



SPECIFICATION FOR WELDING INSPECTIONS

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TABLE OF CONTENTS

- 1.0 Scope**
- 2.0 General Procedure**
 - 2.1 Control of Documents, Codes and Standards**
 - 2.2 Technical Requirements**
 - 2.3 Examination Requirements**
 - 2.4 Acceptance Standards**



SPECIFICATION FOR WELDING INSPECTIONS

1.0 Scope

This document contains the methods and acceptance criteria for visual inspection of welding for the LIGO Vacuum Components. The Seller shall incorporate these requirements in their welding procedures.

2.0 General Procedure

2.1 Control of Documents, Codes and Standards

2.1.1 The Quality Plan, the fabrication drawings and other procedures specify the required visual inspection and physical dimensions. It is not the intent of this procedure to duplicate those requirements. It is however, the intent of this procedure to provide a consistent method of performing visual inspection.

2.2 Technical Requirements

2.2.1 **Illumination** - lighting, natural or artificial shall be sufficient to illuminate the area being examined.

2.2.2 **Personnel** - Personnel performing visual examination shall be familiar with the welding technique being used, welding procedure requirements, machining operations, and the type of discontinuities that may occur in the weld or base material being examined.

2.2.3 **Examination** - Direct visual examination shall be used when access is sufficient to place the eye within 24 inches of the surface to be examined and at an angle not less than 30 degrees to the surface to be examined. Mirrors may be used to improve the angle of vision, and aids such as a magnifying lens may be used to assist examinations.

NOTE: Unless impossible, direct visual examinations will be used for all visual examinations performed to this procedure.

In some cases, remote visual examinations may have to be substituted for direct examination. Remote visual examinations may use visual aids such as mirrors, borescopes, cameras or other suitable instruments.

2.3 Examination Requirements

2.3.1 Visual Examination of Welding

A. Equipment

1. Artificial Light Source
2. Mirrors
3. Magnifiers

**SPECIFICATION FOR WELDING INSPECTIONS**

4. Straight Edges or Rules
5. Weld Gages

B. Visual Inspection and Identification of Base Material and Joint Preparation as follows:

1. Base material type compatible with the detailed weld procedure.
2. Weld being made in accordance with drawing.
3. Weld preparation and adjacent base material clean free of paint, scale, rust, oil, grease and any other foreign material that would be deleterious to the process.
4. Weld preparation has fairly smooth surfaces free from deep notches, grooves, nicks, and other gross irregularities.
5. Weld preparation free from base material defects such as laminations, laps, non metallic inclusions, pin holes, porosity, that are open to the surface.

C. Visual Inspection of Weld Preparation Geometry as follows:

1. Alignment of parts to be welded.
2. Size of root face (land) and root gap.
3. Groove angle.
4. I.D. mismatch of Butt Joints.

D. Visual Inspection of Tack Welds as follows:

1. Tack welds are properly prepared to be incorporated into the weld or completely removed. When left in place, each end should be feathered.
2. Examine tacks for discontinuities.
3. Check for cleanliness.

E. Visual Inspection of Intermediate Weld Passes as follows:

1. Cleanliness
2. Weld spatter
3. ARC strikes
4. Slag
5. Oxide removal
6. Discontinuities

**SPECIFICATION FOR WELDING INSPECTIONS****F. Visual Inspection of Final Surfaces of Welding shall be verified as follows:**

1. Cleanliness
2. Weld spatter
3. ARC strikes
4. Butt weld reinforcement (1/8" max)
5. Fillet weld size
6. Fillet weld throat
7. Fillet weld length/spacing
8. Concavity/Convexity
9. Transition must be minimum of 3 to 1 taper
10. Surface porosity
11. Overlap
12. Undercut
13. Inadequate penetration
14. Cracks
15. Underfill

G. Visual Examination of Machined Surfaces shall be verified as follows:

1. Surface Finish
2. Discontinuities
3. Cleanliness

2.4 Acceptance Standards**2.4.1 Cleanliness**

Reference should be made to the LIGO Cleaning Procedure, for specific methods. Prior to welding, the weld preparation and adjacent base material (1 inch minimum beyond each side of weld joints) shall be free of moisture, oil, grease, paint, scale, chips and other foreign matter on the final weld surface. The affected area shall be cleaned of slag and oxidation. Iridescent temper films and black, tightly adherent films resulting from welding, are acceptable on finished weld surfaces.

Prior to Welding

Weld preparations and adjacent base material (1 inch for carbon steel and 2 inches for stainless steel beyond each side of weld joint) shall be free of moisture, oil, grease, paint, scale, chips and other foreign matter.



SPECIFICATION FOR WELDING INSPECTIONS

After Welding

The affected area of the final weld surface shall be cleaned of slag and oxidation. Iridescent temper films resulting from welding are acceptable on finished weld surfaces.

2.4.2 Tack Welds

Tack welds shall show no cracks or linear indications. Slag deposits or indication of surface porosity shall also be cause for rejection. Edges of tack welds shall be feathered (when necessary) to provide a smooth transition during root pass welding.

2.4.3 Final Weld Condition

- A. As welded, as-cast or as-forged surfaces are permitted, provided the surface of welds are sufficiently free from coarse ripples, overlaps and abrupt ridges and valleys.
- B. Cracks or other linear indications are unacceptable.
- C. Porosity open to the surface is unacceptable.
- D. Undercut shall not exceed 1/32" in. depth.
- E. Weld reinforcement on all butt welds may be flush with the surface or may have a crown up to 1/8" max.
- F. Concavity on the root side of a single side welded circumferential butt weld is permitted when the resulting thickness of the weld is at least equal to the thickness of the thinner member of the two (2) sections being joined and the contour of the concavity is smooth.
- G. Offset of final butt welded joints shall not be greater than the following:

| Nominal Wall Section Thickness. in. (mm) | Maximum Offset, in. (mm) |
|--|---------------------------------|
| 0.0060" Thru 0.500" | All LIGO Project Joints 1/4t |

Note: t is the nominal thickness of the thinner section of the joint.

- H. Any offset within the allowable tolerance shall be flared at a three to one taper over the width of the finished weld, or if necessary, by adding additional weld metal beyond what would otherwise be the edge of the weld.

2.4.4 Examples of Conditions That Are Unacceptable.

OVERLAP

Welds shall be free from overlap.

**SPECIFICATION FOR WELDING INSPECTIONS****CRATERS**

All craters shall be filled to the full cross section of the weld.

CRACKS

Welds shall have no cracks. When cracks are observed visually, the crack shall be completely removed and re-welded. Refer to repair procedure.

SLAG INCLUSIONS

Welds having slag inclusions larger than 3/32" are unacceptable. Also unacceptable are groups of slag inclusions when the sum of their greatest dimension exceeds 3/8" in any linear inch of weld.

INCOMPLETE FUSION

Acceptability requirements are the same as those for slag inclusions.

MISALIGNMENT AND WARPING

Tolerances shall be within the drawing tolerances governing the work. ASME Section VIII allows a maximum misalignment of 1/4" the thickness of the thinner section at the joint for thickness to 1/2".

CONVEXITY FILLET

Convexity shall not exceed $0.1 S + 0.03$ ", where S is the size of the fillet weld in inches.

CONVEXITY, GROOVE WELDS

Reinforcement to be 1/8" max, and shall have a gradual transition to the plane of the base metal surface when the thinner base metal is less than 1/2" thick.

INSUFFICIENT THROAT, FILLETS

The throat shall not be under an imaginary profile line drawn from each leg end.

INSUFFICIENT THROAT, GROOVE WELDS

The weld shall be slightly convex.



SPECIFICATION

SPECIFICATION FOR WELDING INSPECTIONS

INSUFFICIENT LEG

The leg dimension of a fillet weld shall not be less than the thickness of the lighter of the two sections being welded, providing configurations allow this.