



<b>TITLE</b> BEAM TUBE CAN SECTION FABRICATION SEQUENCE		IDENTIFICATION <p style="text-align: center;"><b>FABSEQ</b> LIGO-E950048-02-B</p>			
		REFERENCE NO. <p style="text-align: center;"><b>930212</b></p>		SHT 1 OF 13	
<b>PRODUCT</b> LIGO BEAM TUBE MODULES CALIFORNIA INSTITUTE OF TECHNOLOGY		OFFICE <p style="text-align: center;">PCR</p>		REVISION <p style="text-align: center;"><b>3</b></p>	
		MADE BY GLW	CHKD BY KHF	MADE BY WLR	CHKD BY SWP
		DATE 2/3/94	DATE 4/5/94	DATE 8/21/95	DATE 8/21/95

## 1.0 SCOPE

This procedure outlines the fabrication sequences to be followed during the stiffener attachment, expansion bellows installation, pump port installation, testing and cleaning of the beam tube assemblies. Detail or supporting procedures for welding, testing, cleaning, etc. are referenced as required.

The following section headings are included:

- 2.0 Fabrication Sequence
- 3.0 Testing Sequence
- 4.0 Cleaning Sequence
- 5.0 Referenced Procedures
- 6.0 Sequence Diagram and Sketches

## 2.0 FABRICATION SEQUENCE

- 2.1 Deliver factory tube sections, stiffeners, pump port materials, weld materials, etc. to receiving area. Valves, blind flanges and associated bolting furnished by others will also be received at the storage area and handled in a similar manner.
- 2.2 Visually inspect factory tubes, stiffeners, pump port materials, welding materials, etc. for shipment damage and compare to shipping papers or packing list.

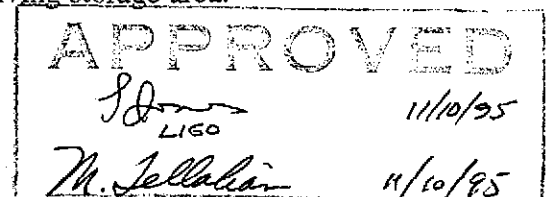
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### Note

Factory Tubes, Expansion Bellows, Stiffeners,  
Pump Port Materials and Valves will have  
inspection and factory release papers with shipment.

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- 2.3 Complete material receiving reports for all contract materials received at the site will be prepared. The receiving report will have attached any applicable inspection, certification, release, shipping manifests or other related documents.
- 2.4 Store beam tube cans or other materials in designated receiving storage area.





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		REFERENCE NO. <b>930212</b>		SHT 2 OF 13	
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**Warning**

**Do not perform any welding  
or tacking on beam tubes until proper  
backing purge has been established.**

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**Use nylon slings and designated rigging for  
handling beam tubes and expansion bellows.**

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**Do not use screw clamps or chains for handling beam tubes.**

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2.5 Move beam tube to desired stiffener fitting and weld area.

**Note:**

**Clean clothing and shoe covers shall be worn  
for all work inside the beam tube.**

2.6 Mark beam tube serial number identification on beam tube exterior using CBI approved ball point paint markers or paint stencil with 3" high letters. Markings to be a minimum of three places approximately 120° around on each end of bare beam tube can section.

Mark location of machined support stiffener and all other stiffeners. Indicate beam tube can section final installation direction at each end of beam tube can section and location of expansion bellows and pump port, if applicable. Layout pump port reinforcing ring, if applicable. Verify that pump port reinforcing ring does not cross spiral weld.

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**Notes:**

**1. For convention, beam tube  
direction is outward from apex.**

**2. Pump port layout to be between spiral  
welds so that reinforcing ring welding does  
not cross spiral weld. Rotate tube as required  
to obtain required spacing.**

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2.7 Slide on and rough position near final location all vacuum stiffeners.

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Reference

See

Fitting/Purge Procedure for Stiffener

Attachment Welds for LIGO

Doc ID "FPStiffener"

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2.8 Install machined support stiffener(s) with bolts (no welding). Machined stiffener halves to be placed in final position.

2.9 Set beam tube in stiffener fit-up and weld area. Position end turning trunnion and opposite end support.

2.10 Purge beam tube interior with nitrogen gas. Purge until oxygen level is less than 1.0% oxygen. End point to be verified with oxygen analyzer. Upon reaching 1.0% oxygen, establish nitrogen flow rate to a minimum flow rate necessary to maintain adequate purge level (light positive flow).

Purge to be maintained at less than 1.0% oxygen within tube. Check periodically during any tacking and welding operation.

2.11 Tack machined support stiffener(s).

2.12 Final position, fit and tack balance of stiffeners. Vacuum stiffener splice to be positioned over tube spiral weld. Do not tack within 2" of spiral weld.

2.13 Weld machined support and vacuum stiffeners.

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Note:

Do not weld on or over the beam  
tube can section spiral weld.

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<b>PRODUCT</b> LIGO BEAM TUBE MODULES CALIFORNIA INSTITUTE OF TECHNOLOGY		OFFICE PCR		REVISION <b>3</b>	
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**References:**

See

**Weld Procedure Specification for Stiffener Welds**  
Doc ID "WPS-ER308L/Stiffener"

&

**Weld Procedure Specification for**  
**GMA Welding for 304L Materials**  
Doc ID "WPS-ER308L/GMA"

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- 2.14 Fit and weld pump port reinforcing ring, if applicable. Verify prior to welding that pump port reinforcing ring does not cross spiral weld.
- 2.15 Steps 2.16 through 2.29 are for installation of expansion bellows. Skip if not applicable to specific beam tube can section.
- 2.16 Move stiffened tube section can section to expansion bellows fit/weld area.

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**Reference**

See

**Fitting/Purge Procedure for**  
**Circumferential Butt Welds for LIGO**  
Doc ID "FPCircumferential"

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- 2.17 Start aligning expansion bellows using mechanical alignment jig. The expansion bellows needs to be mechanical rough aligned (no tacking or welding) to allow installation of the inflatable purge ring.

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**Warning**

**Do not perform any tacking**  
**or welding at this time.**

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DATE	2/3/94	DATE	4/5/94	DATE	8/21/95	DATE	8/21/95

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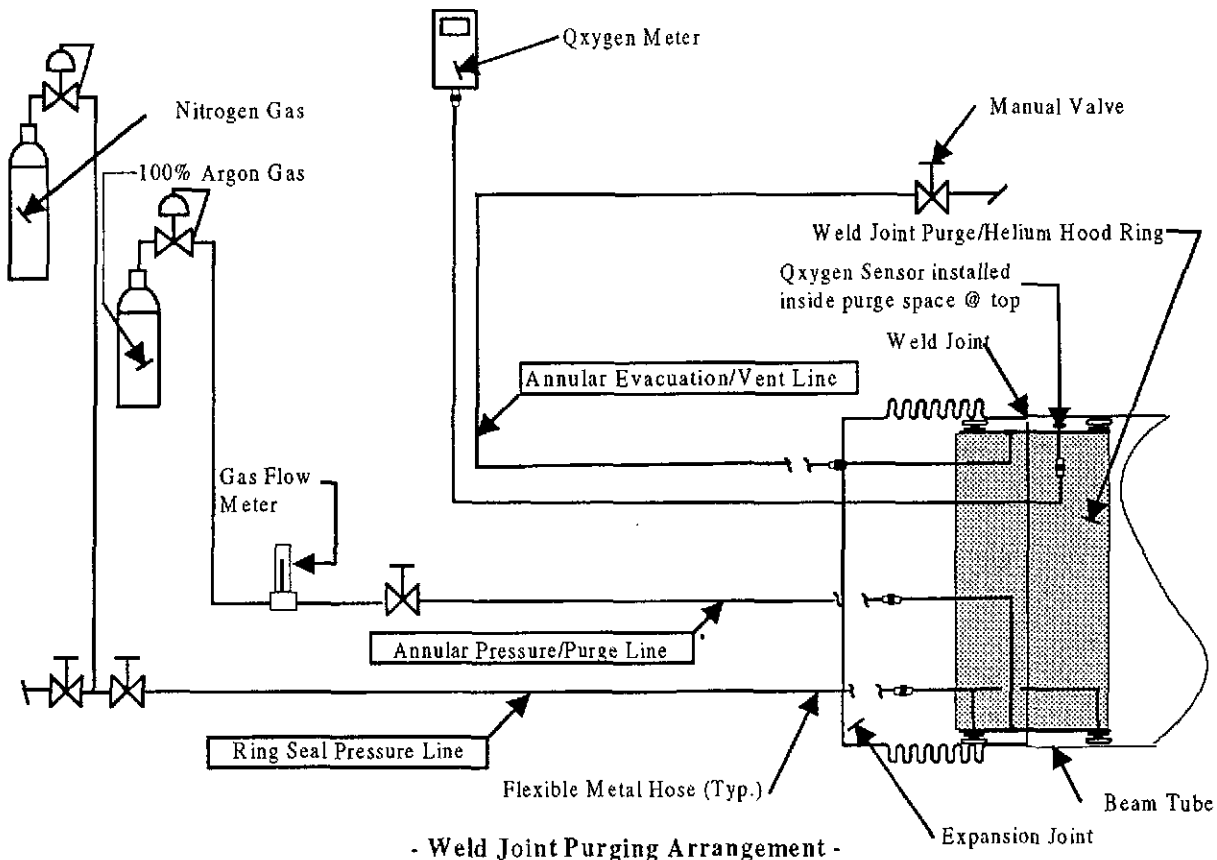
Note:

Clean clothing and shoe covers shall be worn  
for all work inside the beam tube.

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2.18 Install inflatable purge ring, centered on weld seam, and connect 3/8" diameter stainless steel purge/evacuation lines listed below:

- Annular space vent line (weld purge gas).
- Ring seal pressure line (nitrogen ring seal gas).
- Annular space pressure/purge line (weld purge gas).





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2.19 Inflate purge ring outer seals by opening valve on nitrogen ring seal gas supply holding inflatable purge ring in position centered on the beam tube/expansion joint weld joint to be welded. Regulator should be set at 5 psig.

2.20 Open evacuation line valve and annular space pressure line valve allowing 100% Argon backing purge gas to purge annular space. Purge until oxygen level is less than 1.0% oxygen. End point to be verified with oxygen analyzer. Upon reaching 1.0% oxygen, establish Argon flow rate to a minimum flow necessary to maintain adequate purge level (light positive flow).

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**Warning**

**Welding or tack welding at weld joint to be only performed after completion of the above weld purge.**

\*\*\*\*\*

2.21 Complete fit up of weld joint. Tack welding is allowed at this step. See visual inspection procedure DOC ID "VI8X" for fit up check.

\*\*\*\*\*

**Reference**

See

**Weld Procedure Specification  
for Circumferential Welds  
Doc ID "WPS-ER308L/Circumferential"**

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- 2.22 Set up and position automatic weld equipment and complete welding of beam tube weld joint.
- 2.23 Shut valve on annular space pressure/purge line to 100% Argon weld purge gas.
- 2.24 Valve on annular space evacuation line should be open and remain open.
- 2.25 Shut nitrogen ring seal gas supply.
- 2.26 Open purge ring outer seal vent valve
- 2.27 Close both evacuation valves associated with annular space evacuation line and purge ring outer seals after venting stops and weld joint purge ring has slackened.
- 2.28 Disconnect and remove the three (3) 3/8" diameter stainless steel purge/evacuation lines.



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- 2.29 Remove inflatable purge ring.
- 2.30 Steps 2.31 through 2.41 are for installation of pump port. Skip if not applicable to specific beam tube can section.
- 2.31 Move stiffened tube section to pump port fit and weld area.

\*\*\*\*\*

**Reference**

See  
**Fitting/Purge Procedure for Pump  
 Port Attachment Welds for LIGO  
 Doc ID "FPPumpPort"**

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**Note:**

**Clean clothing and shoe covers shall be worn  
 for all work inside the beam tube.**

- 2.32 Install pump port nozzle per procedure ID No. FPPUMPPORT.
- 2.33 Install end caps.
- 2.34 Move beam tube assembly to post fabrication storage area. The beam tube assembly shall be supported using temporary cribbing or loaded on transfer trailers while in storage to avoid contact with mud or other contamination.

**3.0 TESTING SEQUENCE**

- 3.1 Move beam tube assembly to test area and remove end caps.
- 3.2 Perform pretest record review and verification.
- 3.3 Perform visual examination noting any suspect areas.
- 3.4 Perform leak test on beam tube can section.



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**Reference**

See

**Helium Mass Spectrometer Hood Test  
of Beam Tube Can Sections**

**Doc ID "HMST1N"**

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- 3.5 Complete test records for beam tube can section.
- 3.6 Steps 3.7 through 3.10 are for repeat leak testing and repair of beam tube assemblies that have failed previous test. *Skip if not applicable to specific beam tube section.*
- 3.7 Perform visual examination noting any suspect areas.
- 3.8 Localize leaks by probe or bag testing.
- 3.9 Perform weld repair using appropriate purge method depending upon area to be repaired. Repair per specific contract welding procedures.
- 3.10 Repeat steps 3.4 to 3.6.
- 3.11 Install end caps.
- 3.12 Move beam tube can section to post test storage area.
- 4.0 BEAM TUBE CAN SECTION CLEANING**
- 4.1 Move beam tube assembly to cleaning area and remove end caps.

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**Note:**

**Beam tube can sections should be cleaned  
as required by installation requirements  
with limited storage time between final  
cleaning and installation.**

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- 4.2 Set-up for beam tube assembly cleaning locating movable end clean enclosures at each end of beam tube assembly. Cleaning rack to be sloped to allow drainage from beam tube assembly. Drainage to be towards opposite end from expansion bellows, if applicable.

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**Reference**

See

**Cleaning of Completed Tube Can Sections**

**Doc ID "CL4"**

\*\*\*\*\*

- 4.3 Clean interior of beam tube can section.
- 4.4 Dry interior of beam tube can section.
- 4.5 Install cleaned end protection caps and polyethylene bagged double seal. Do not use tape on the beam tube interior or on the beam tube exterior within 6 inches of the end.
- 4.6 Complete cleaning records for beam tube can section.
- 4.7 Move cleaned and sealed beam tube can section to post clean storage area. The beam tube assembly shall be supported using temporary cribbing or loaded on transfer trailers while in storage to avoid contact with mud or other contamination.



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**5.0 REFERENCED PROCEDURES**

This fabrication sequence is to be used in conjunction with the following procedures:

- 5.1 Planned Approach to Leak Testing for LIGO Project  
Doc ID "LIGOTP"
- 5.2 Helium Mass Spectrometer Hood Test of Beam Tube Can Sections  
Doc ID "HMST1N"
- 5.3 Planned Approach to Cleaning and Cleaning Maintenance for LIGO Project  
Doc ID "LIGOCP"
- 5.4 Cleaning of Beam Tube Can Sections  
Doc ID "CL4"
- 5.5 Fitting/Purge Procedure for Pump Port Attachment Welds  
Doc ID "FPPUMPPORT"
- 5.6 Fitting/Purge Procedure for Circumferential Butt Welds for LIGO  
Doc ID "FPCircumferential"
- 5.7 Welding Procedure Specification for Circumferential Welds  
Doc ID "WPS-ER308L/Circ"
- 5.8 Welding Procedure Specification for Pump Port Welds  
Doc ID "WPS-ER308L/Port"
- 5.9 Welding Procedure Specification for Stiffener Welds  
Doc ID "WPS-ER308L/Stiffener"
- 5.10 Welding Procedure Specification for GMA welding of 304L materials  
Doc ID "WPS-ER308L/GMA"
- 5.11 Welding Procedure Specification for repair welding of 304L materials  
Doc ID "WPS-ER308L/REPAIR"



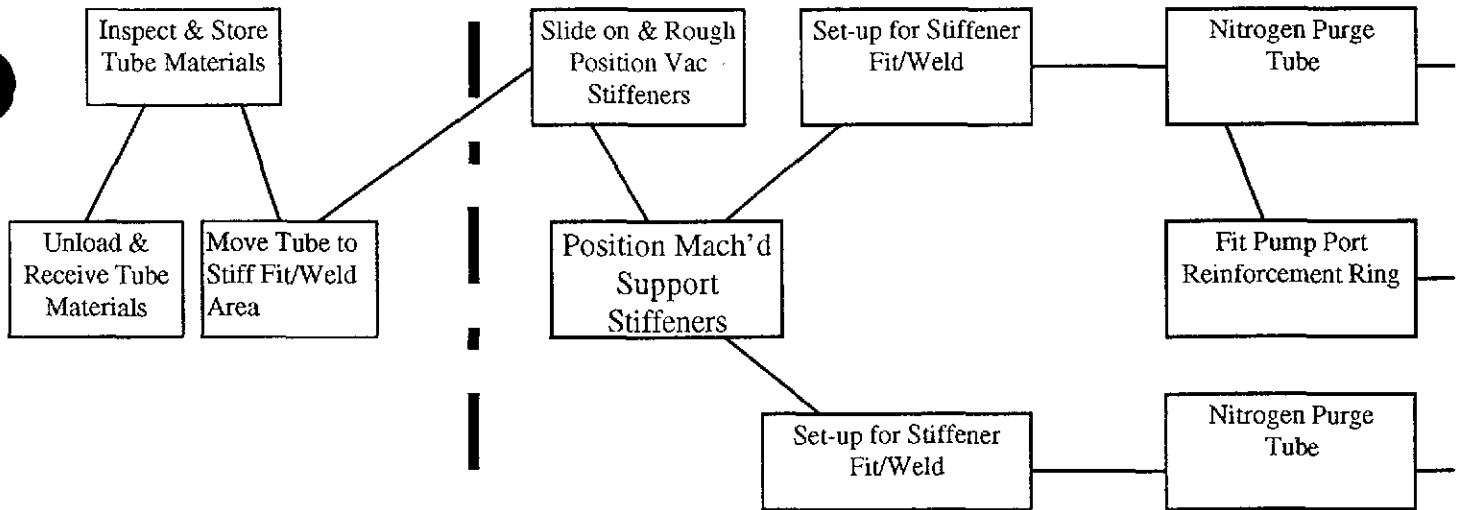
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**6.0 SEQUENCE DIAGRAM**

Attached find the following fabrication sequence diagrams:

- 6.1 Beam Tube Fabrication Sequence Logic Diagram  
(Page 11 of 13 to Page 13 of 13)

**\*\* Pre Fabrication Storage \*\*** | **\*\*\*\*\* Fabrication Task \*\*\*\*\***



**LIGO Beam Tube Fabrication Sequence**  
**Hanford, WA & Livingston, LA**

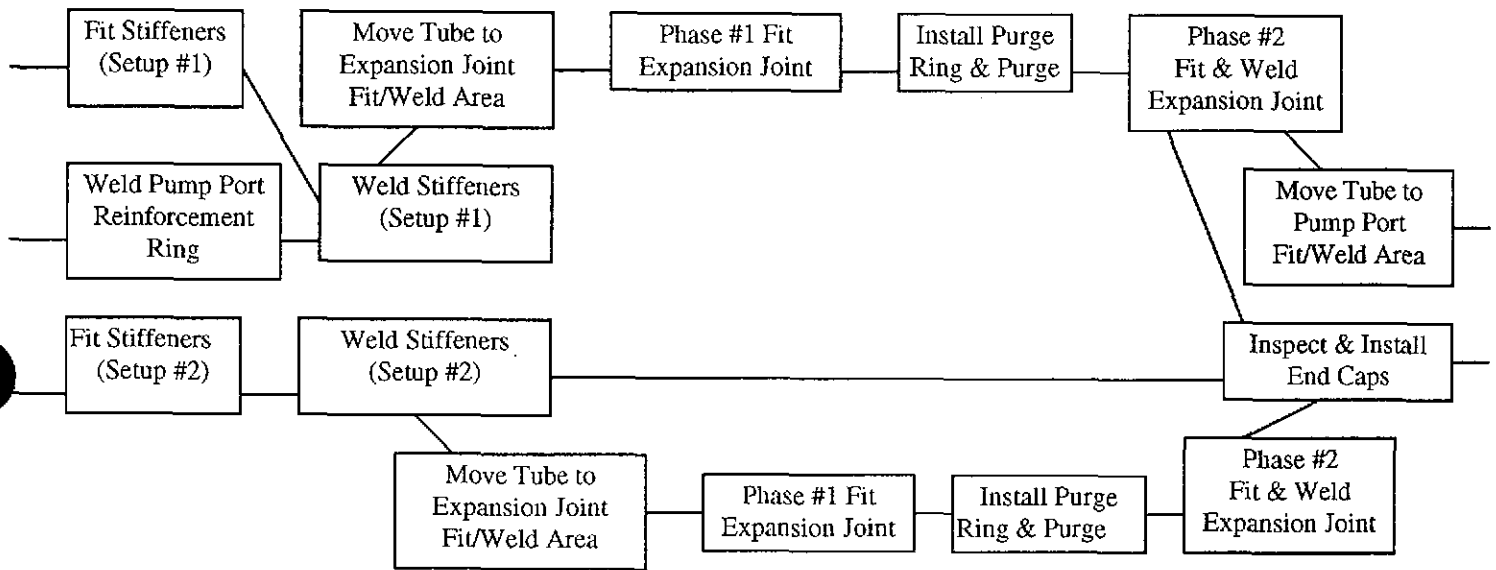
**Sequence**  
**Task Description**

Legend



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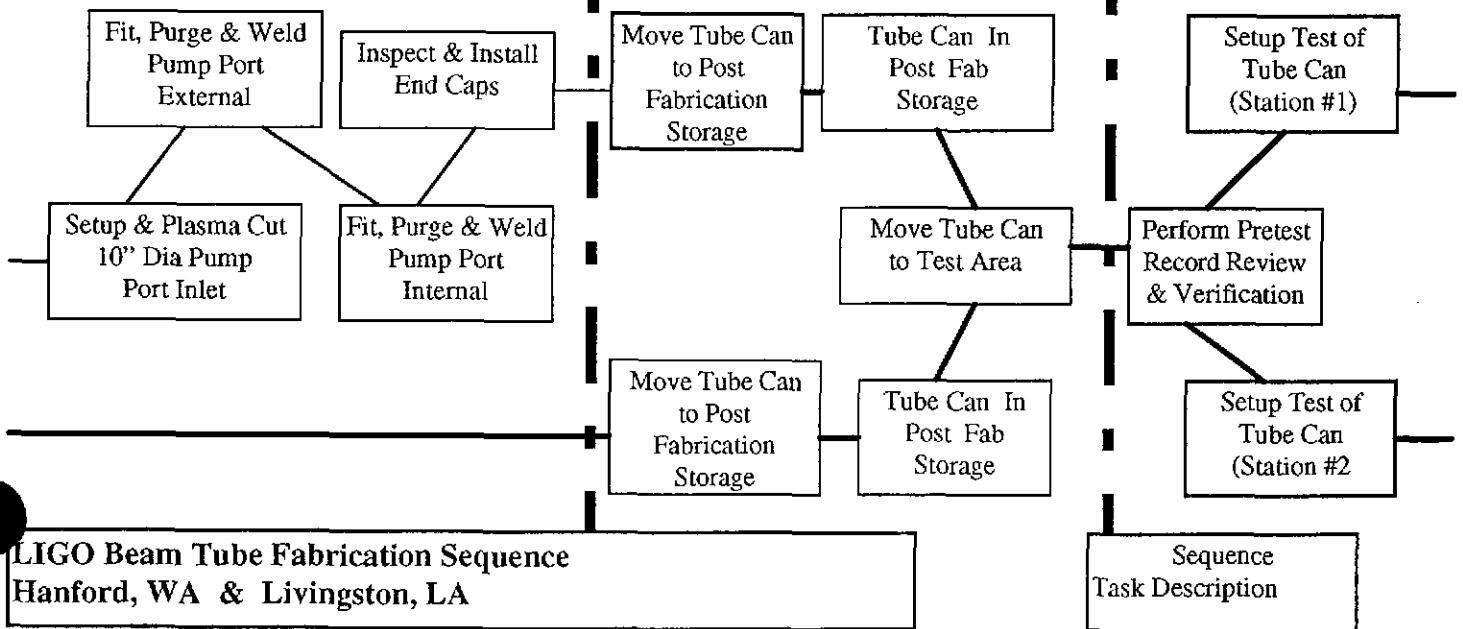
\*\*\*\*\* Fabrication Task (Continued) \*\*\*\*\*



\*\*\* Fabrication Task (Continued) \*\*\*

\*\*\*\* Post Fabrication Storage \*\*\*\*

\*\*\* Testing Task \*\*\*\*



LIGO Beam Tube Fabrication Sequence  
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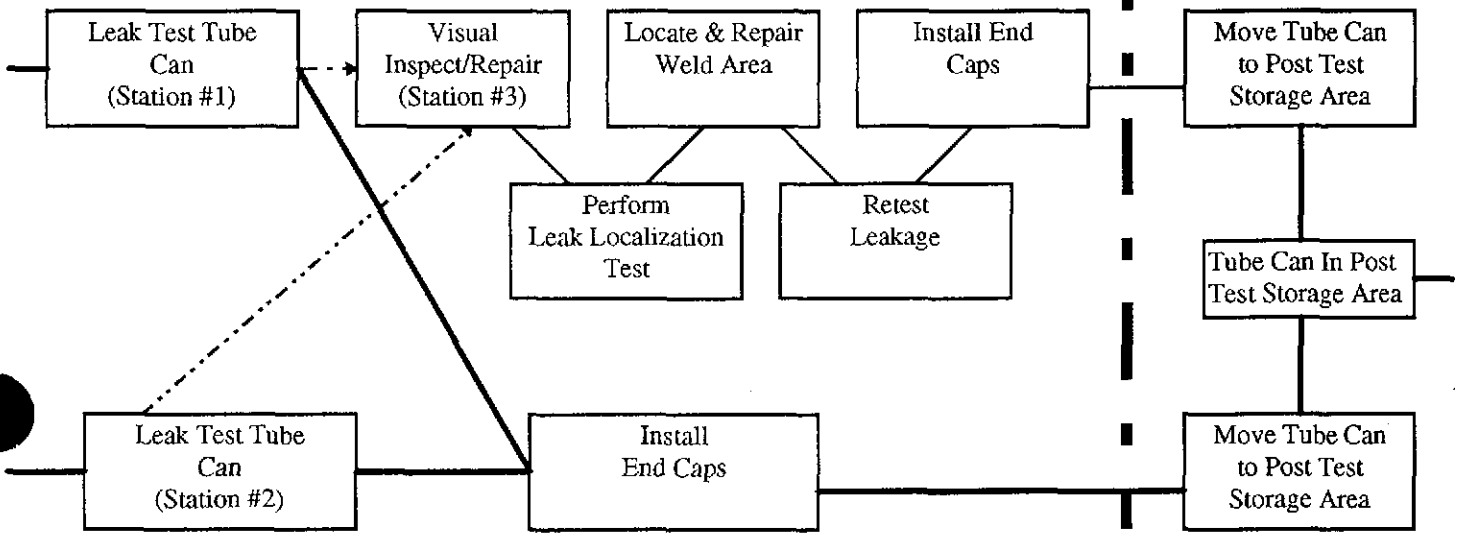
Sequence Task Description

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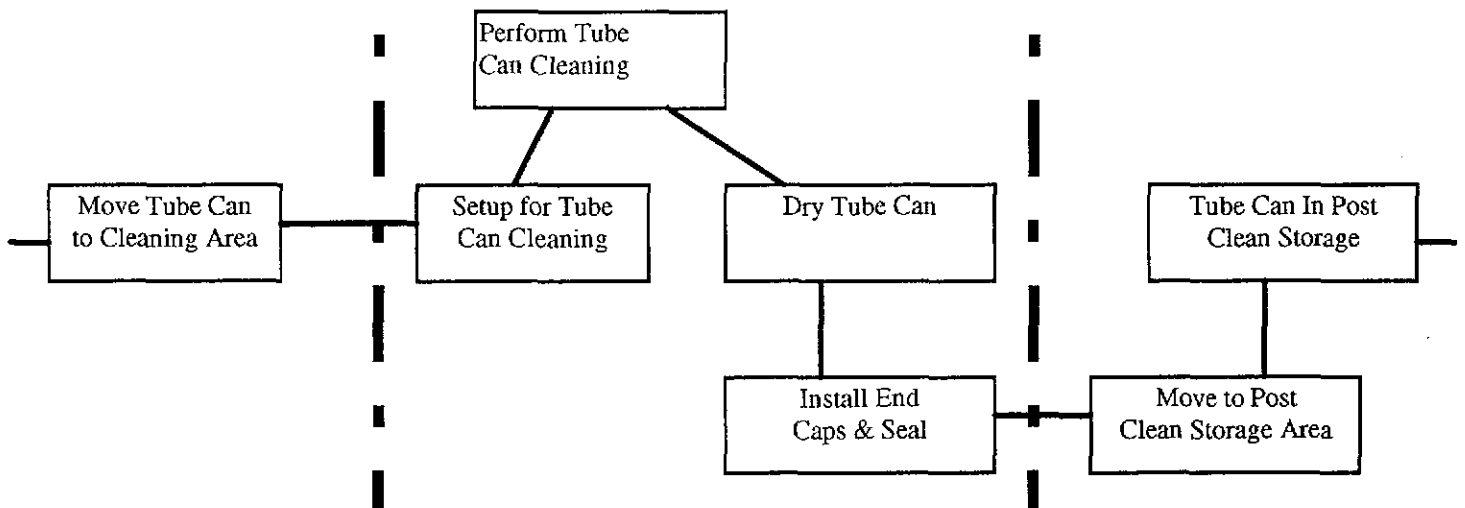


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\*\*\*\*\* Testing Task \*\*\*\*\* | \*\*\* Post Test Storage \*\*\*



\* Post Test Storage \*\* | \*\*\*\*\* Cleaning Task \*\*\*\*\* | \*\*\* Post Clean Storage \*\*\*\*



LIGO Beam Tube Fabrication Sequence  
 Hanford, WA & Livingston, LA

Sequence  
 Task Description

Legend