tube sections are covered by this specification. All tube sections shall have a nominal inside diameter of 48.75". The tube end shall have an inside diameter of 48.875" for a minimum length of 4 inches.

4.0 TOLERANCES

Close circumferential tolerance at the tube section ends are required to enable tube sections to be butt welded to either adjacent tube sections or expansion joints. All tube ends must have the same nominal diameter and lie within the circumferential tolerance specified. Tube ends must be perpendicular to the tube axis and flat to produce a straight butt welded tube section and to provide close fit up for welding. Tube ends must therefore be machined. Tube sections shall have the following tolerances:

Perpendicularity of the end of the tube to the axis of the tube:	.010"
Flatness of the tube end:	.010"
Circumference of the tube ends only:	+/-3/64"
Longitudinal straightness of tube:	+/- 1/16"
Nominal diameter when supported to prevent sag or stiffened:	+ .25, -0
Concentricity of expanded end to tube axis (if ends are expanded)	.010"

5.0 SUBMITTALS, DOCUMENTATION, AND RECORDS

5.1 Information Required With Quotation

5.1.1 The vendor shall state in the quotation that the quotation complies with this technical specification with any exceptions or alternatives noted and explained. Purchaser will assume complete conformance unless deviations are noted.



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- 5.1.2 A description of the vendor's Quality Assurance Manual in accordance with ANSI/ASQC Standard Q91(Certification not required) or ASME Section VIII Quality Control System Manual. In particular, vendor's material traceability plan shall be described.
- 5.1.3 Procedures for making and documenting measurements of dimensions with specified tolerances.
- 5.1.4 A description of the vendor's manufacturing facilities and equipment required to perform the work covered by this specification.
- 5.1.5 Identification of any sub-contractors if applicable.
- 5.1.6 A description of the vendor's management plan, including the process by which the work covered by this specification will be monitored and controlled, and the identification and function of key personnel to be assigned.
- 5.1.7 All material requirements to enable tube fabrication in accordance with this specification including but not limited to coil material dimensional requirements, tolerances required, special chemical requirements, and processing requirements.
- 5.1.8 Equipment and procedures to be used for beam tube end preparation including diameter of sized ends if applicable.
- 5.2 Information Required After Receipt of Order and 4 Weeks Prior to Fabrication For Approval
 - 5.2.1 Welding procedures with supporting procedure qualification records in accordance with ASME Section IX.
 - 5.2.2 Welder Performance Qualification Test Records in accordance with ASME Section IX. (Available for review)
 - 5.2.3 Repair Procedures.
 - 5.2.4 NDE procedures and NDE personnel qualifications (Qualifications available for review).
 - 5.2.5 Cleaning Procedures.
 - 5.2.6 Packaging and Handling procedures. Beam tube handling procedures shall approved by the purchaser prior to beam tube fabrication. Stress levels in an unstiffened beam tube may approach the yield stress of the tube material. Caution must be taken to minimise this stress level.
- 5.3 Information Required for Record and Documentation at the Completion of the Work

The vendor shall send copies of the following records and documentation with each shipment:



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- 1) Record of measured tolerance dimensions of each spiral welded tube section provided with the tube section.
- 2) Record drawings and check lists indicating welder identification to each weld joint and traceability of Certified Material Test Reports (CMTR) to the location in each tube section.
- 3) Signed off checklist and reports indicating that all required NDE was completed.

6.0 FABRICATION

6.1 Welding

- 6.1.1 ER308L weld material shall be cleaned per CBI Specification WMS-ER308L.
- 6.1.2 All welding exposed to the vacuum shall be done by the gas tungsten arc welding (GTAW) process. Welding shall be autogenous with the exception that weld passes on the outside of the tube section spiral weld joints may use filler metal meeting the requirements of paragraph 6.1.1.
- 6.1.3 For all welding, an inert gas purge on the vacuum side is required.
- 6.1.4 Unless directed otherwise by the purchaser, temporary attachments and weld tacks for fit up, lifting, or handling shall not be used.
- 6.1.5 Welding procedures shall be submitted prior to production welding. Welder and welding operator performance qualification test records shall be submitted prior to any individual performing welding. Welding procedures, welders and welding operators shall comply with Section IX of the ASME Boiler and Pressure Vessel Code. The purchaser shall have the option to require re-qualification of any welder at any time, if in the purchaser's opinion, the welder's qualifications are suspect or welds appear not to be of proper quality.
- 6.1.6 Edge registry for spiral welds must be within 1/4 of the thickness which is 1/32". Edge registry for coil splices must be within .010". All edges including strip edges must be power brushed with stainless steel brushes just prior to tube fabrication.
- 6.1.7 The minimum depth of penetration for the inside and outside weld is 60% which will provide an overlap of approximately .025". An effective monitoring plan must be developed to ensure 100% weld penetration. As a minimum, cut ends of the beam tube sections shall be ground, polished, and etched with a solution containing one part concentrated nitric acid and two parts concentrated hydrochloric acid (Aqua Regia or equal) immediately after fabrication. Lack of 100% penetration shall be cause for rejection of the tube section.
- 6.1.8 Coil splices shall be made with end tabs if coil edges are not removed by slitting prior to tube fabrication. Tabs are to be made from SA240 type 304L material, baking is not required. Tabs shall be removed by mechanical means such that a full edge at the coil splice is provided.



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6.2 Cleaning and Cleanliness Maintenance

- 6.2.1 All contact made with the stainless steel material during fabrication shall be such that carbon steel contamination is prevented.
- 6.2.2 After fabrication of the spiral welded tube sections is complete, the inside surface shall have all visible traces of oil, grease, or other foreign material removed with a solvent wipe. Detergent / water solutions are not allowed. Vendor shall submit a cleaning procedure stating solvents to be used for approval by the Purchaser.

6.3 Spiral Mill

- 6.3.1 Spiral mills shall have variable speed DC drives to enable smooth material flow at speeds ranging from 5" per minute to 24" per minute.
- 6.3.2 Cleanliness of the stainless steel shall be preserved. Cleaning of the spiral mill may be required to accomplish the cleanliness requirements of the stainless steel tube sections. The manufacturer is to evaluate the contamination potential and advise the necessary course of action. Spiral mills may have to be steam cleaned of all hydrocarbons prior to the tube fabrication and located or placed such that cleanliness is preserved during tube manufacturing.
- 6.3.3 Only the necessary guides and rollers of the mill shall contact the coil material and tube sections before, during, and after fabrication. All items of the mill which contact the strip material or inside surface of the fabricated tube should be cleaned by wiping with alcohol prior to fabrication.
- 6.3.4 Coil strip edges shall be power brushed just before welding to remove the oxide layer developed during coil bake. The cleaned edged width shall be between 1/4" and 3/8".
- 6.3.5 All bearings and lubrication fittings which could allow hydrocarbons to leak or drip onto the coil or fabricated tube shall be wiped free of excessive lubrication with a solvent wipe.

6.4 Material Identification

- 6.4.1 Material traceability shall be maintained throughout fabrication and shipping. Material marking and traceability requirements specified in ASME, Section VIII, Division 1 shall apply. Markings shall be located on the outside surface of the beam tube section at both ends and shall be either marking fluid or vibratory tool with a minimum tip radius of 0.005 inches. See ASME Section II SA-480, paragraph 20.1.1. Chlorine and fluorine contaminants from markers must not exceed the residual levels shown in ASME Section V, paragraph T-641 for liquid penetrant materials.



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The following markers are approved for use:

MARKER	MANUFACTURER	COLOR
Sharpie or Sharpie Tec Ink	Sanford	Black
Action Markers High Purity Ink	Mark-Tex	White/Black/Red
Marks-A-Lot	Avery-Denison	Black/Red
GP-X Markers	Diagraph	White/Black/Yellow
Mighty Mark 7000, 7007	Fiber-Castell	All
American 7000	Eberhard-Faber	Black
Low Chloride Penemark Metal Marker (Paint)	John P. Nissen	White/Black/Yellow
Tempil Marker or Pyromarker (Paint)	Tempil	All colors except blue

6.4.2 Each beam tube section shall be uniquely identified. The identification shall enable the complete history of each tube to be maintained. A record drawing for each beam tube section shall be prepared which indicates all weld repairs, stops and starts, and fabrication abnormalities including locations of coil butt splices. Beam tube section record drawings must accompany the tube shipment.

7.0 INSPECTION / REPAIRS

7.1 The National Science Foundation and Caltech, through their authorized representatives, have the right to inspect and evaluate the work performed or being performed under this specification, including the premises where the work is being performed at all reasonable times. The NSF and Caltech shall have non-escort privileges to all areas of the facilities where work is being performed under this specification. This shall include access to fabrication, assembly, cleaning, and test area for the purpose of monitoring activities. The vendor shall furnish all reasonable facilities and assistance for the safe and convenient inspection of the work if requested.

7.2 Each tube section shall be inspected to determine the tubes dimensional tolerances and weld abnormalities.

7.3 Each beam tube section shall be uniquely identified. The identification shall enable the complete history of each beam tube to be maintained. A record drawing for each beam tube section shall indicate all weld repairs, stops and starts, and fabrication abnormalities. Dimensional information, weld abnormalities, and any relevant information concerning the tube fabrication shall be recorded on a unique drawing(s) for each tube section.

8.0 REJECTIONS AND REPAIR OF DEFECTS

8.1 No weld splices or repair welding is permitted to the material without approval by the Purchaser using approved repair procedures and qualified welders.

8.2 Circumferential weld joints in the beam tube sections are not permitted.

8.3 Coil splice weld joints are not permitted within 6" of the tube ends.



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9.0 PROCESS QUALIFICATION

- 9.1 Beam tube sections shall not be incorporated into the LIGO facilities until the vendor's process has been tested and qualified by the Purchaser.
- 9.2 The Qualification Test shall consist of leak testing and outgas testing of two sections of beam tube. Vendor shall provide two unstiffened beam tube sections from material supplied by the purchaser for stiffening and testing by the Purchaser.

10.0 HANDLING, PACKAGING, STORING AND SHIPPING

- 10.1 Vendor is to provide procedures for approval by the Purchaser for handling, packaging, storing, and shipping of the beam tube sections. These procedures shall include details for end sealing and protection of the tube ends and interior, any internal bracing for shipment and storage, and external shipping saddles.
- 10.2 Tubes shall be shipped four to a truck and be supported between 4' and 7' from the tube ends. Tube shall be supported or braced at the support points to prevent ovaling of the tube cross section. The supports shall prevent relative motion between the tubes and supports or adjacent tubes. Tubes shall be packaged to permit standard width unescorted trucks which have a maximum width of 8'-6" and a maximum length of 65'. Tube sections must be shielded from the sun during shipping and storage. As a minimum, the shipping plan must meet the requirements of CBI Erection Drawings ER-015 and ER-016.