



**REQUEST FOR QUOTATION NO. AO-509a**  
FOR  
**Fabrication of the Manifold Cryopump ETM Weldment**

**DATE OF ISSUANCE: January 9, 2013**

**QUOTES TO BE RECEIVED BY CALTECH NO  
LATER THAN**

**DATE: Friday, January 25, 2013**  
**TIME: 4:00 PM PACIFIC TIME (PT)**

**COMMUNICATIONS TO REFERENCE  
RFQ NO. AO-509a**

**Send completed copy of your Quote to the attention of:**

Name: Paula Willis  
Email: [pwillis@ligo.caltech.edu](mailto:pwillis@ligo.caltech.edu)  
Department: LIGO PROJECT  
Title: Procurement Agent  
California Institute of Technology  
Mail Station: 100-36  
1201 E. California Blvd.  
Pasadena, CA 91125  
Phone: (626) 395-8741  
Fax: (626) 304-9834

## Table of Contents

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2. Quotation Responses
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### **1. INTRODUCTION AND GENERAL INSTRUCTIONS**

This is a request for information. This solicitation does not constitute a commitment, implied or otherwise, that Caltech will take procurement action in this particular matter. The Institute is seeking a qualified firm for the procurement of the fabrication of the Manifold Cryopump ETM Weldment.

The following provides background information and general instructions regarding preparation of your quote in response to this RFQ.

#### **1.1. LIGO – Information**

The Laser Interferometer Gravitational-Wave Observatory ([LIGO](#)) is being built by the [California Institute of Technology \(Caltech\)](#) and the [Massachusetts Institute of Technology \(MIT\)](#). Funded by the [National Science Foundation](#), LIGO functions as a national resource for both physics and astrophysics. When it reaches maturity, the observatories will be open for use by the national community and will become part of a planned worldwide network of gravitational-wave observatories.

#### **1.2. Instructions**

Quotes must contain a complete response to requests in the RFQ.

- Electronic submissions are preferred and can be made to the email address on the cover page of this document.
- Printed submissions must be on 8 ½” x 11” paper and addressed to the Procurement Agent using the name and address on the cover page of this document.
- Each must be identified with RFQ No. appearing on the cover page.

#### **1.3. Submittal Deadline**

One (1) copy of your complete quote must be delivered no later than 4:00pm PT on the due date identified on the cover page of this document. All late quotes will be considered non-responsive and returned unopened to the vendor except under the following circumstances:

- When sent by U.S. Postal Service, and the postmark or receipt for registered or certified mail establishes the time of deposit with the postal service, and Caltech determines that the late receipt was due solely to delay in the mail for which the offeror was not responsible; or
- When only one responsive, responsible quote is received.

Any quote, portion of a quote or unsolicited offer revision received by Caltech after the time and date specified for receipt of quotes is late. Any volume of a quote received after the time and date specified will cause the entire quote to be late. Caltech’s policy is not to consider revisions or supplementary information received after the time and date

specified on the cover page, unless the revisions or supplements have been specifically requested by Caltech, and then only to the extent specified

#### **1.4. Reimbursement of RFQ Costs**

No reimbursement shall be made by Caltech for any cost incurred in preparing a quote or in response to this request.

All responses shall be deemed to be the property of Caltech.

#### **1.5. Offer or Authorized Representative**

Responses should be signed by personnel authorized to bind your company to a contract and include the contact information of the person or persons assigned to conduct negotiations.

#### **1.6. Caltech Authorized Representative**

All inquiries concerning this request shall be in writing (electronic or hard copy) and shall be emailed (preferred method), mailed, or faxed to the contracting officer listed on the cover page of this document.

#### **1.7. Interpretation and Addenda**

During the solicitation period, requests to clarify certain aspects of the solicitation package, or for additional information, must be in writing (electronic or hard copy) and addressed directly to the Contracting officer listed on the cover page of this document. Caltech's responses providing additional information or clarification will be sent to all prospective offerors. In addition, any Caltech-initiated changes to the governing documents in the solicitation package will be provided to all prospective offerors as addenda to the package. Caltech will not be responsible for explanations or interpretations of the package by any other means.

#### **1.8. Quote Validity Time**

Quote shall be valid for at least ninety (90) calendar days.

## **2. QUOTE RESPONSES**

Quotation responses should include the following:

### **2.1. Price**

A firm, fixed price is requested for the procurement of the fabrication of the Manifold Cryopump ETM Weldment.

In particular, please provide unit pricing for the parts and quantities found in Section 5.0 of the Statement of Work [C1001790](#) (see section 3, below).

### **2.2. Quality Control**

Deliver a QA/QC plan with the quote, or submit a plan for implementing a suitable QA/QC plan/system.

### **2.3. Schedule**

The delivery schedule will be in accordance with Section 8.0 of the Statement of Work [C1001790](#) (see section 3, below). Note: FOB is Destination.

If this cannot be accommodated, please provide an alternative delivery schedule for consideration with your bid package. Early and/or partial delivery is welcomed.

## 2.4 Exceptions

Identify supplier exceptions to the Terms, Specifications or Drawings. A large number of exceptions or one or more significant exceptions may make your quote unacceptable for evaluation. You must provide a detailed explanation, including the rationale, for any exceptions you take. Offers who submit quotes with exceptions may be selected.

## 2.5 Technical Approach

Provide a brief description of your company's approach for the assembly of the included work. This summary should include reference to the drawings and any specification documents included.

## 3. STATEMENT OF WORK

Reference: [Statement of Work, Fabrication of the Manifold Cryopump ETM Weldment, LIGO C1001790-v3.](#)

## 4. SELECTION

The selection will be based on the following items:

1. Delivery
2. Quality
3. Past Experience with LIGO
4. Cost



**LIGO LABORATORY**  
California Institute of Technology  
1200 E. California Blvd.  
Pasadena, CA 91125

# Statement of Work

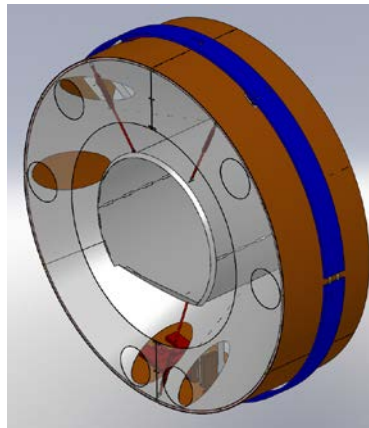
## Manifold Cryopump Tube Baffle ETM

### Weldment Assembly

#### C1001790-v3

### 1.0 Scope

This Statement of Work (SOW) is for the fabrication of two Manifold Cryopump Tube Baffle ETM<sub>x</sub> and two Manifold Cryopump Tube Baffle ETM<sub>y</sub> weldment assemblies. The primary baffle piece parts are large. A completely assembled baffle will reside within an 8' by 8' area. This Manifold Cryopump Tube baffle will reside inside ultra-high vacuum. Materials, fabrication processing and cleanliness must adhere to the requirements specified within the LIGO control documents.



### 2.0 Document Access

Many supplemental documents and specifications are incorporated into and made a part this Statement of Work. Click on the document links to access these documents from the LIGO Document Control Center (DCC) or go on line to the LIGO Public DCC at <https://dcc.ligo.org/> to access the DCC#.

### 3.0 Commercial Terms and Applicable LIGO Specifications:

**Note: The documents listed below are invoked for this Statement of Work and comprise additional requirements which are integral to this Statement of Work.**

- [LIGO-C080185-v1](#) LIGO Commercial Items or Services Contract General Provisions
- [LIGO-Q0900001-v5](#) Advanced LIGO Supplier Quality Requirements
- [LIGO-Q1100003-v1](#) Acceptable Quality Level (AQL) for Inspection of LIGO Components
- [LIGO-E0900364-v8](#) Metal Components for use in the Advanced LIGO Vacuum System
- [LIGO-E0900048-v9](#) Welding Specification for Weldments used within the Advanced LIGO Vacuum System

#### 4.0 Quality System:

Referring to the above referenced LIGO Specification Q0900001, Suppliers should include a copy of their current ISO 9001, AS9100, or TS16949 certification in their bid package. Suppliers lacking current certification should send a copy of their Quality Manual with their bid package.

#### 5.0 Parts/Assemblies to be manufactured, Quantity Required, and Inspection requirements:

Note: refer to Section 8.0 for delivery schedule and location

##### 5.1 Parts

Item	Part Number	Description	Material	Total QTY	Starting Serial Number
1	D1003189	FACE PLATE A, ETM X	18 GAUGE 304 SSTL	2	001
2	D1003203	FACE PLATE B, ETM X	18 GAUGE 304 SSTL	2	001
3	D1101502	LOWER FACE PLATE, ETM X	18 GAUGE 304 SSTL	2	001
4	D1200516	LEFT HALF FACE, ETM Y	18 GAUGE 304 SSTL	2	001
5	D1200517	RIGHT HALF FACE, ETM Y	18 GAUGE 304 SSTL	2	001
6	D1200518	LOWER FACE PLATE, ETM Y	18 GAUGE 304 SSTL	2	001

##### 5.2 Assemblies

Item	Part Number	Description	Total QTY	Starting Serial Number
7	D1001348	MANIFOLD-CRYO BAFFLE CYLINDER-SCRAPER ASSEMBLY	4	005
8	D1003184	MANIFOLD -CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMX H1, BOTTOM	2	001
9	D1003186	MANIFOLD CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMX H1, RIGHT	2	001
10	D1003188	MANIFOLD-CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMX H1, LEFT	2	001
11	D1003229	MANIFOLD -CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMY H1, BOTTOM	2	001
12	D1003231	MANIFOLD CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMY H1, RIGHT	2	001
13	D1003233	MANIFOLD-CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMY H1, LEFT	2	001

### 5.3 Parts required for Assemblies - for REFERENCE ONLY

Item	Part Number	Description	Material	Total QTY	Starting Serial Number
14	D0902620	RADIAL SEGMENT, BOTTOM	18 GAUGE 304 SSSL	(4)	012
15	D0902621	MANIFOLD CRYO BAFFLE BRACKET	14 GAUGE 304 SSSL	(24)	037
16	D1000536	BAFFLE BRACE BRACKET	14 GAUGE 304 SSSL	(24)	037
17	D1000558	RADIAL SEGMENT, LEFT	18 GAUGE 304 SSSL	(2)	012
18	D1000559	RADIAL SEGMENT, RIGHT	18 GAUGE 304 SSSL	(2)	012
19	D1000570	MANIFOLD-CRYO BAFFLE CYLINDER	18 GAUGE 304 SSSL	(4)	012
20	D1001018	ELLIPSE SCRAPER BLADE	18 GAUGE 304 SSSL	(4)	012
21	D1001073	RADIAL ATTACHMENT NUT PLATE	14 GAUGE 304 SSSL	(12)	024
22	D1002849	WELDMENT BRACE	14 GAUGE 304 SSSL	(12)	024
23	D1003185	INNER SEGMENT, ETMX H1, BOTTOM	18 GAUGE 304 SSSL	(2)	012
24	D1003187	INNER SEGMENT WELDMENT, ETMX H1, RIGHT	18 GAUGE 304 SSSL	(2)	012
25	D1003191	INNER SEGMENT WELDMENT, ETMX H1, LEFT	18 GAUGE 304 SSSL	(2)	012
26	D1003230	INNER SEGMENT, ETMY H1, BOTTOM	18 GAUGE 304 SSSL	(2)	012
27	D1003232	INNER SEGMENT WELDMENT, ETMY H1, RIGHT	18 GAUGE 304 SSSL	(2)	012
28	D1003234	INNER SEGMENT WELDMENT, ETMY H1, LEFT	18 GAUGE 304 SSSL	(2)	012
29	D1201125	ETM X_Radial Segment Right	18 GAUGE 304 SSSL	(2)	001
30	D1201405	ETM Y_Radial Segment Left	18 GAUGE 304 SSSL	(2)	001

Note: **AQL = 1.0**, refer to Q1100003 for the AQL table, see link in Section 3.0.

## 6.0 Manufacturing

### 6.1 Requirements:

Suppliers must refer to the LIGO Specifications referenced in Section 3 for additional, and in some cases, non-industry standard requirements.

### 6.2 Sub-Contracted Work:

- LIGO expects that at least 2/3 (by dollar value) of the contracted work be performed by the Supplier named on the Purchase Order. The Supplier shall be responsible for all sub-contracted work.
- The Supplier's quote shall state their intent to sub-contract any welding operations performed on components intended for Vacuum use. If E0900048 is invoked in Section 3, then the component will be used in Vacuum.

### 6.3 Precedence:

The drawings typically represent the finished part as needed for use in service. There may be requirements on the drawing (such as coatings) which are specifically defined as not the responsibility of the supplier in this SOW. Suppliers shall always contact a LIGO representative to resolve any discrepancies/uncertainties in the documentation or instructions.

### 6.4 Special Instructions:

- All parts shall be shipped as specified in Section 8.0. Shipping containers shall be supplied by the awarded vendor and constructed for multiple uses.
- Selected vendor shall purchase 18 gauge 304 Super #8 Stainless Steel material from approved LIGO supplier.
- Clean Rollers before forming parts. Cover with paper when forming.
- Do not remove PVC layer on 18 gauge 304 Stainless Steel materials. It is expected that PVC will be peeled back to allow for welding.
- Weld samples and Documentation are required per LIGO-E0900048.

### 6.5 Exclusions:

- Supplier is NOT responsible for cleaning except as specified in E0900364 above.
- Supplier is NOT responsible for the oxidation process.

## 7.0 End Item Data Package:

Before delivery of the parts, the Supplier shall provide the following data, as a minimum:

- Any as-built modifications (with approval of the LIGO Contracting Officer) as mark-ups to the drawings
- Material certifications
- Heat Treat and/or Stress Relief certifications, if applicable
- Electro-polish certifications, if applicable
- Pickle/Passivation certifications, if applicable



- Inspection reports of all dimensional features for the number of parts specified per the AQL number and referenced in the AQL table Q1100003 and any other inspection requirements detailed in Section 5 of this SOW
- Certificate of compliance for each part number stating conformance to contract and drawing requirements

## **8.0 Delivery Requirements:**

### **8.1 Shipping Containers and Packaging:**

The contractor is responsible for providing shipping containers and transportation which protects these parts from damage from the transportation environment (weather, handling, accidents, etc.). Mating edges of parts shall be especially protected from damage during shipping.

### **8.2 Shipping Destination(s):**

The deliveries are FOB at these destinations, i.e. the Supplier has the responsibility for shipping title and control of goods until they are delivered and the transportation has been completed. The contractor selects the carrier and is responsible for the risk of transportation and for filing claims for loss or damage.

- Caltech will determine the ship to location at time of award.
- Shipping terms will be prepay and add.

### **8.3 Delivery Schedule:**

Deliveries are to be completed as specified below. If this cannot be accommodated, please provide an alternative delivery schedule for consideration with your bid package. Early or partial deliveries are welcome.

- Requested delivery - 8 weeks ARO.

**NOTES CONTINUED:**

⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR TYPE IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS. UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX. DO NOT APPLY MARK ON SUPER #8 SIDE.

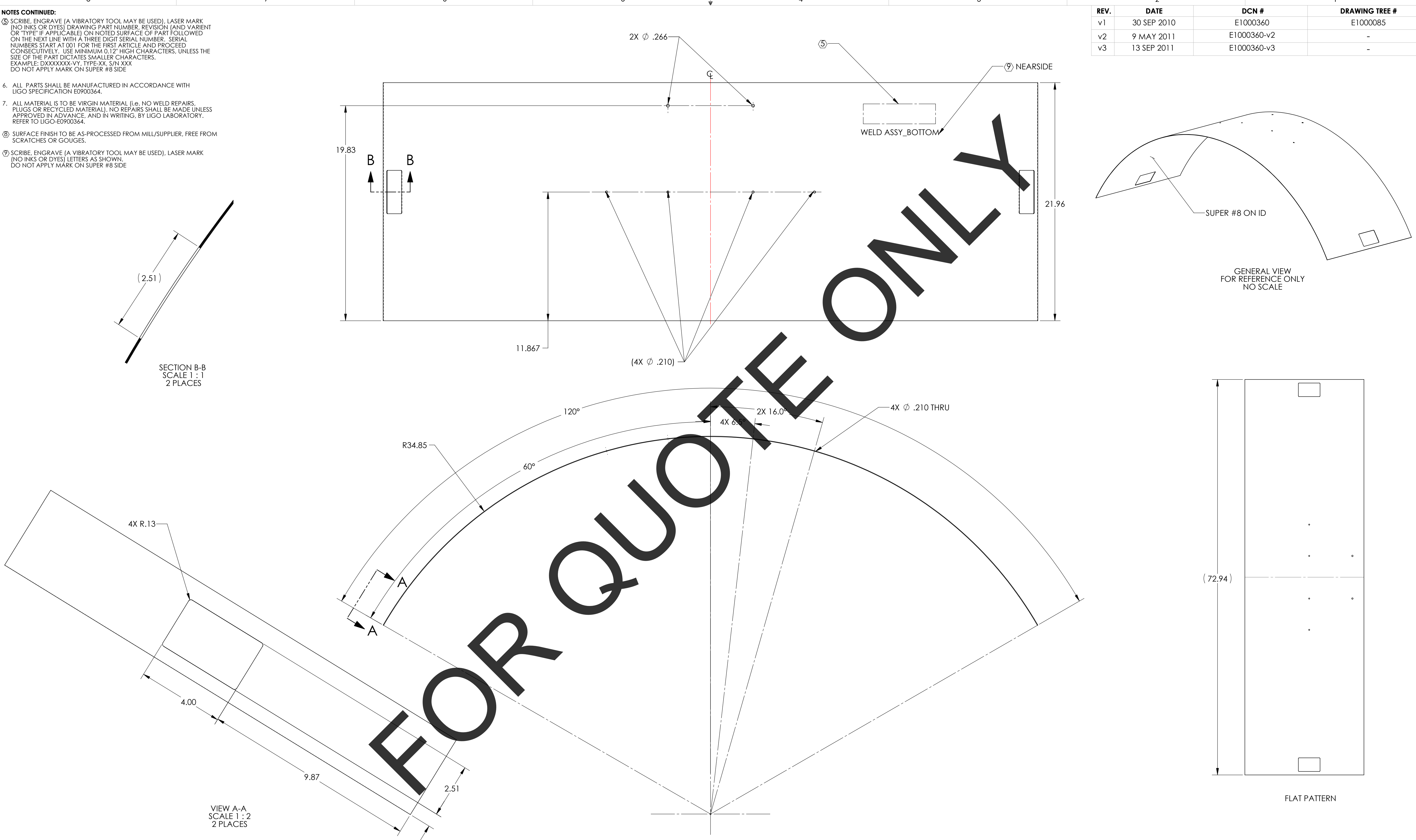
6. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

7. ALL MATERIAL IS TO BE VIRGIN MATERIAL (I.E. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

⑧ SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

⑨ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) LETTERS AS SHOWN. DO NOT APPLY MARK ON SUPER #8 SIDE.

REV.	DATE	DCN #	DRAWING TREE #
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v2	9 MAY 2011	E1000360-v2	-
v3	13 SEP 2011	E1000360-v3	-



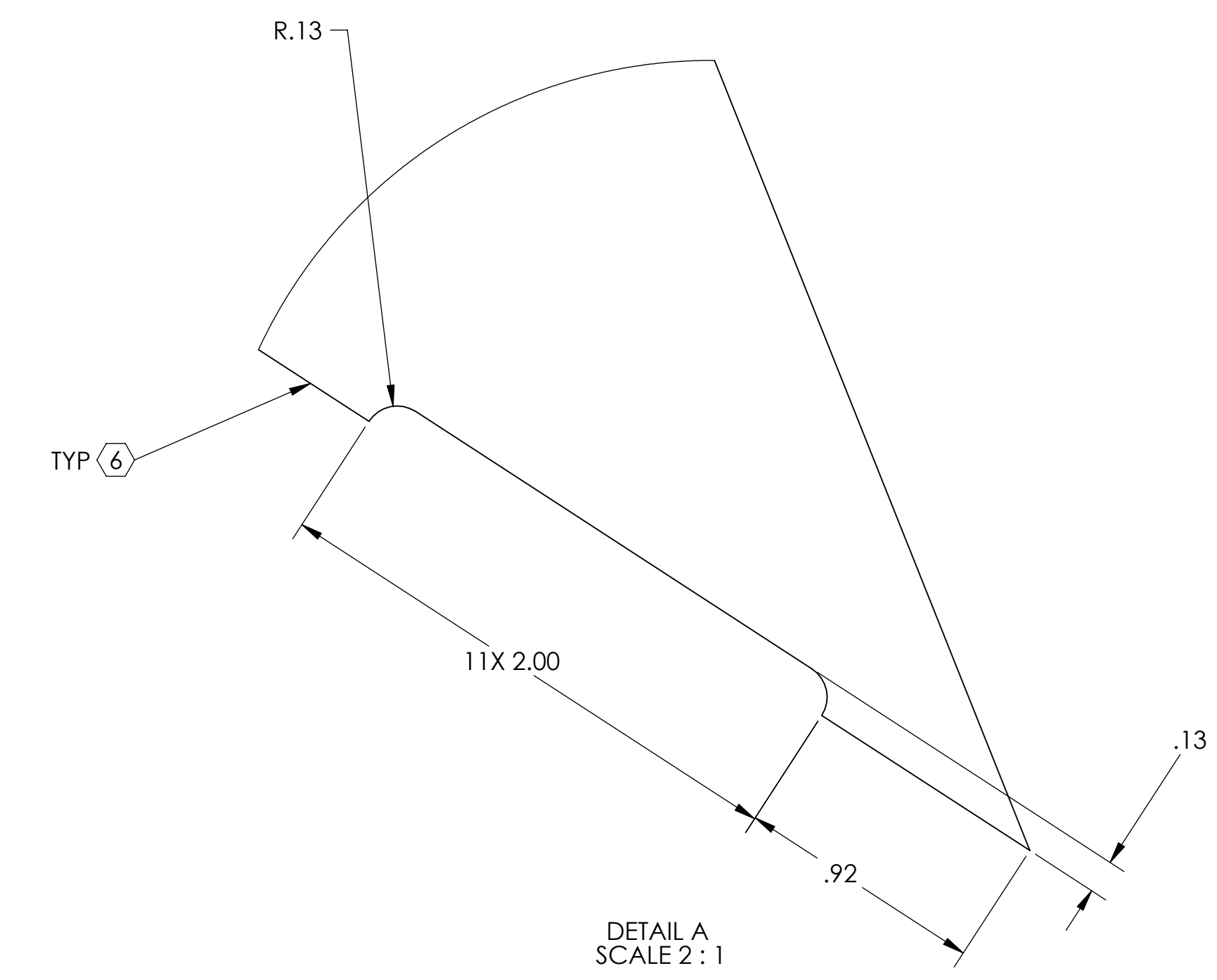
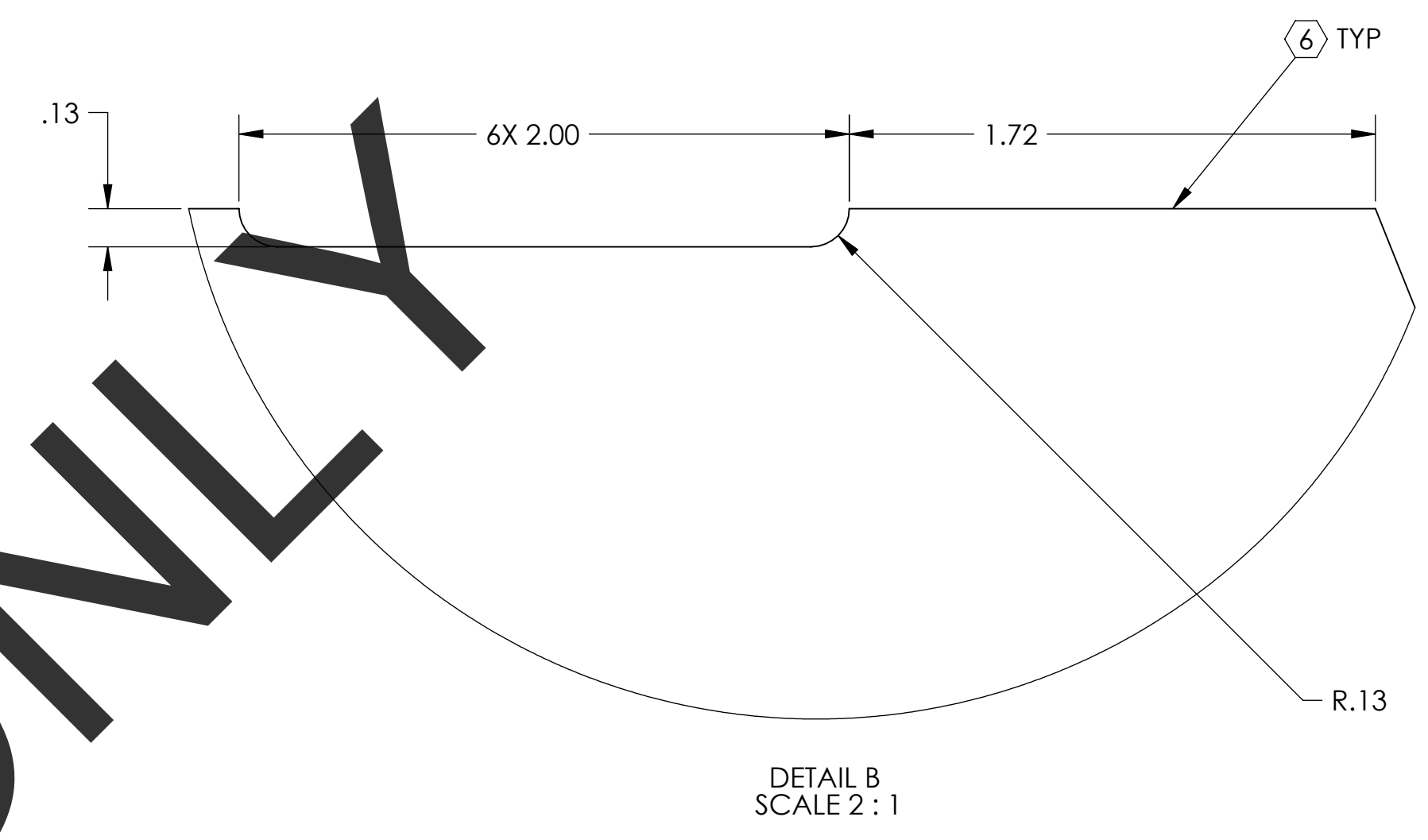
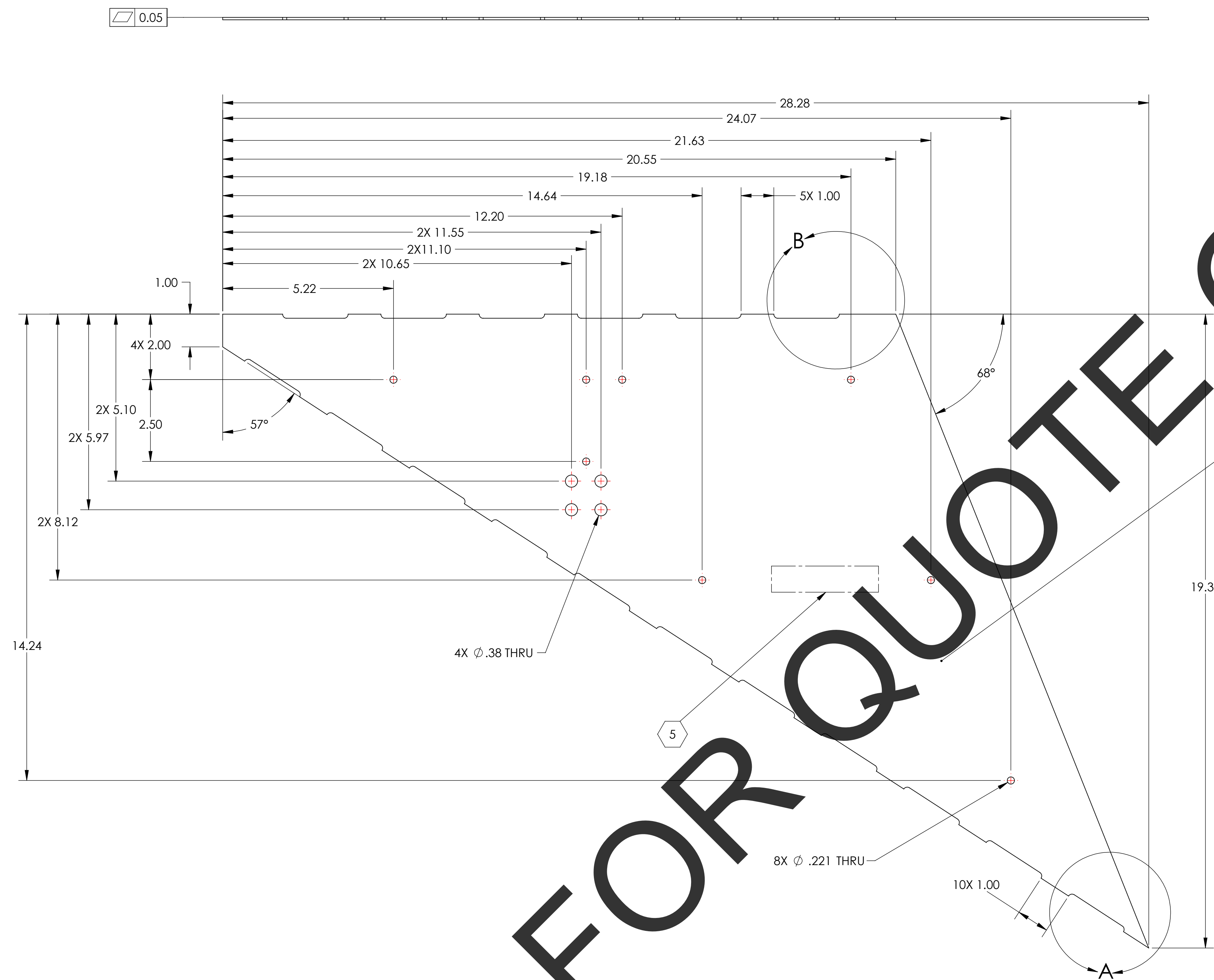
NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)				LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
DIMENSIONS ARE IN INCHES				SYSTEM		RADIAL SEGMENT, BOTTOM	
TOLERANCES: .XX ± .03 .XXX ± .010				ADVANCED LIGO		AOS	
ANGULAR ± 0.1°				NEXT ASSY		DESIGNER H. Kellman 28 SEPT 2010	
MATERIAL 18 GAUGE 304 SSTL		FINISH ⑧ SUPER #8		D0902655, D1003229, D1003184		SIZE DWG. NO. D D0902620	
						REV. v3	
						SCALE: 1:4 PROJECTION: SHEET 1 OF 1	

D:\0202620.dwg\_Media\_Coyle\_Radial\_Segment1 Bottom: PART PDM REV: X.003, DRAWING PDM REV: X.028

**NOTES CONTINUED:**  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK OR MECHANICALLY STAMP (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX  
 6. CASTELLATION ON MATERIAL EDGES ARE FOR WELD PURPOSES IN ASSEMBLIES (D0902654, D0902655, D0902656).  
 7. DELETED

8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.  
 9. ALL MATERIAL IS TO BE VIRGIN MATERIAL (I.E. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.  
 10. SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

REV.	DATE	DCN #	DRAWING TREE #
v1	17 MAR 2010	E1000360	E1000085-v1
v2	12 MAY 2011	E1000360-v2	E1000090-v1
v3	4 OCT 2011	E1000360-v3	E1000091-v1



FOR QUOTE ONLY

THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE NEXT ASSEMBLY FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDING.

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)		LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME					
DIMENSIONS ARE IN INCHES		SYSTEM ADVANCED LIGO NEXT ASSY VARIOUS		MANIFOLD CRYO BAFFLE BRACKET					
TOLERANCES: .XX ± .06 .XXX ± .010 ANGULAR ± 1.0°				DESIGNER	H. KELMAN	17 MAR 2010	SIZE	DWG. NO.	REV.
MATERIAL		FINISH		DRAFTER	TQ. NGUYEN	16 AUG 2010	D	D0902621	v3
14 GAUGE 304 SSTL		10		CHECKER	M. SMITH	27 SEPT 2011			
				APPROVAL	D. COYNE		SCALE: 1:8	PROJECTION:	SHEET 1 OF 1

NOTES CONTINUED:

5. BAG AND TAG WITH DRAWING PART NUMBER AND REVISION FOLLOWED BY A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. EXAMPLE: DXXXXXX-VY, S/N 001.

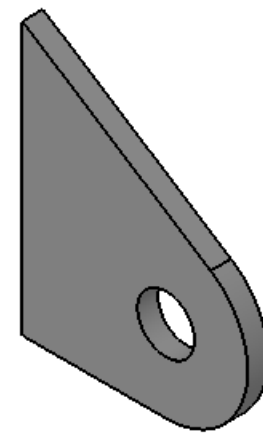
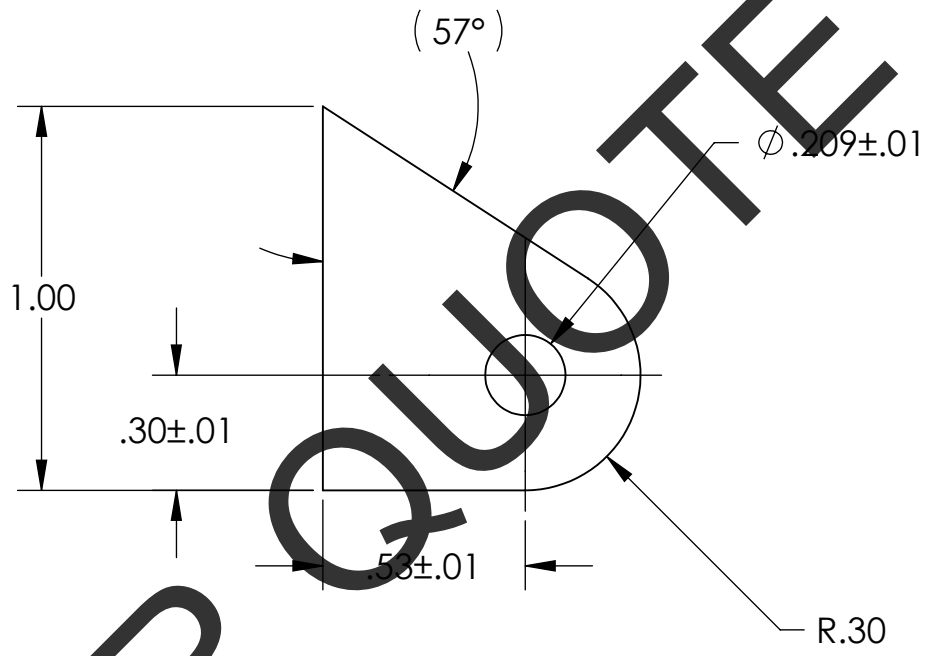
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REV.	DATE	DCN #	DRAWING TREE #
v1	17 MAR 2010	E1000360	-
v2	12 MAY 2011	E1000360-v2	-
v3	13 SEP 2011	E1000360-v3	-

FOR QUOTE ONLY



GENERAL VIEW FOR REFERENCE ONLY NO SCALE

THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE NEXT ASSEMBLY FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDING.

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
DIMENSIONS ARE IN INCHES	
TOLERANCES: .XX ± .06 .XXX ± .010	
ANGULAR ±1.0°	
1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015 ON ALL EDGES AND HOLES. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.	
MATERIAL	FINISH
14 GAUGE 304 SSSL	7

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
ADVANCED LIGO		BAFFLE BRACE BRACKET	
SYSTEM	SUB-SYSTEM	DESIGNER	DATE
ADVANCED LIGO	AOS	H. Keltman	17 MAR 2010
CHECKER	DATE	DRAFTER	DATE
M. SMITH	27 SEP 2010	TQ. NGUYEN	18 AUG 2011
APPROVAL	DATE	CHECKER	DATE
D. COYNE		M. SMITH	27 SEP 2010

SIZE	DWG. NO.	REV.
B	D1000536	v3
SCALE: 2:1	PROJECTION:	SHEET 1 OF 1

NOTES CONTINUED:  
 ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE

6. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.  
 ⑦ SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.  
 ⑧. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) LETTERS AS SHOWN. DO NOT APPLY MARK ON SUPER #8 SIDE

REV.	DATE	DCN #	DRAWING TREE #
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v2	11 MAY 2011	E1000360-v2	-
v3	13 SEP 2011	E1000360-v3	-

⑤ NEARSIDE

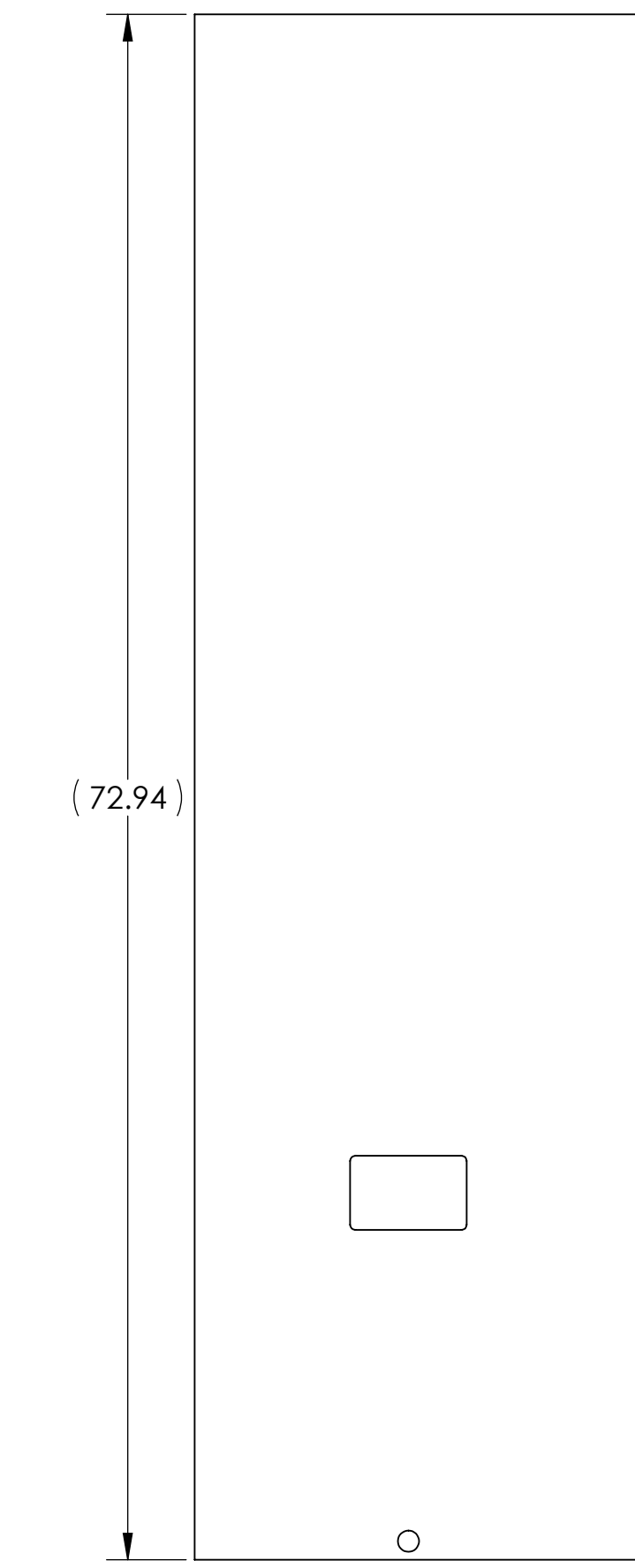
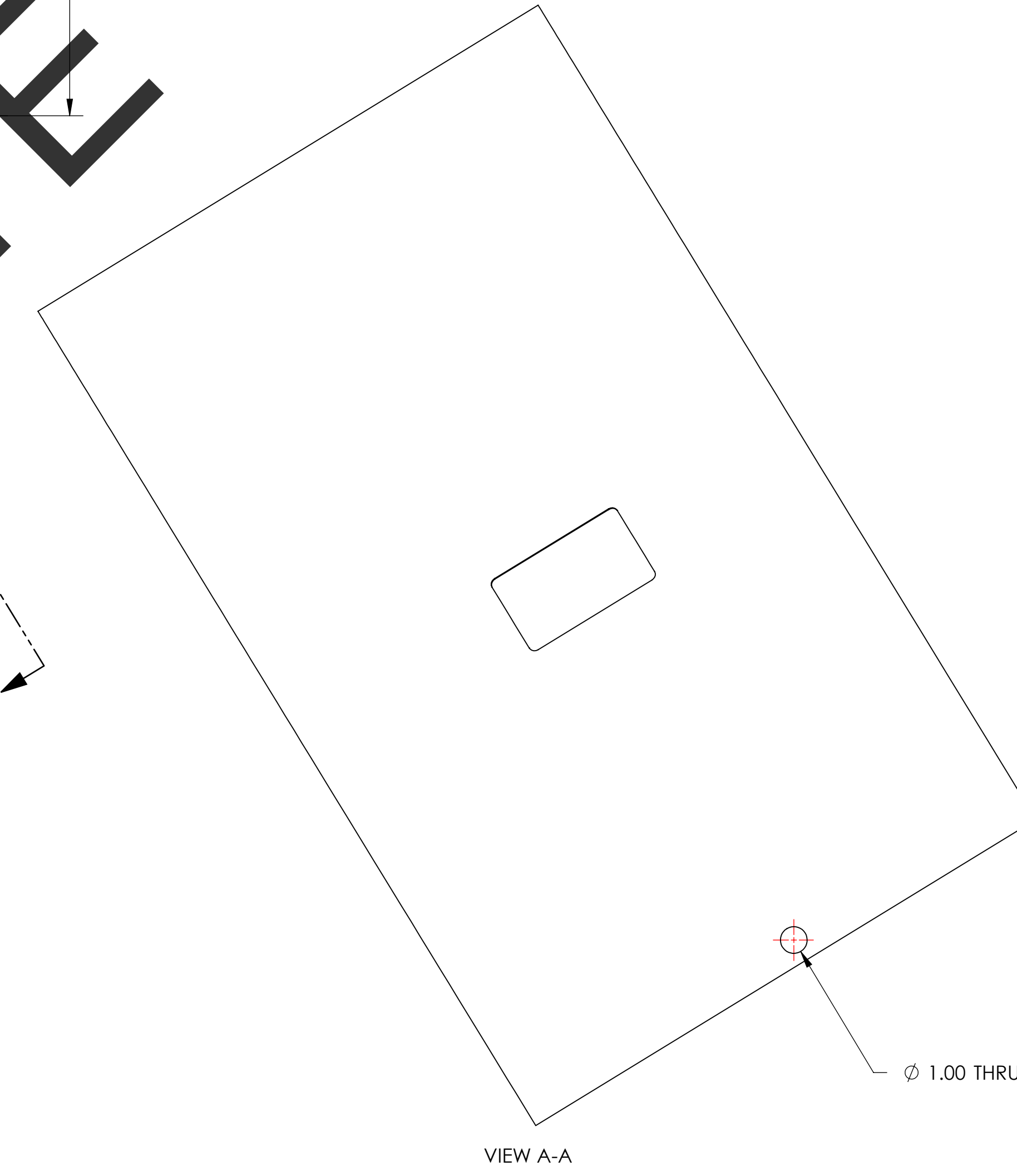
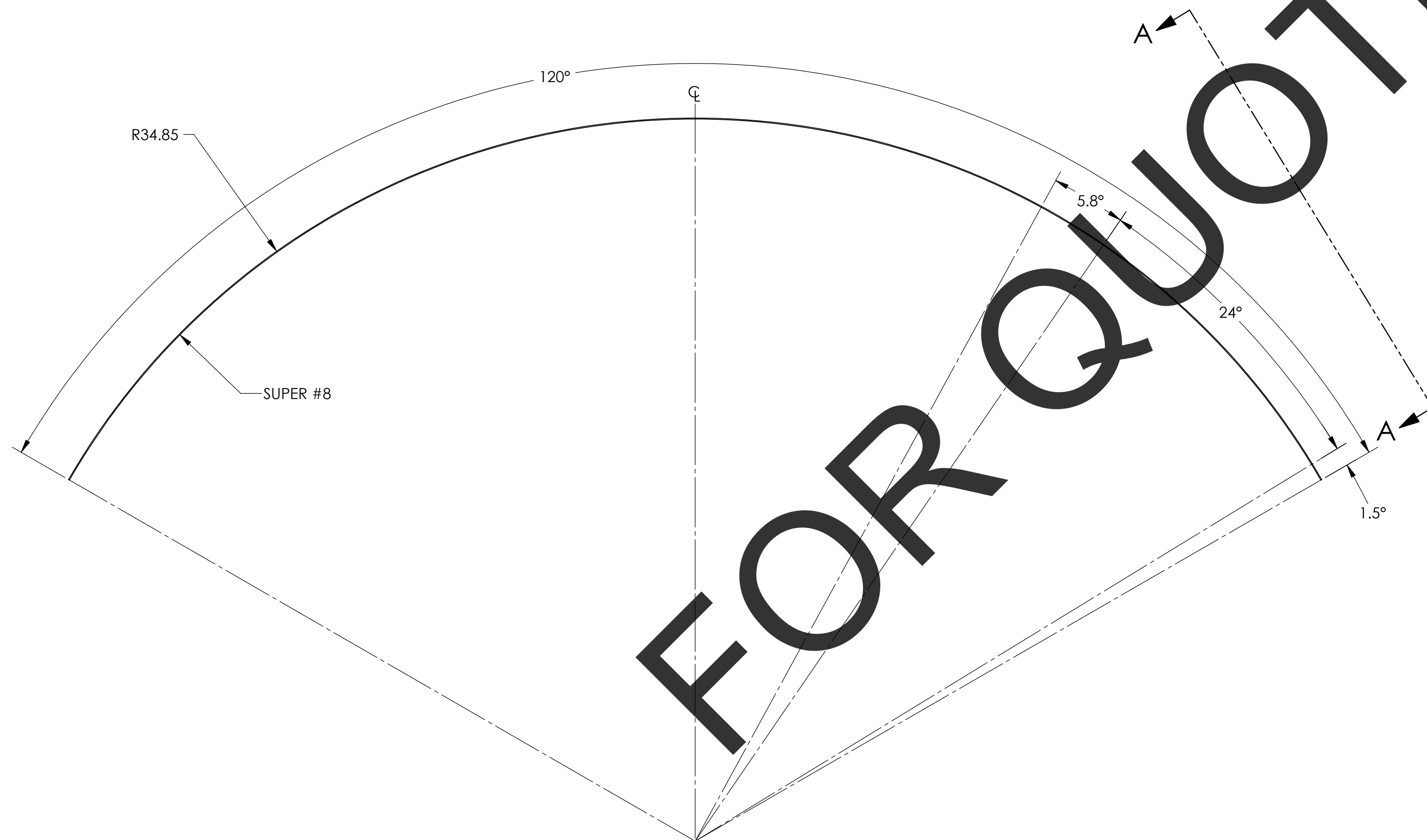
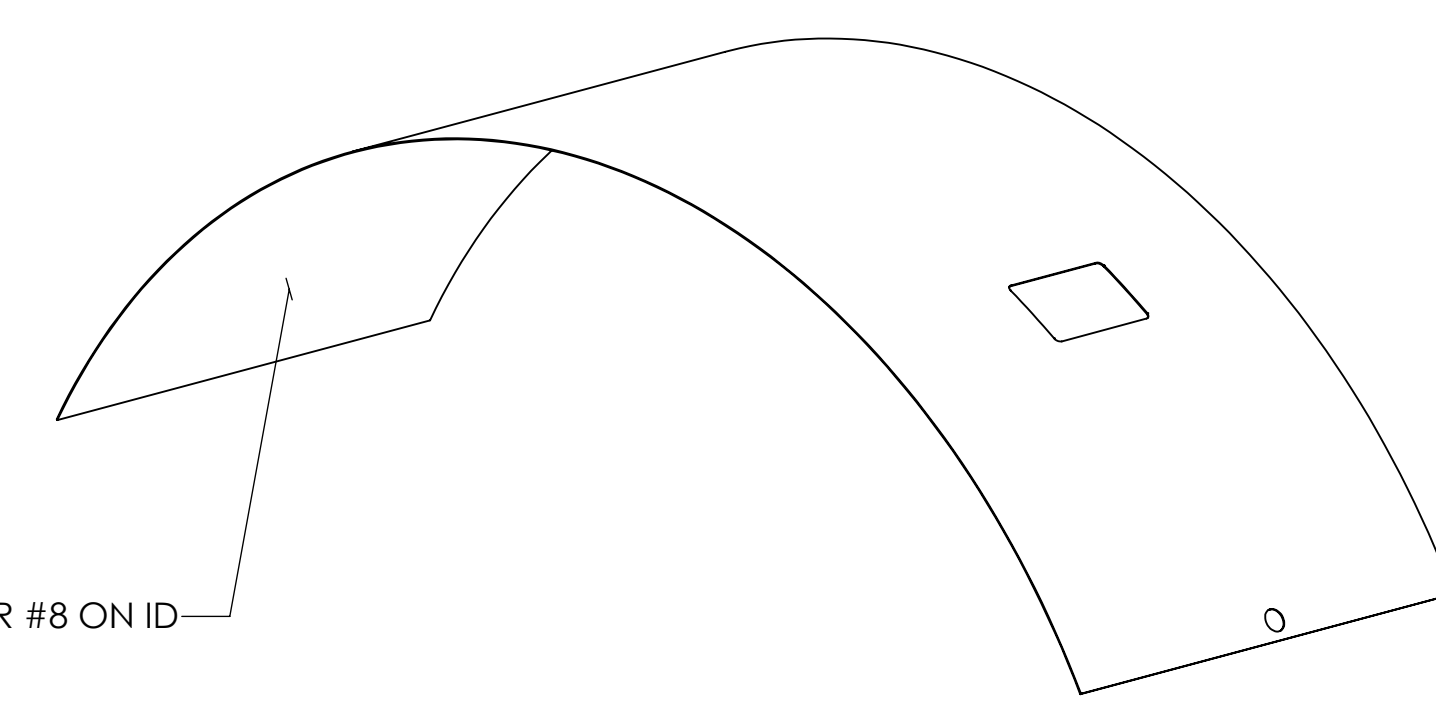
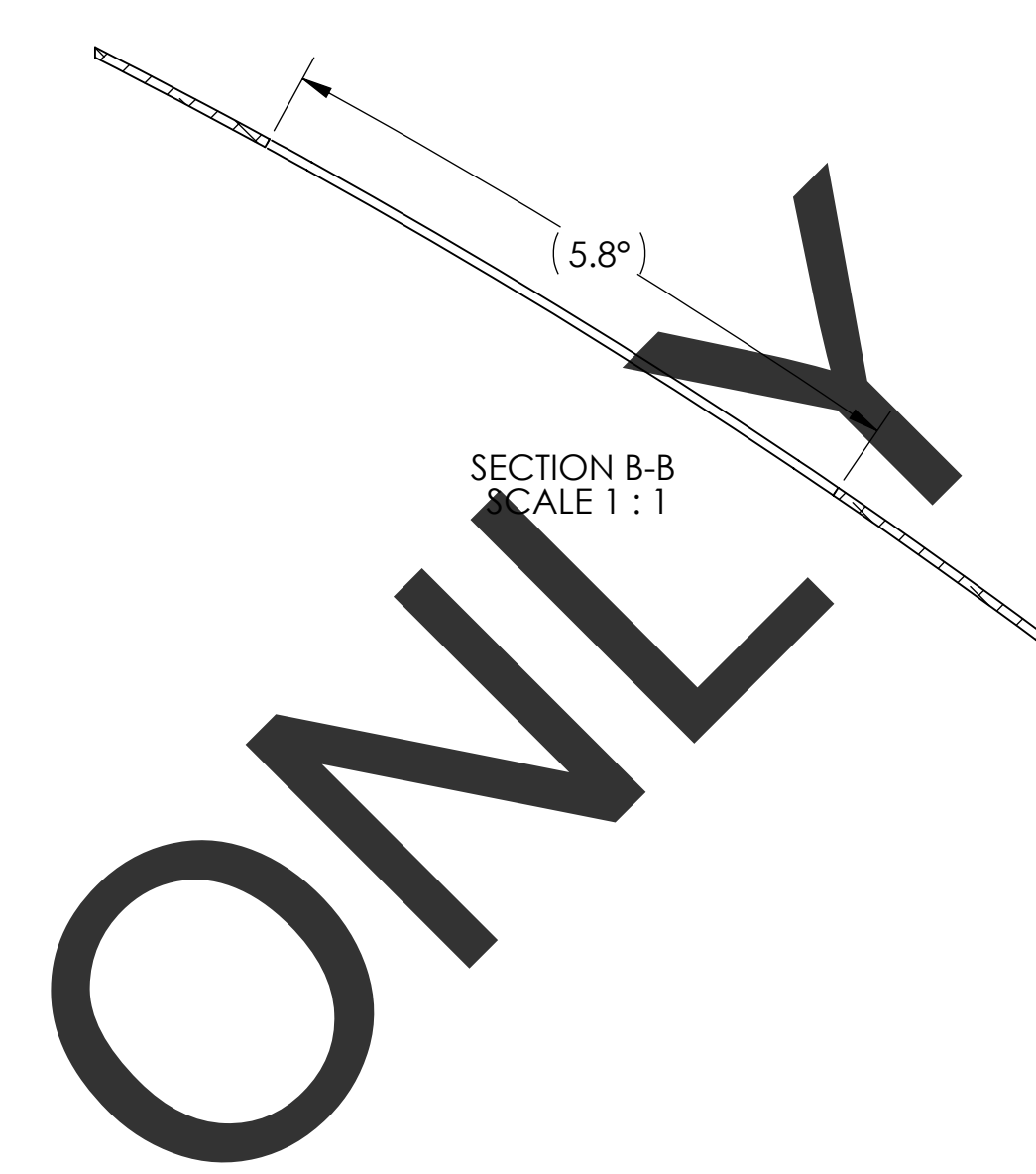
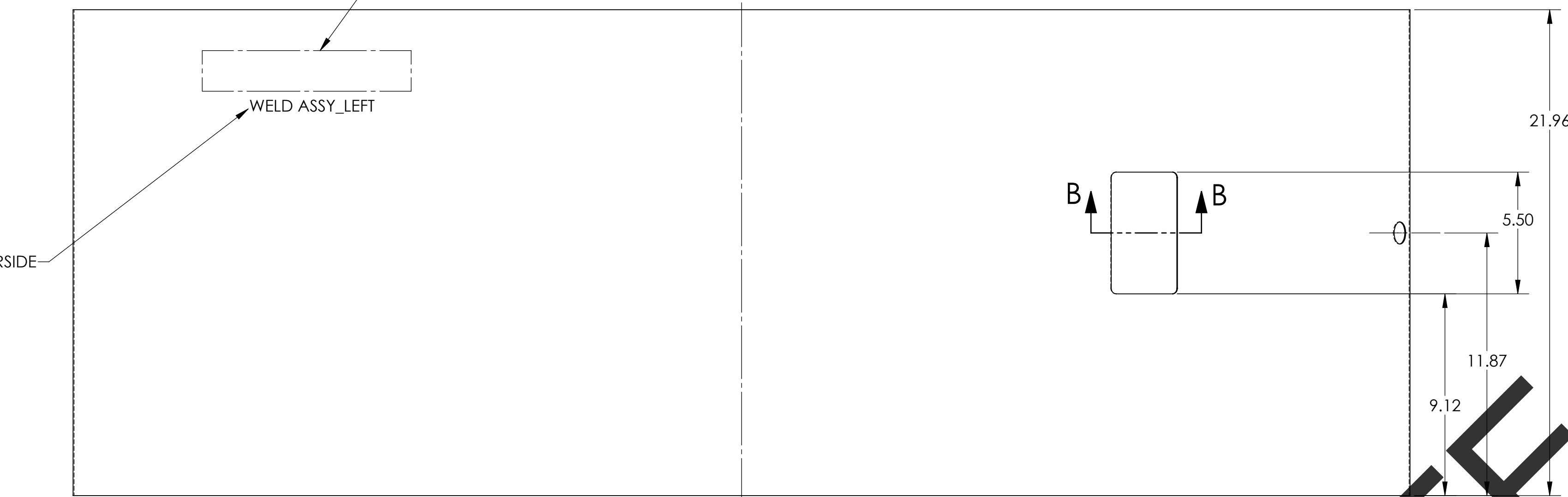
⑧ NEARSIDE

WELD ASSY\_LEFT

SECTION B-B  
SCALE 1:1

SUPER #8 ON ID

GENERAL VIEW  
FOR REFERENCE ONLY  
NO SCALE



FOR QUOTE ONLY

DIMENSIONS ARE IN INCHES		NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
TOLERANCES: .XX ± .03 .XXX ± .010		1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES .005-.015 ON ALL EDGES AND HOLES. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.	
ANGULAR ± 1.0°	MATERIAL 18 GAUGE 304 SSSL	FINISH ⑦ SUPER #8	NEXT ASSY D0902656 D1003188 D1003233

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
SYSTEM ADVANCED LIGO	SUB-SYSTEM AOS	RADIAL SEGMENT, LEFT	
DESIGNER H. KELMAN	17 MAR 2010	SIZE D	DWG. NO. D1000558
DRAFTER TG. NGUYEN	16 AUG 2010	SCALE: 1:4	PROJECTION:
CHECKER M. SMITH	27 JUL 2012	SHEET 1 OF 1	
APPROVAL D. COYNE			

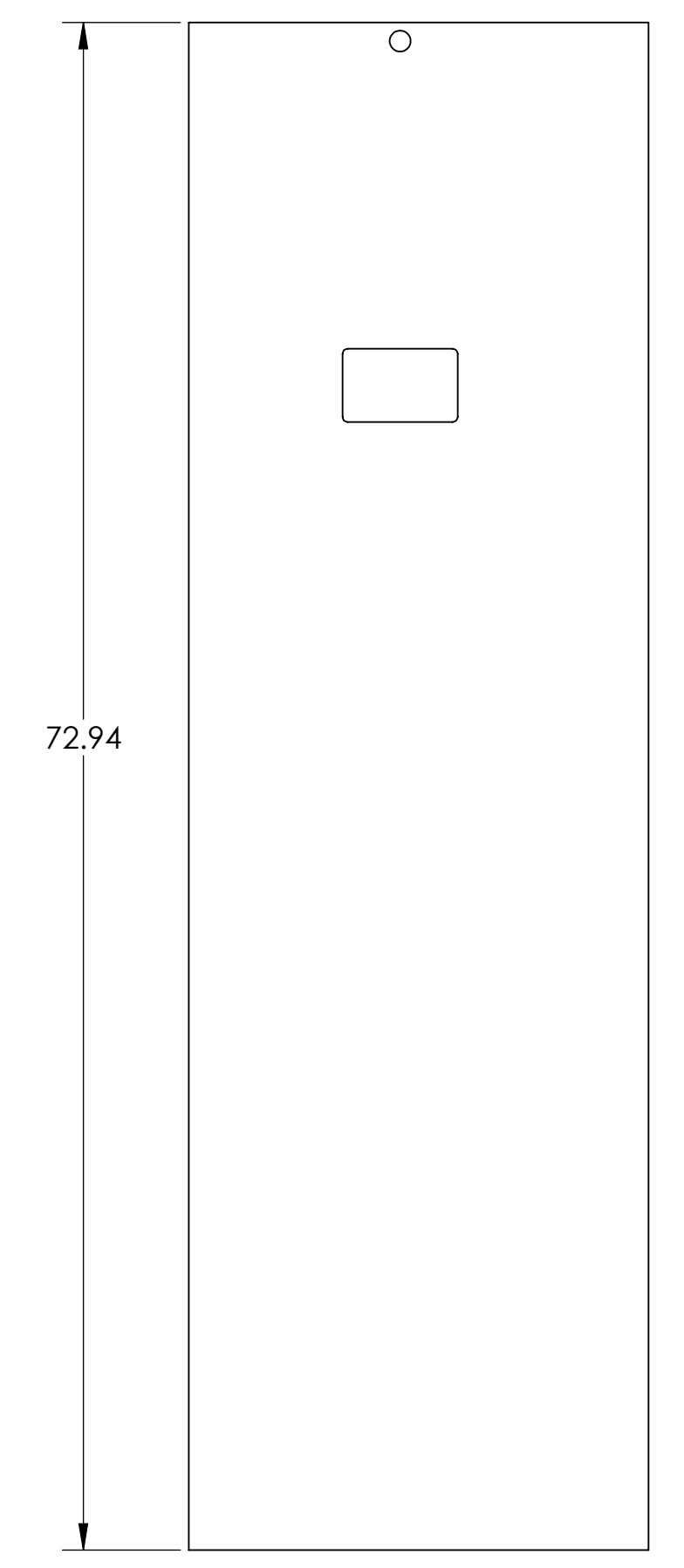
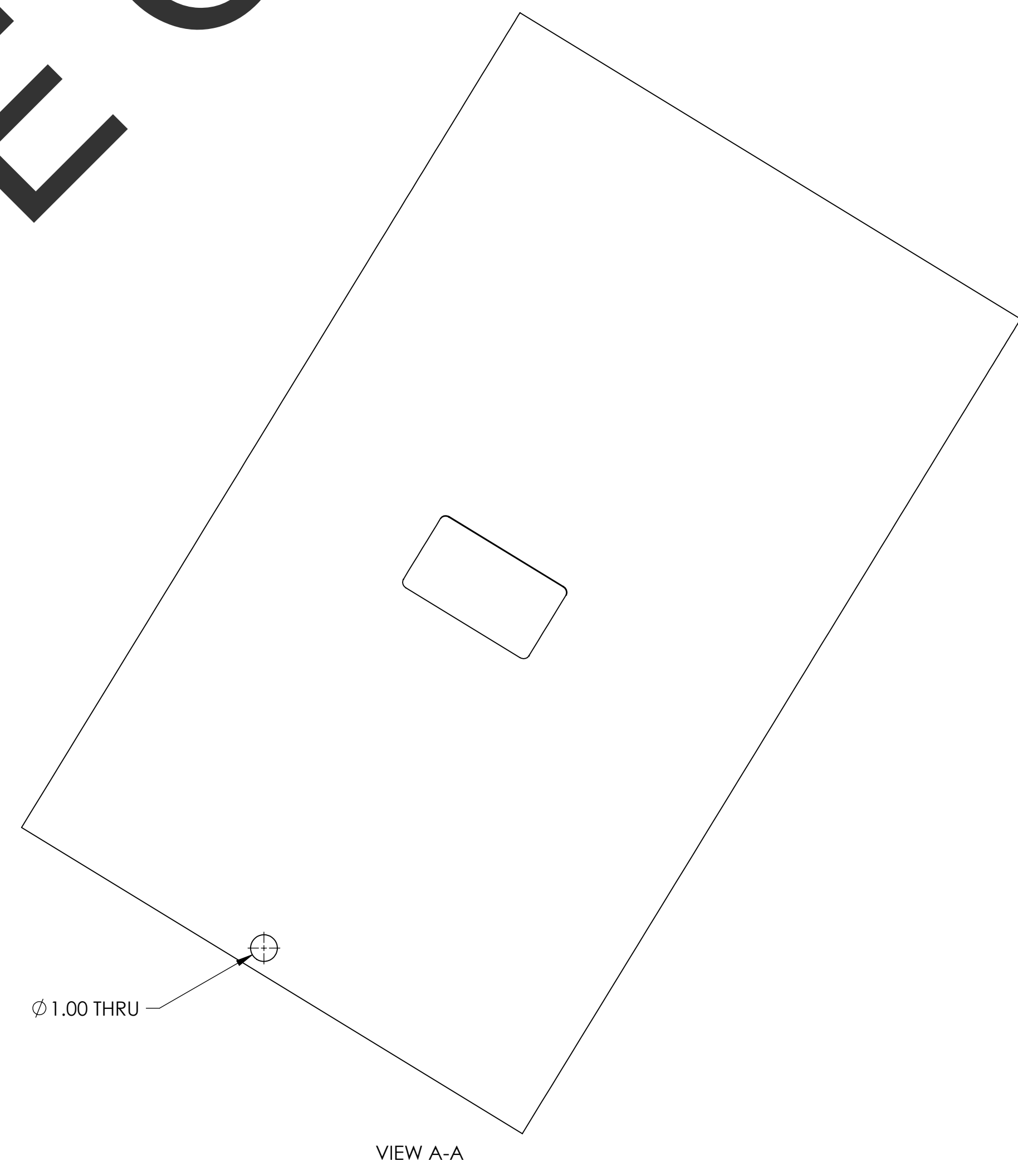
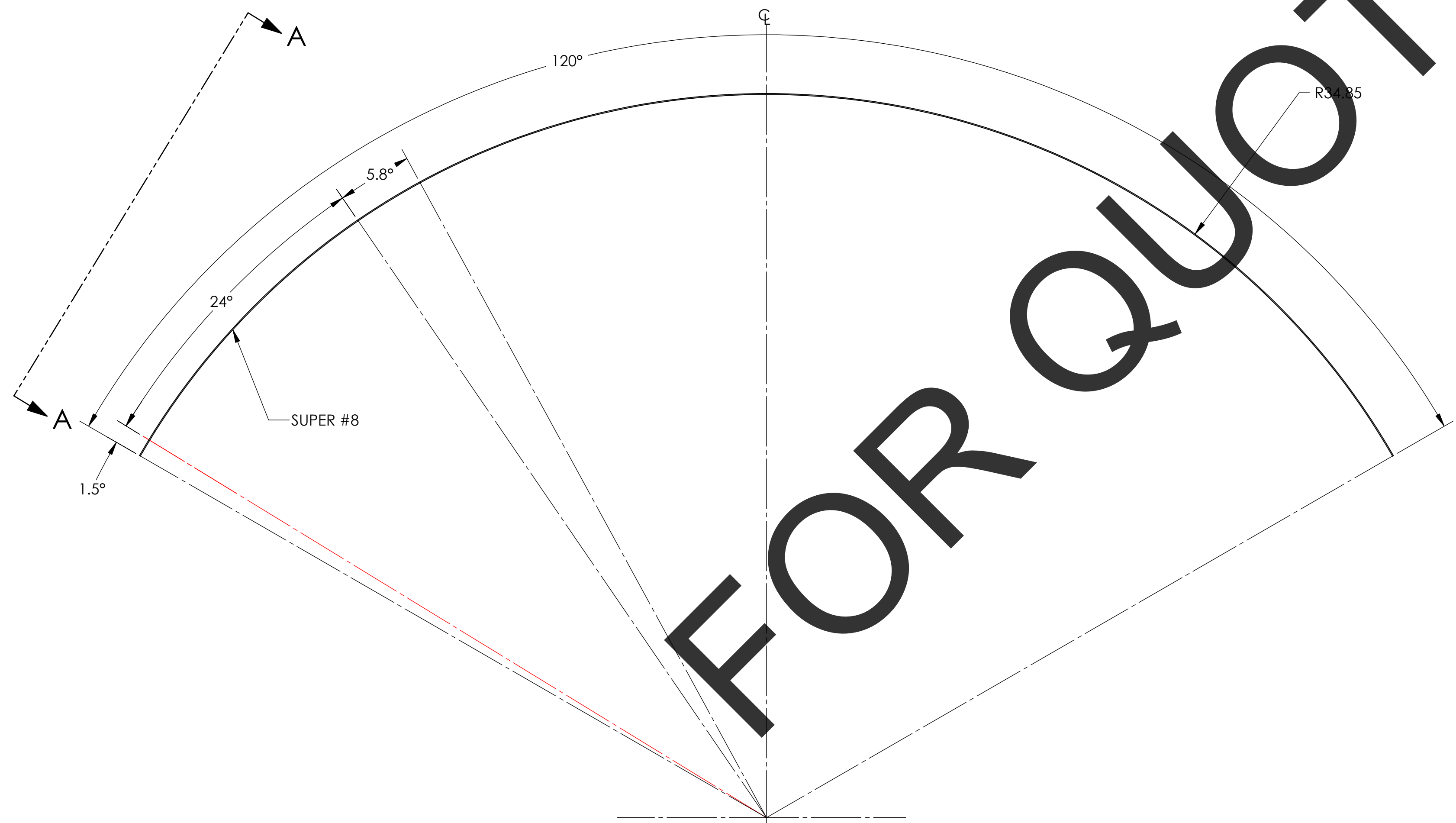
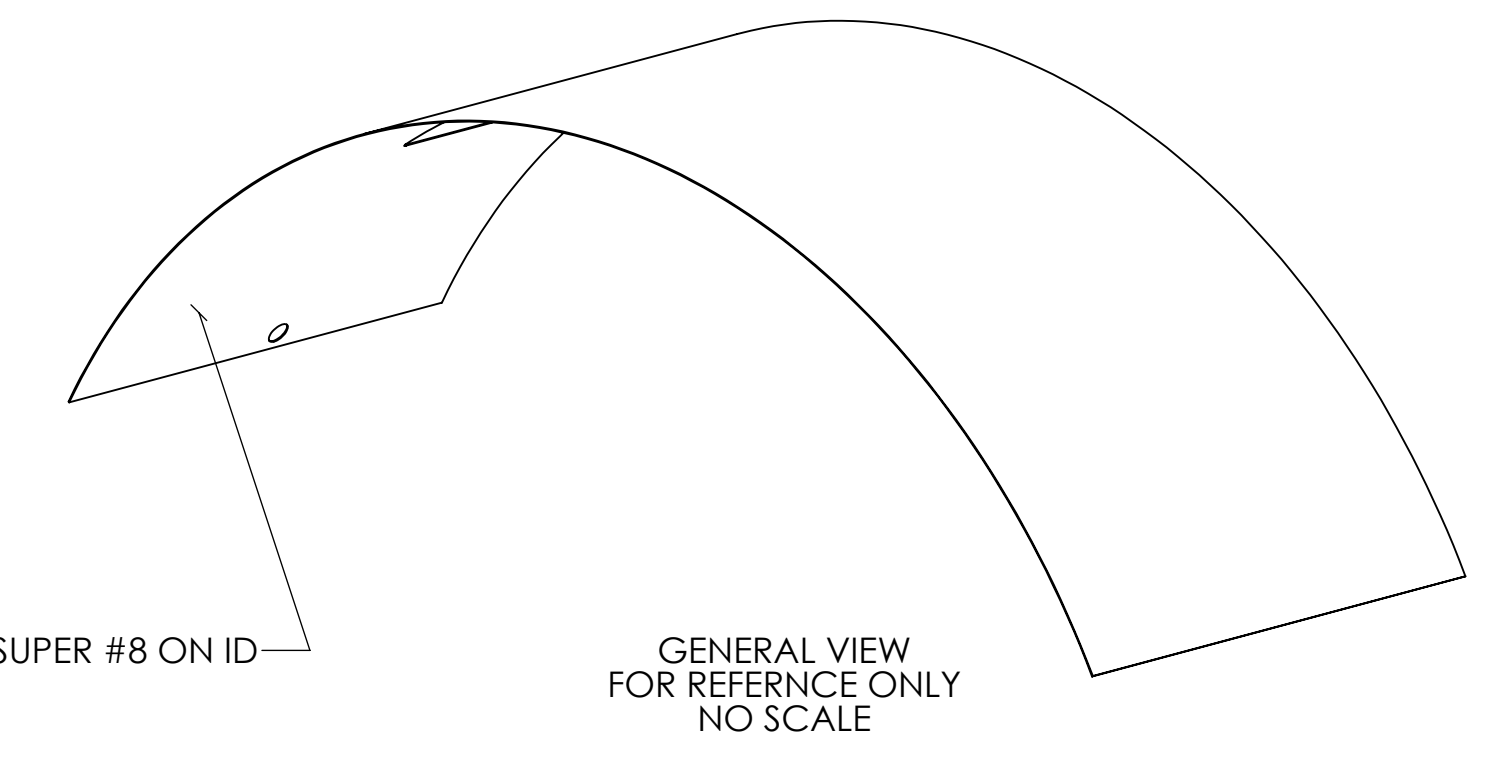
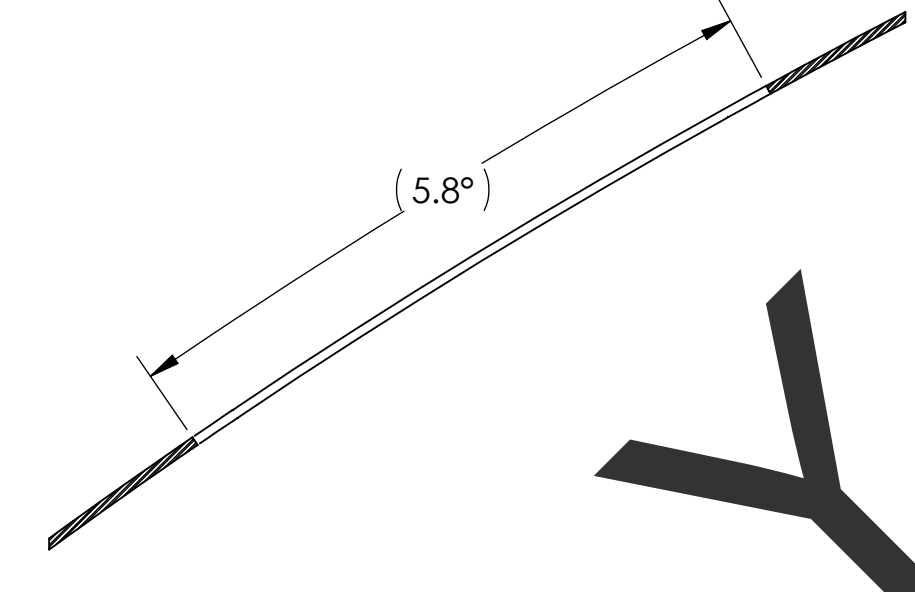
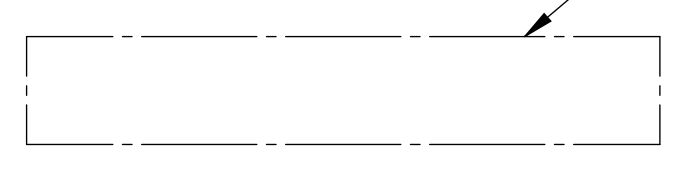
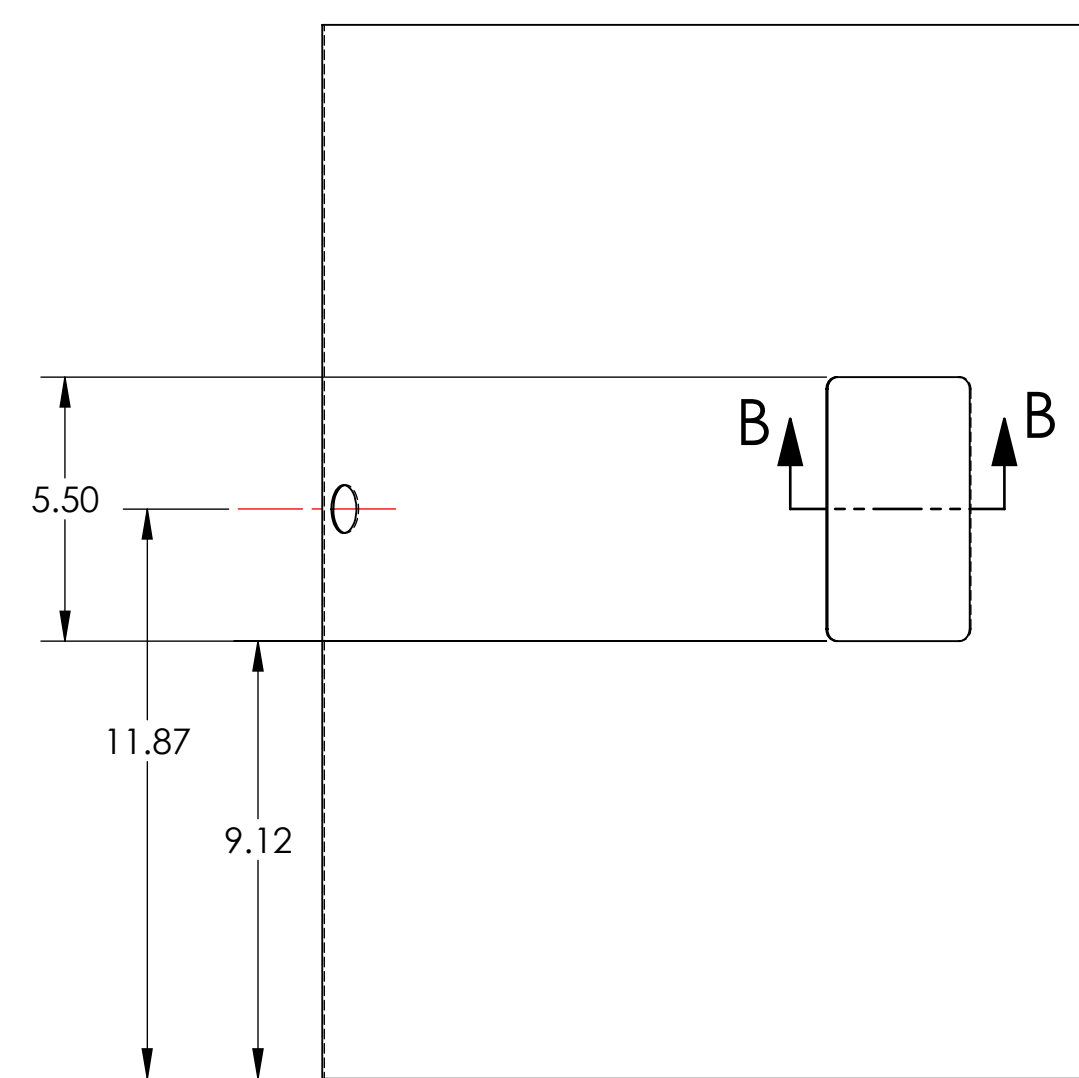
REV.	v3
------	----

D:\000558.dwg\_MonField\_Coyne\_Radial\_Segment\_Left\_PART\_PDM\_REV\_X-025\_DRAWING\_PDM\_REV\_X-023

**NOTES CONTINUED:**  
 ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR 'TYPE' IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE

- 6. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
- ⑦ SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.
- 8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.
- ⑧ SCRIBBLE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) LETTERS AS SHOWN. DO NOT APPLY MARK ON SUPER #8 SIDE.

REV.	DATE	DCN #	DRAWING TREE #
v1	3 SEPT 2010	E1000360	E1000090
v2	11 MAY 2011	E1000360-v2	-
v3	13 SEP 2011	E1000360-v3	-



FOR QUOTE ONLY

DIMENSIONS ARE IN INCHES  
 TOLERANCES:  
 .XX ± .03  
 .XXX ± .010  
 ANGULAR ± 1.0°

**NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)**  
 1. INTERPRET DRAWING PER ASME Y14.5-1994.  
 2. REMOVE ALL SHARP EDGES .005-.015 ON ALL EDGES AND HOLES.  
 3. DO NOT SCALE FROM DRAWING.  
 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

**MATERIAL**  
 18 GAUGE 304 SSSL

**FINISH**  
 ⑦ SUPER #8

**LIGO** CALIFORNIA INSTITUTE OF TECHNOLOGY  
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

**SYSTEM**  
 ADVANCED LIGO

**SUB-SYSTEM**  
 AOS

**NEXT ASSY**  
 D0902654, D1003186, D1003231

**PART NAME**  
 RADIAL SEGMENT, RIGHT

<b>DESIGNER</b>	H. KELMAN	17 MAR 2010	<b>SIZE</b>	<b>DWG. NO.</b>	<b>REV.</b>
<b>DRAFTER</b>	TQ. NGUYEN	16 AUG 2010	<b>D</b>	<b>D1000559</b>	<b>v3</b>
<b>CHECKER</b>	M. SMITH	27 SEP 2010	<b>SCALE: 1:4</b>	<b>PROJECTION:</b>	<b>SHEET 1 OF 1</b>
<b>APPROVAL</b>	D. COYNE				

D:\000559.dwg\_Material\_Coyle\_Baffle\_Radial\_Segment\_Right.PART.PDM.REV.X-029.DRAWING.PDM.REV.X-025

**NOTES CONTINUED:**  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE

6. FILLET WELD WHERE RING AND CYLINDER MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048

7. SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

8. SEAM WELD CYLINDER PER SPECIFICATION E0900048.

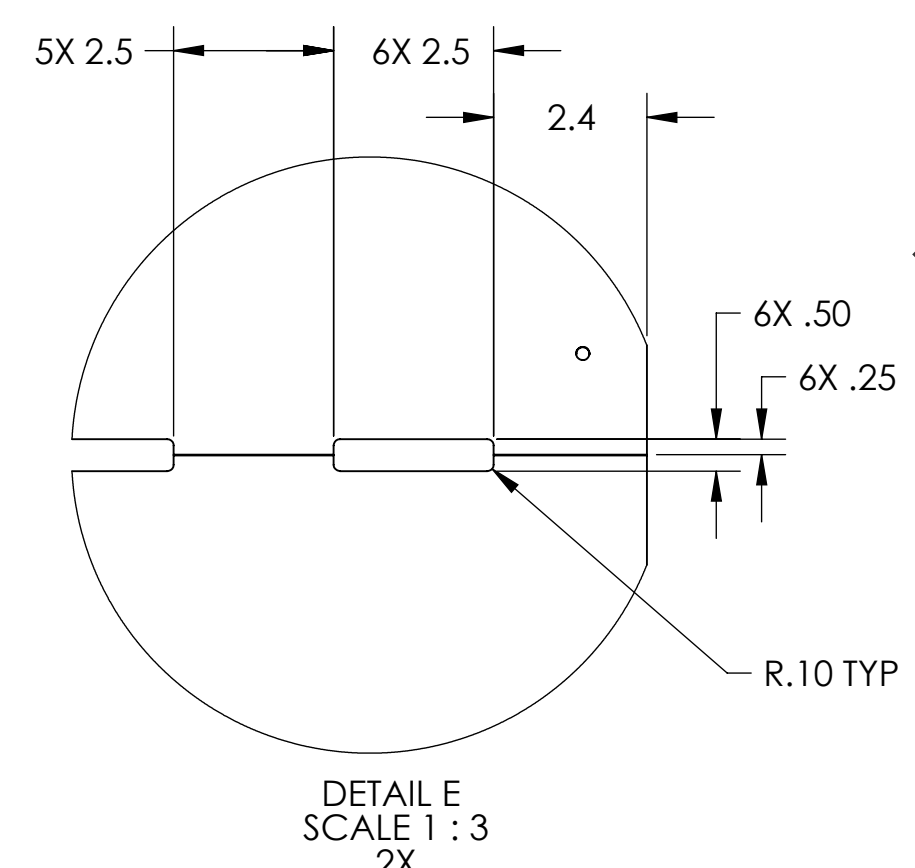
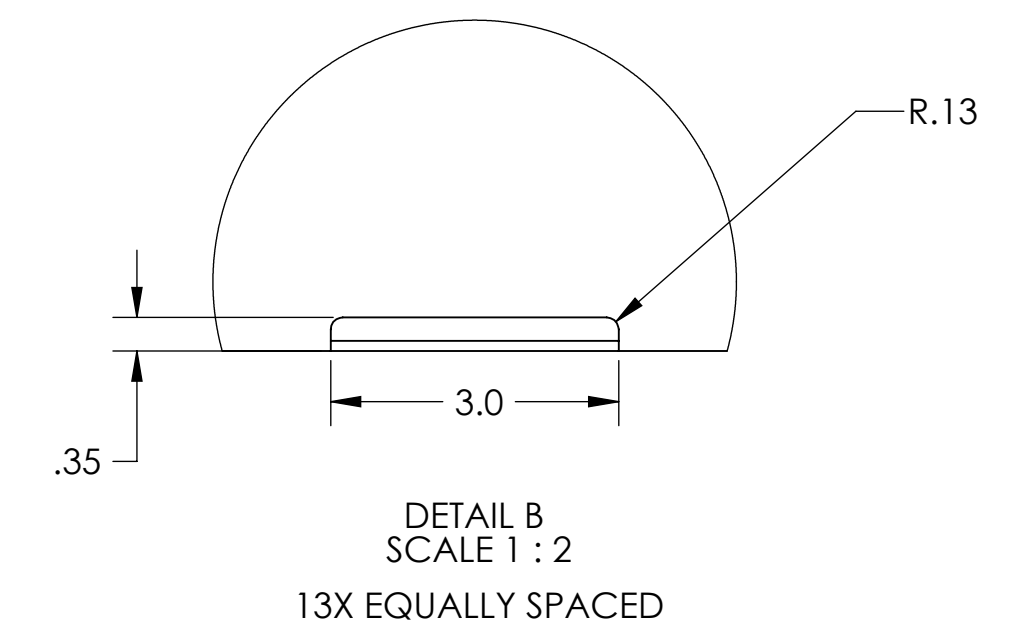
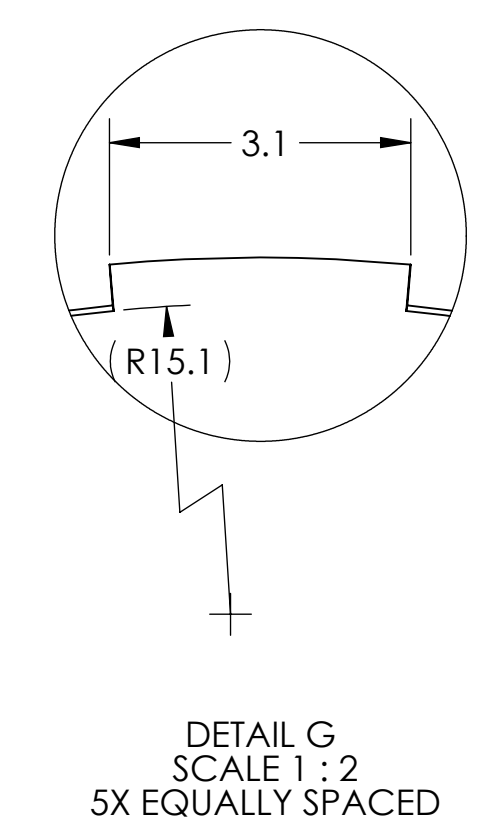
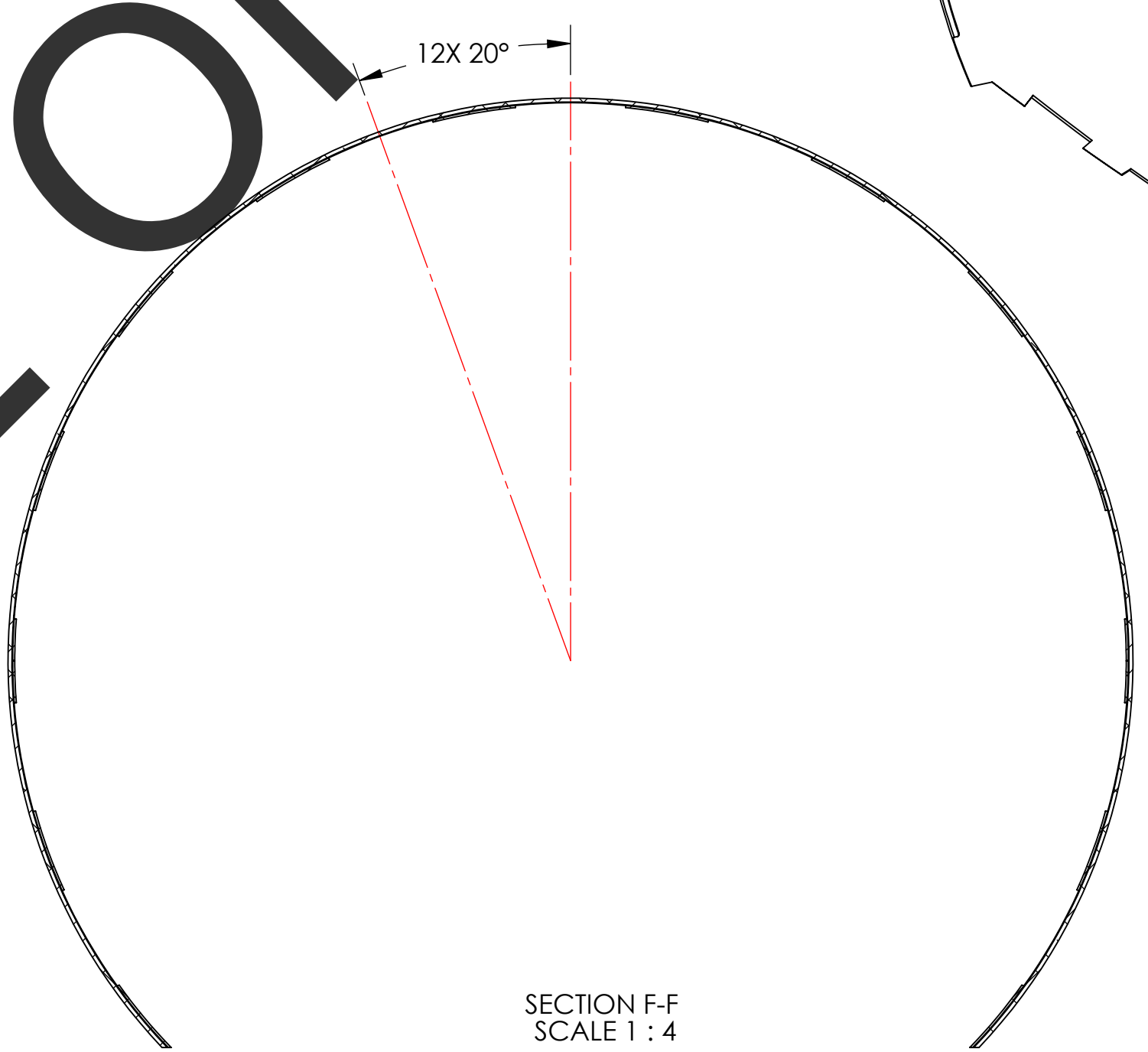
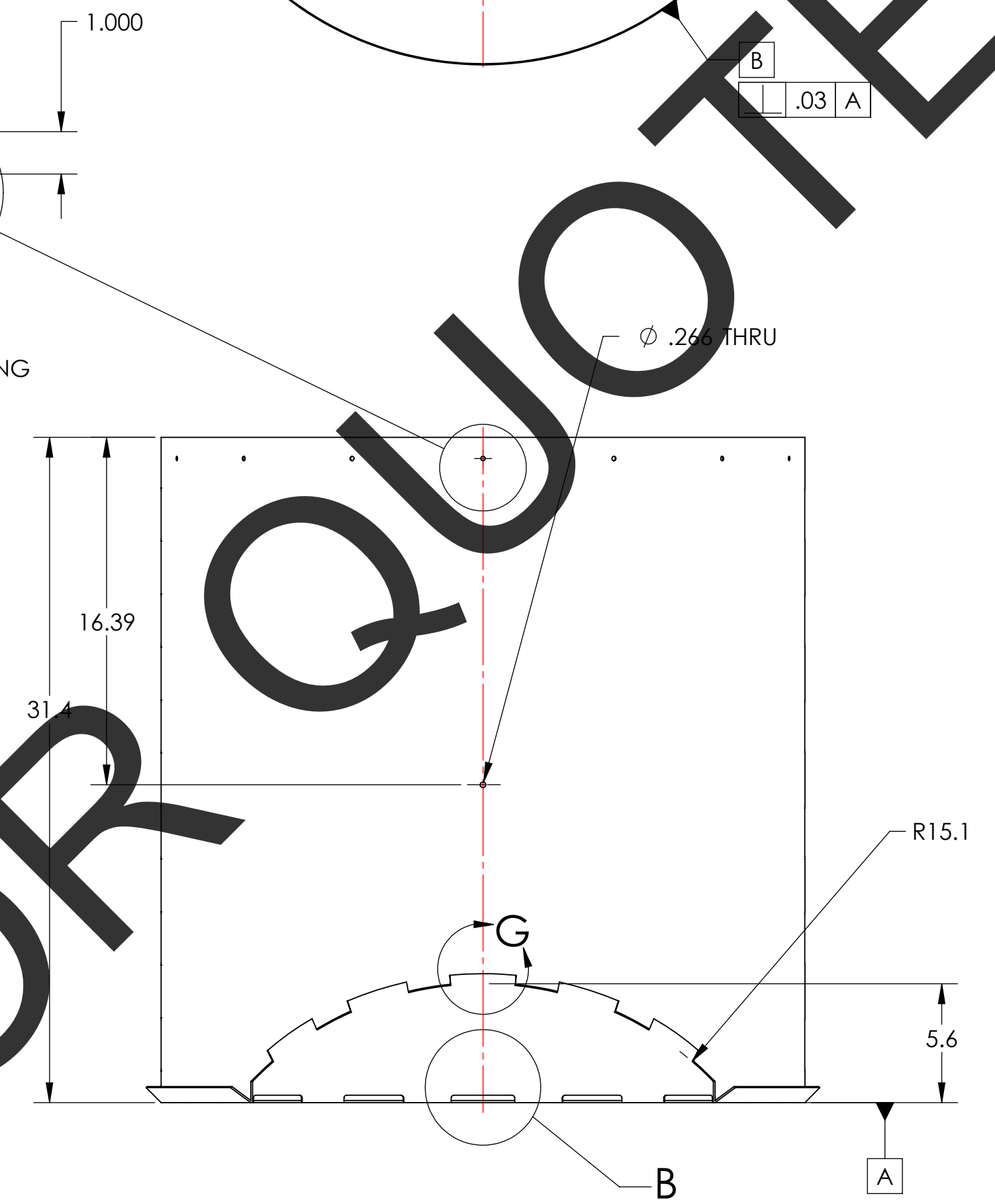
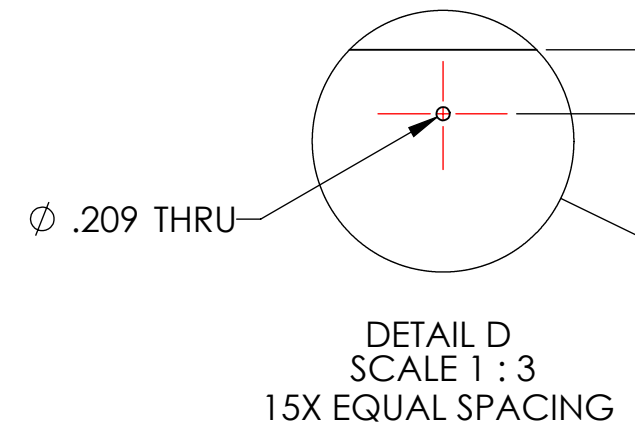
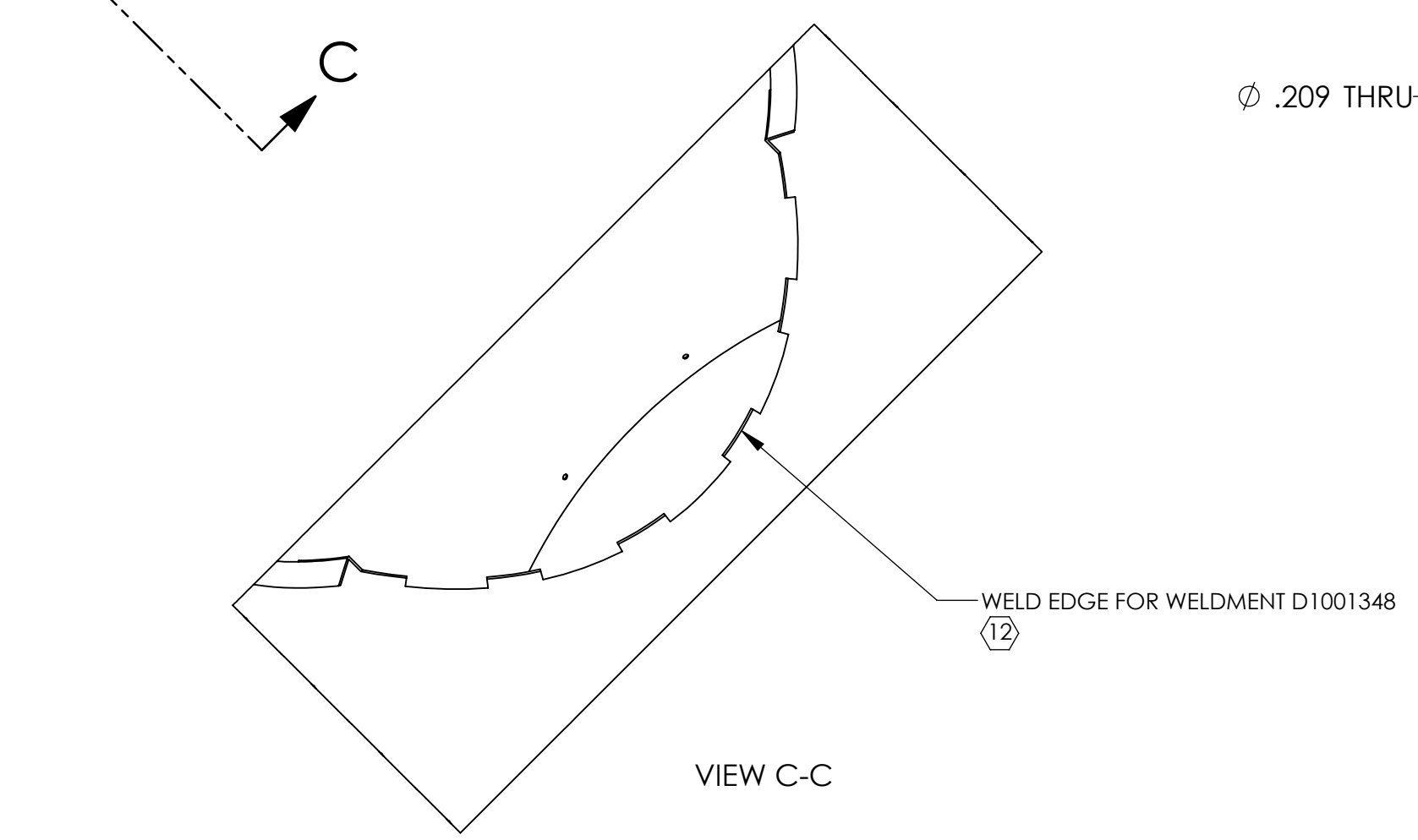
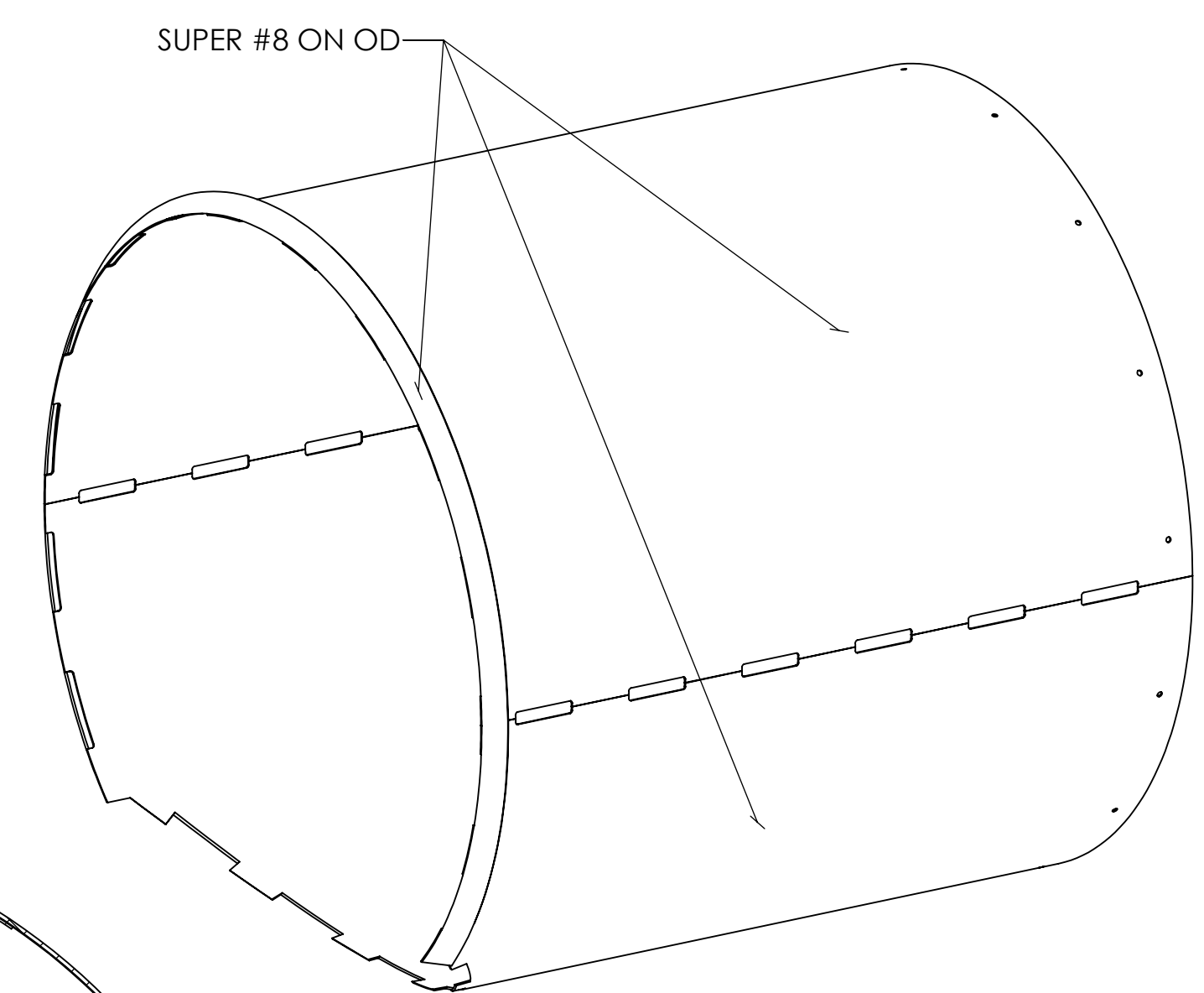
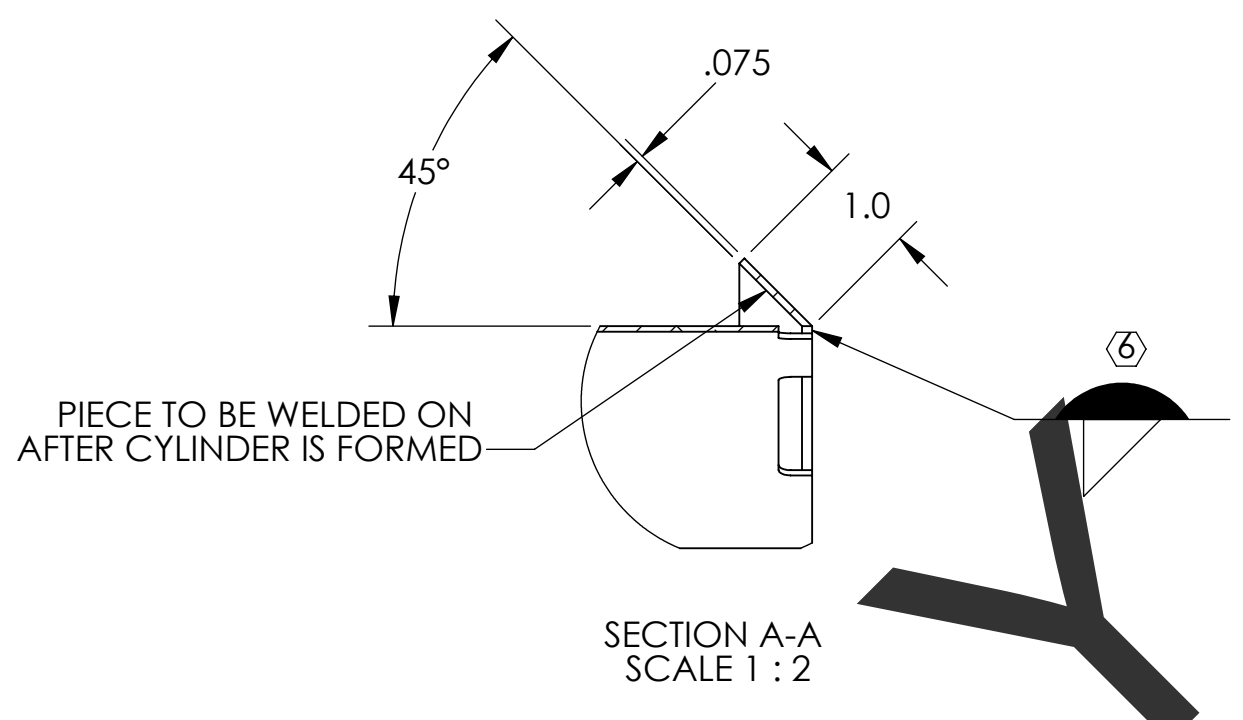
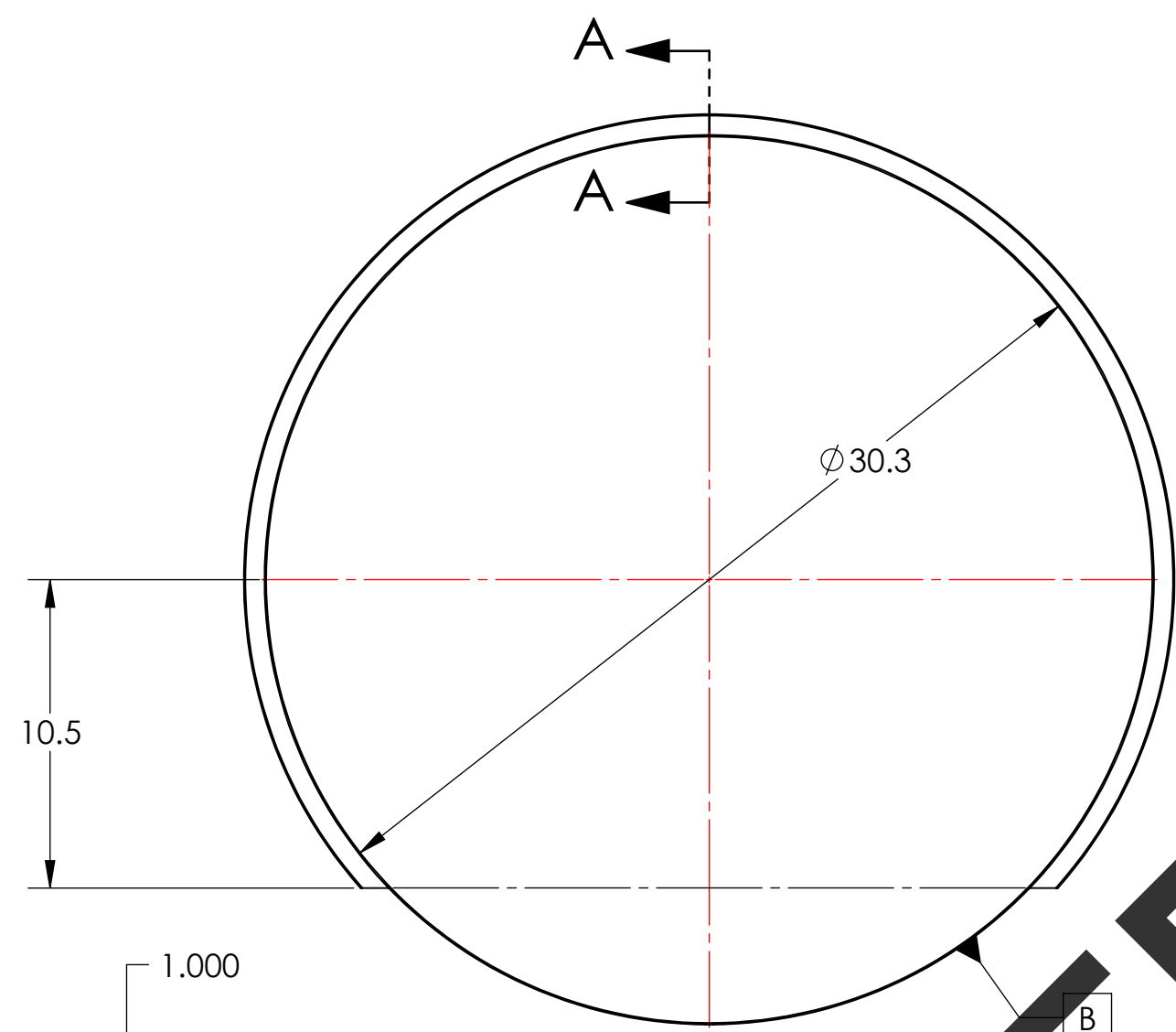
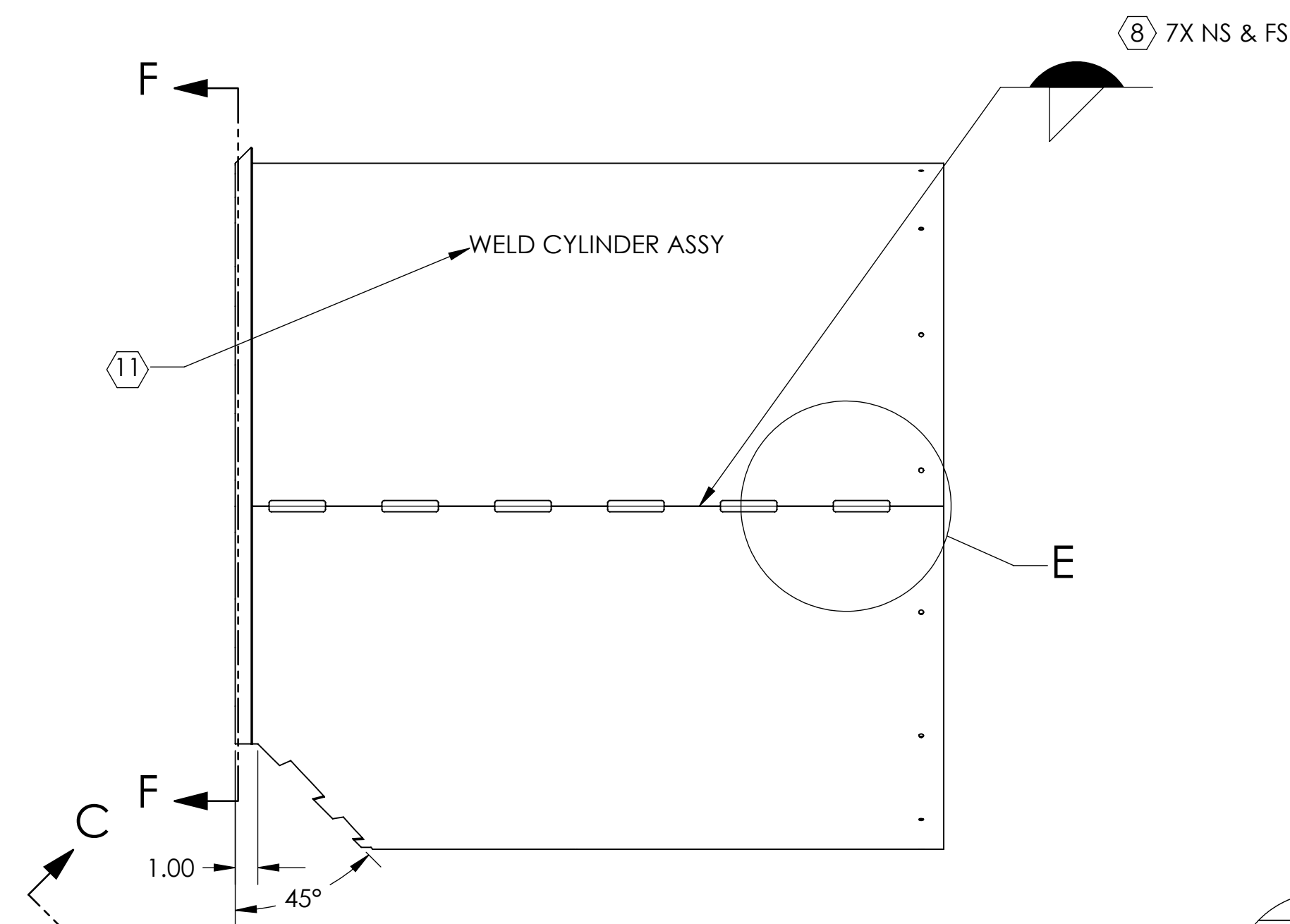
9. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

10. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

11. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) LETTERS AS SHOWN.

12. VENDOR RESPONSIBLE FOR EDGE WELD PREP, IF REQUIRED.

REV.	DATE	DCN #	DRAWING TREE #
V1	07 SEP 2010	E1000360	E1000367
V2	11 MAY 2011	E1000360-v2	
V3	13 SEP 2011	E1000360-v3	



FOR QUOTE ONLY

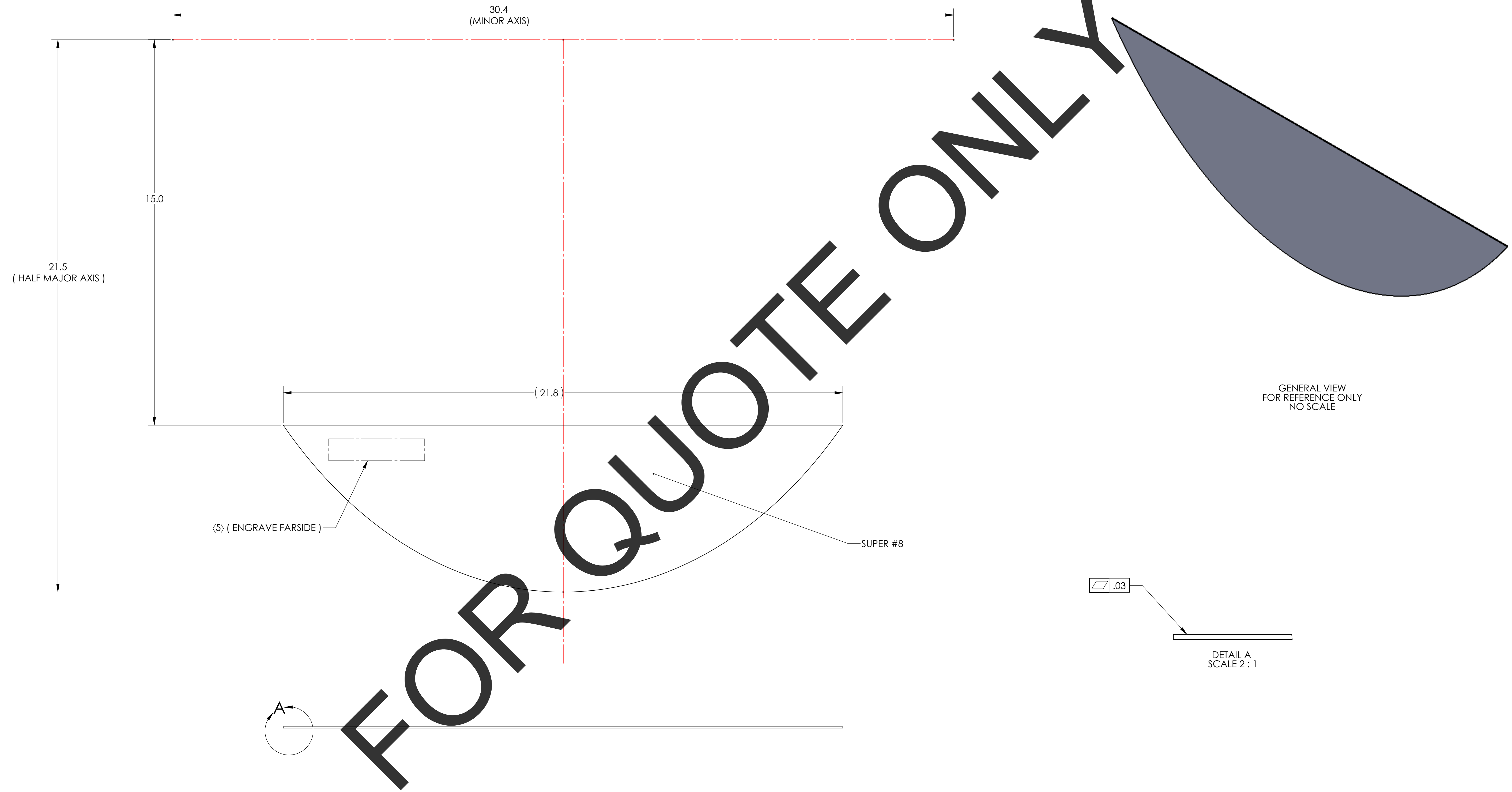
THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D0902654 FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.

DIMENSIONS ARE IN INCHES		NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)		LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
TOLERANCES:		1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015 ON ALL EDGES AND HOLES. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		SYSTEM		MANIFOLD-CRYO BAFFLE CYLINDER	
.X ± .1		MATERIAL		ADVANCED LIGO		DESIGNER	
.XX ± .06		18 GAUGE 304 SSSL		SUB-SYSTEM		H. KELMAN	
.XXX ± .010		FINISH		AOS		5 APR 2010	
ANGULAR ± 1.0°		(7) SUPER #8		NEXT ASSY		SIZE	
				D1001348		DWG. NO.	
						D	
						D1000570	
						REV.	
						v3	
						SCALE: 1:6	
						PROJECTION:	
						SHEET 1 OF 1	

**NOTES CONTINUED:**  
 ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS. UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE  
 ⑥ SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.  
 8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

REV.	DATE	DCN #	DRAWING TREE #
v1	08 SEP 2010	E1000360	E1000367
v2	12 MAY 2011	E1000360-v2	-
v3	13 SEP 2011	E1000360-v3	-



⑤ ( ENGRAVE FAR SIDE )

SUPER #8

DETAIL A  
SCALE 2 : 1

THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D1001348 FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.

DIMENSIONS ARE IN INCHES		NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)		CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
TOLERANCES: .X ±.1 .XX ±.06 .XXX ±.010		1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES .005-.015 FOR ALL EDGES AND HOLES. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		SYSTEM ADVANCED LIGO SUB-SYSTEM AOS		ELLIPSE SCRAPER BLADE	
ANGULAR ± 1.0°		MATERIAL 18 GAUGE 304 SSTL FINISH ⑥ SUPER #8		NEXT ASSY D1001348		DESIGNER H. KELMAN 15 JUN 2010 SIZE DWG. NO. D1001018 REV. v3 DRAFTER TQ. NGUYEN 18 AUG 2010 CHECKER M. SMITH 27 SEPT 2010 APPROVAL D. COYNE	
				SCALE: 1:2 PROJECTION:		SHEET 1 OF 1	

D1001018.dwg\_Monitichl\_Crv\_Baffle\_Scraper\_Blade\_PART.PDM REV: X-203.DRAWING PDM REV: X-019

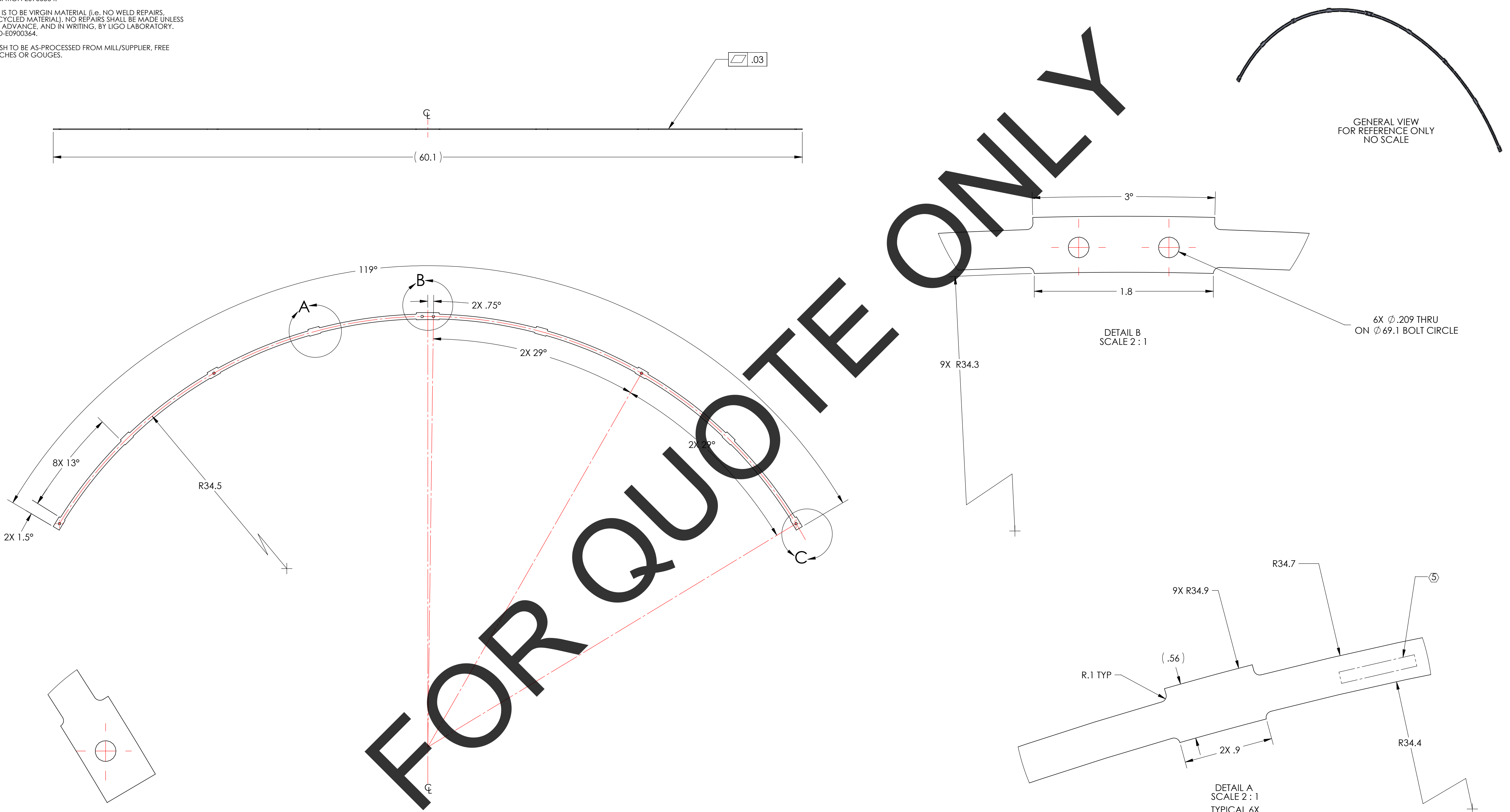


NOTES CONTINUED:  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR 'TYPE' IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE

6. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.  
 7. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

8. SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

REV.	DATE	DCN #	DRAWING TREE #
v1	08 SEP 2010	E1000360	E1000085
v2	12 MAY 2011	E1000360-v2	E1000090
v3	12 SEP 2011	E1000360-v3	E1000091



DETAIL C  
SCALE 2 : 1  
2X

THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE NEXT ASSEMBLY FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.

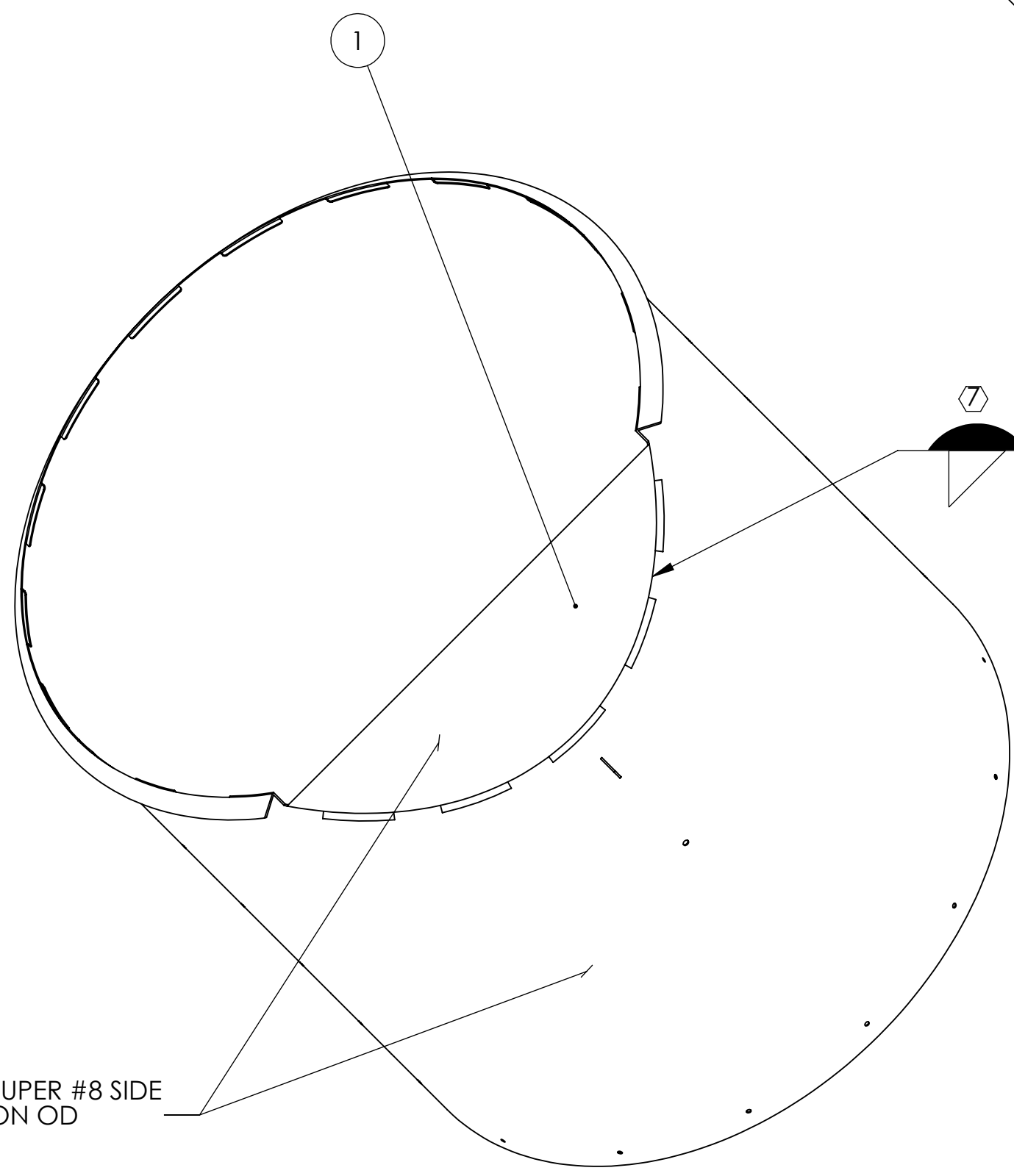
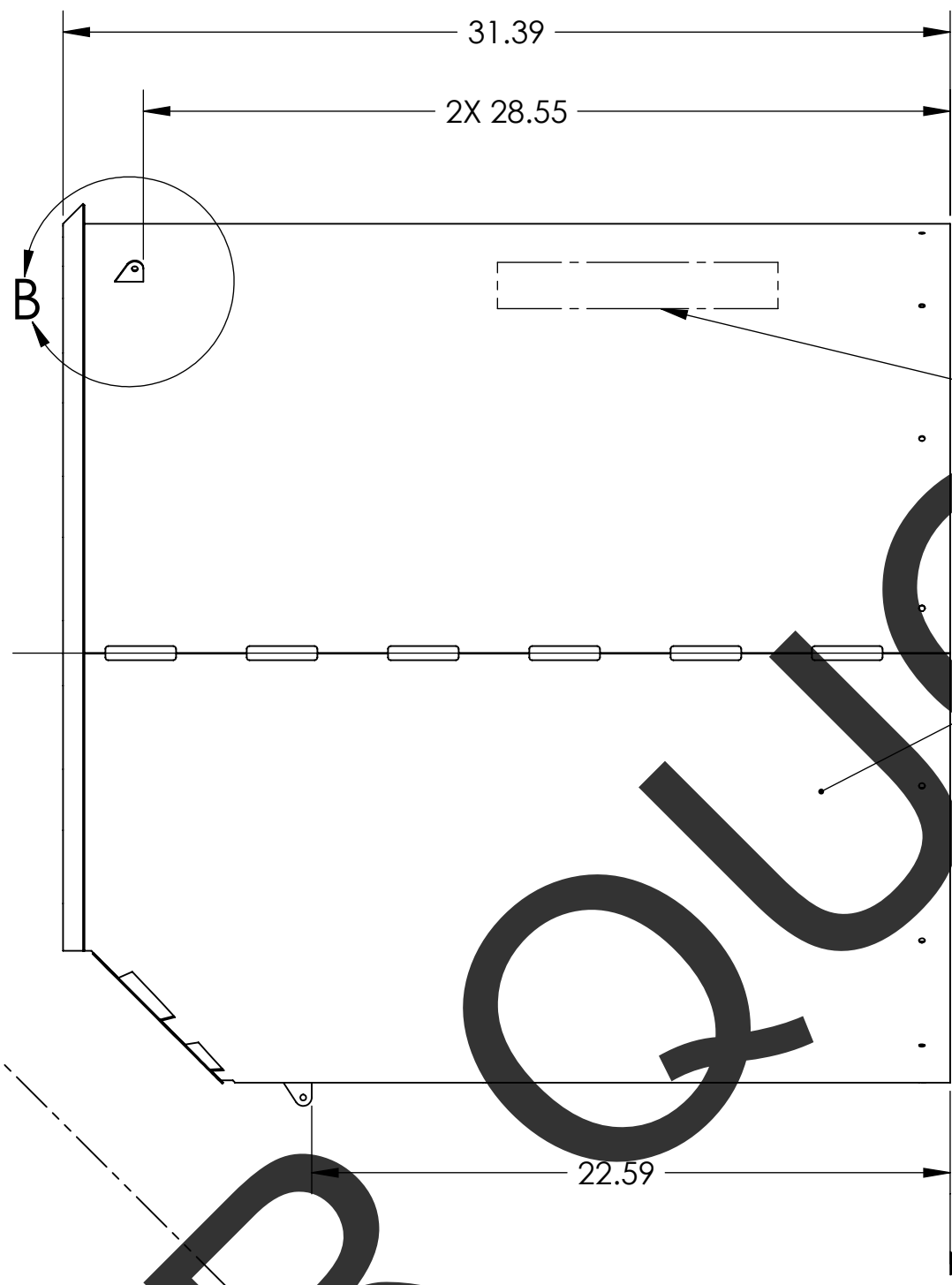
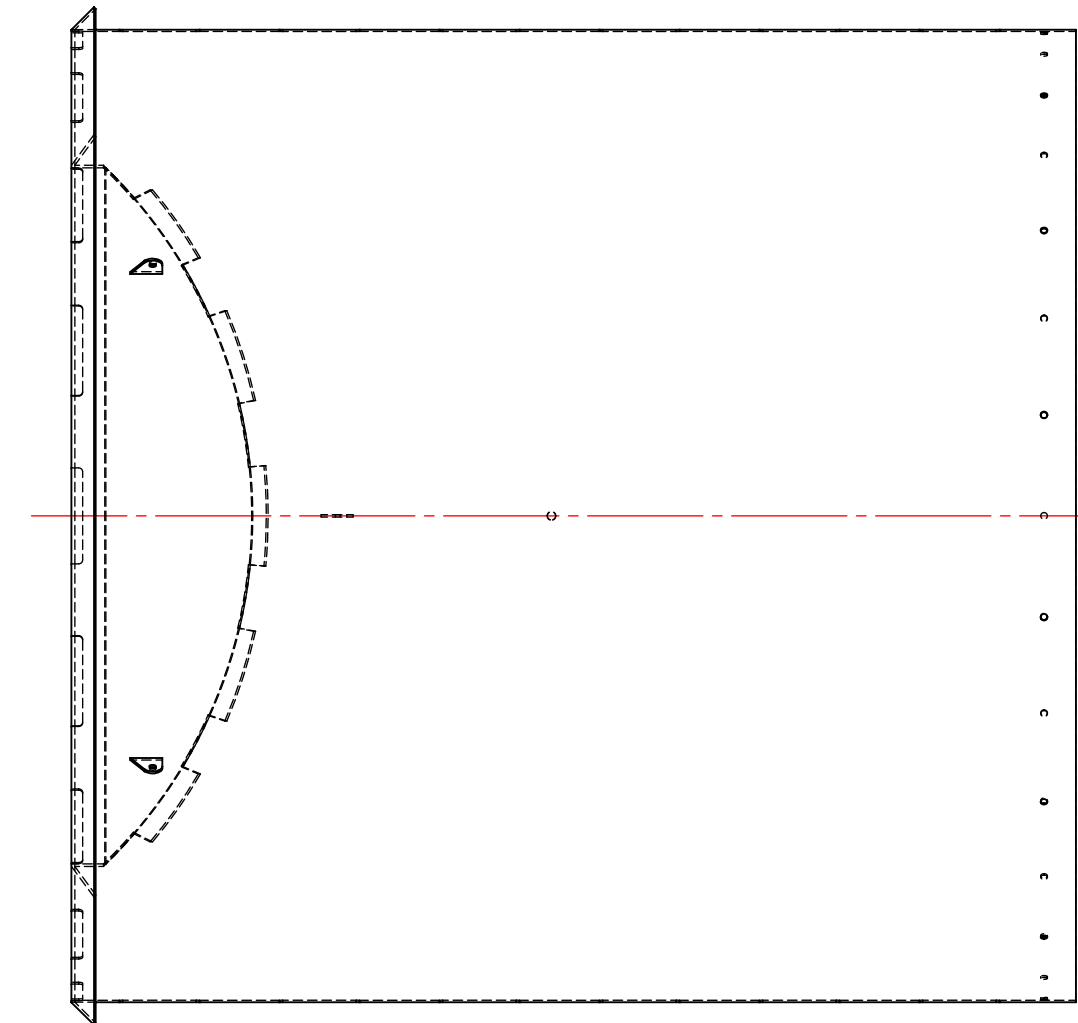
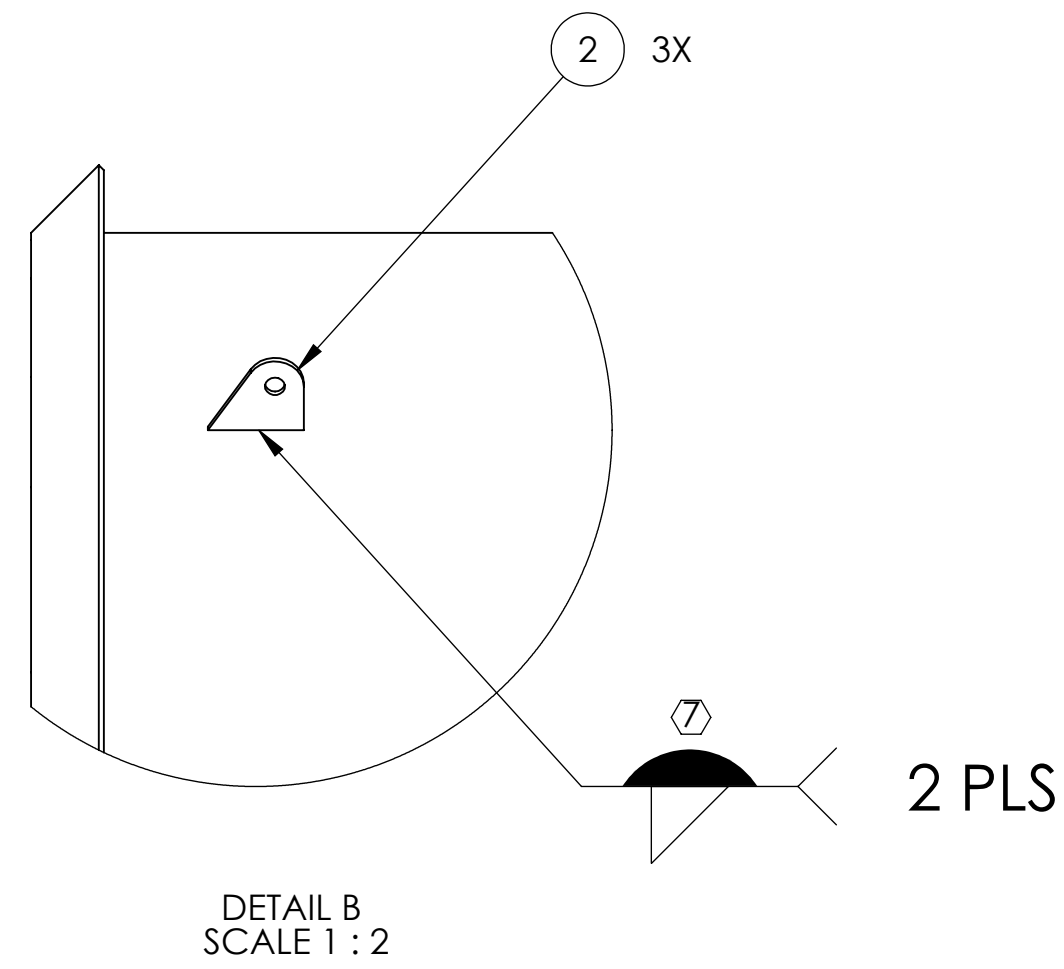
DIMENSIONS ARE IN INCHES		NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
TOLERANCES:		1. INTERPRET DRAWING PER ASME Y14.5-1994.	
.X ± .1		2. REMOVE ALL SHARP EDGES .005-.015 ON ALL EDGES AND HOLES.	
.XX ± .06		3. DO NOT SCALE FROM DRAWING.	
.XXX ± .010		4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.	
MATERIAL	FINISH	NEXT ASSY	
14 GAUGE 304 SSTL	(8)	VARIOUS	
ANGULAR ± 1.0°			

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
ADVANCED LIGO		RADIAL ATTACHMENT NUT PLATE	
DESIGNER	H. KELMAN	6 APRIL 2010	SIZE DWG. NO.
DRAFTER	TQ. NGUYEN	17 AUG 2010	D D1001073
CHECKER	M. SMITH	27 SEP 2011	REV. v3
APPROVAL	D. COYNE	SCALE: 1:4	PROJECTION:
		SHEET 1 OF 1	

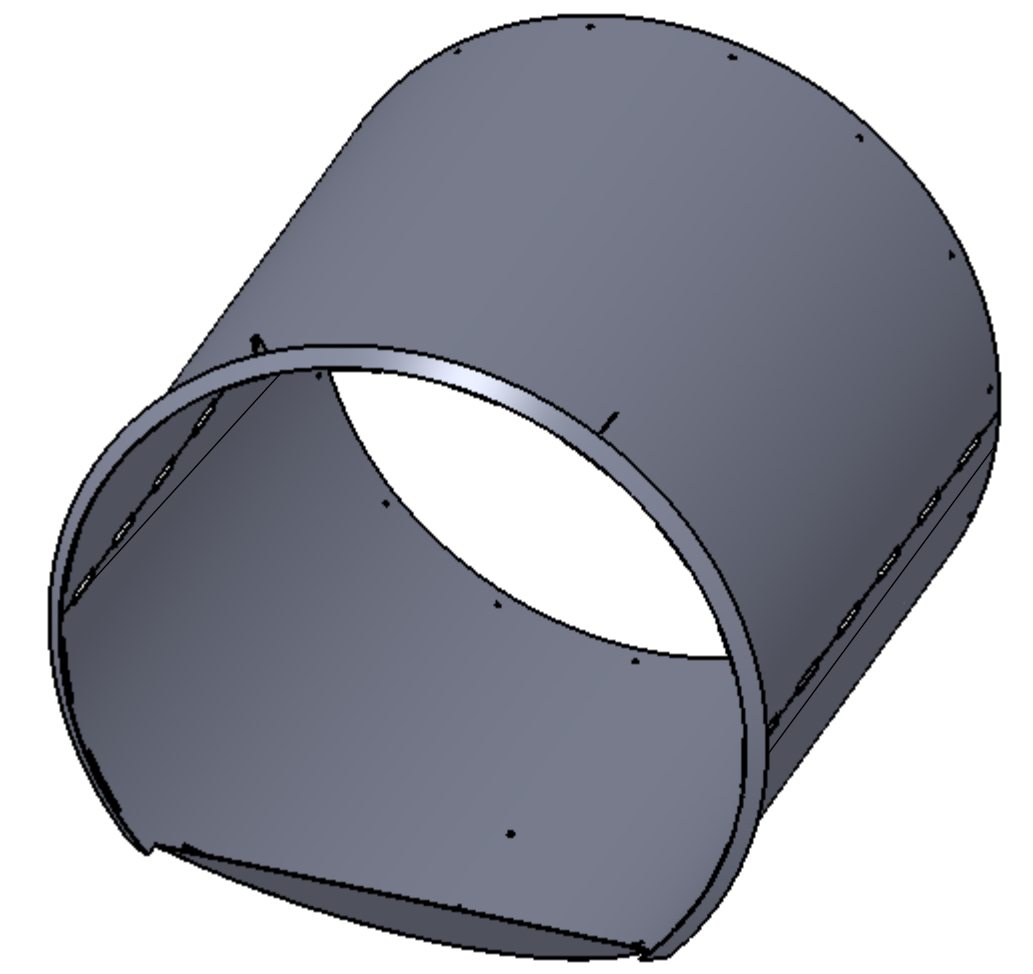
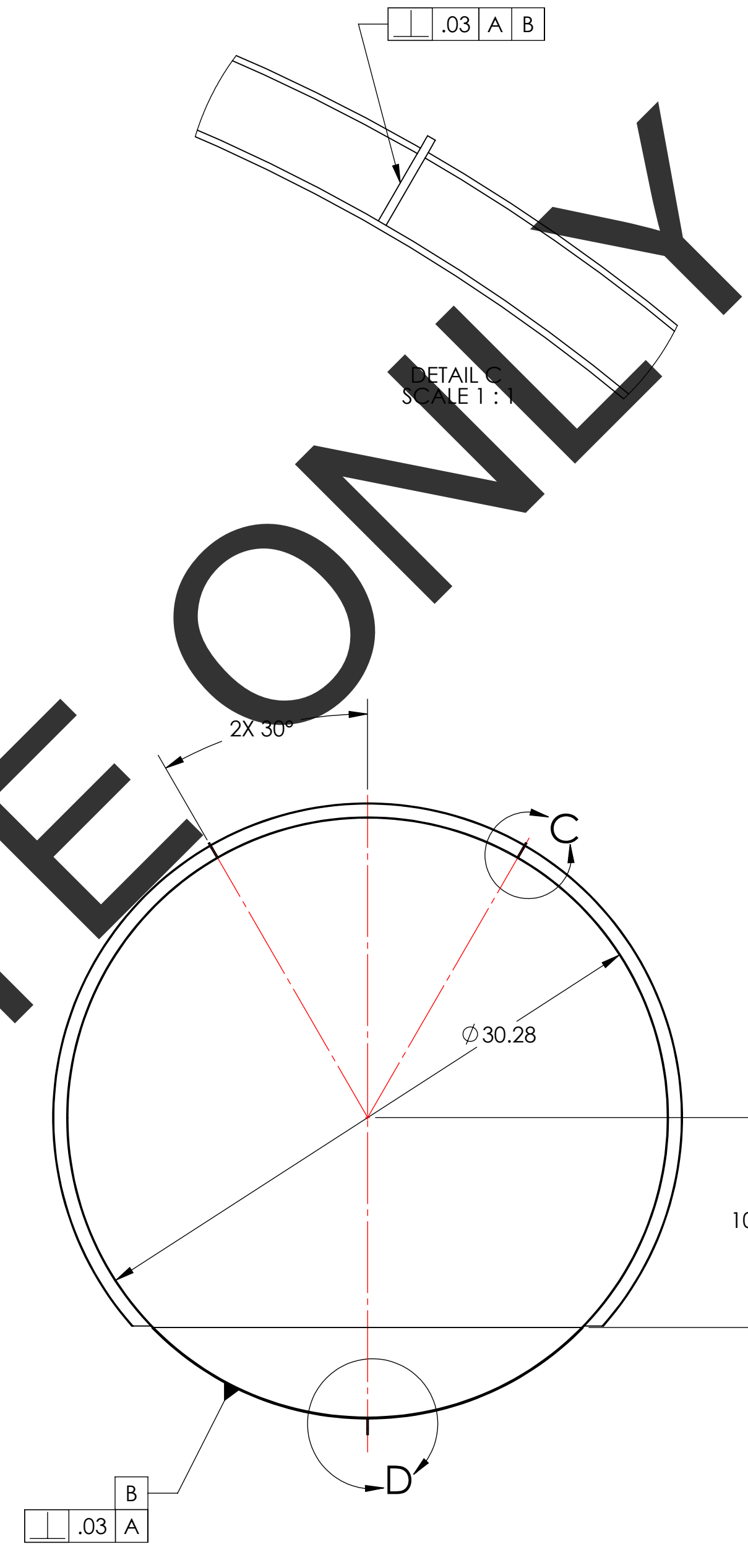
D1001073.dwg; Part FDM REV: X-025; DRAWING FDM REV: X-019

NOTES CONTINUED:  
 ⑤ DELETED.  
 6. ASSEMBLY TO BE OXIDIZED AFTER WELDMENT IS COMPLETED PER SPECIFICATION ET1100842.  
 ⑦ FILLET WELD WHERE ITEMS ① & ③ AND ③ & ② MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048.

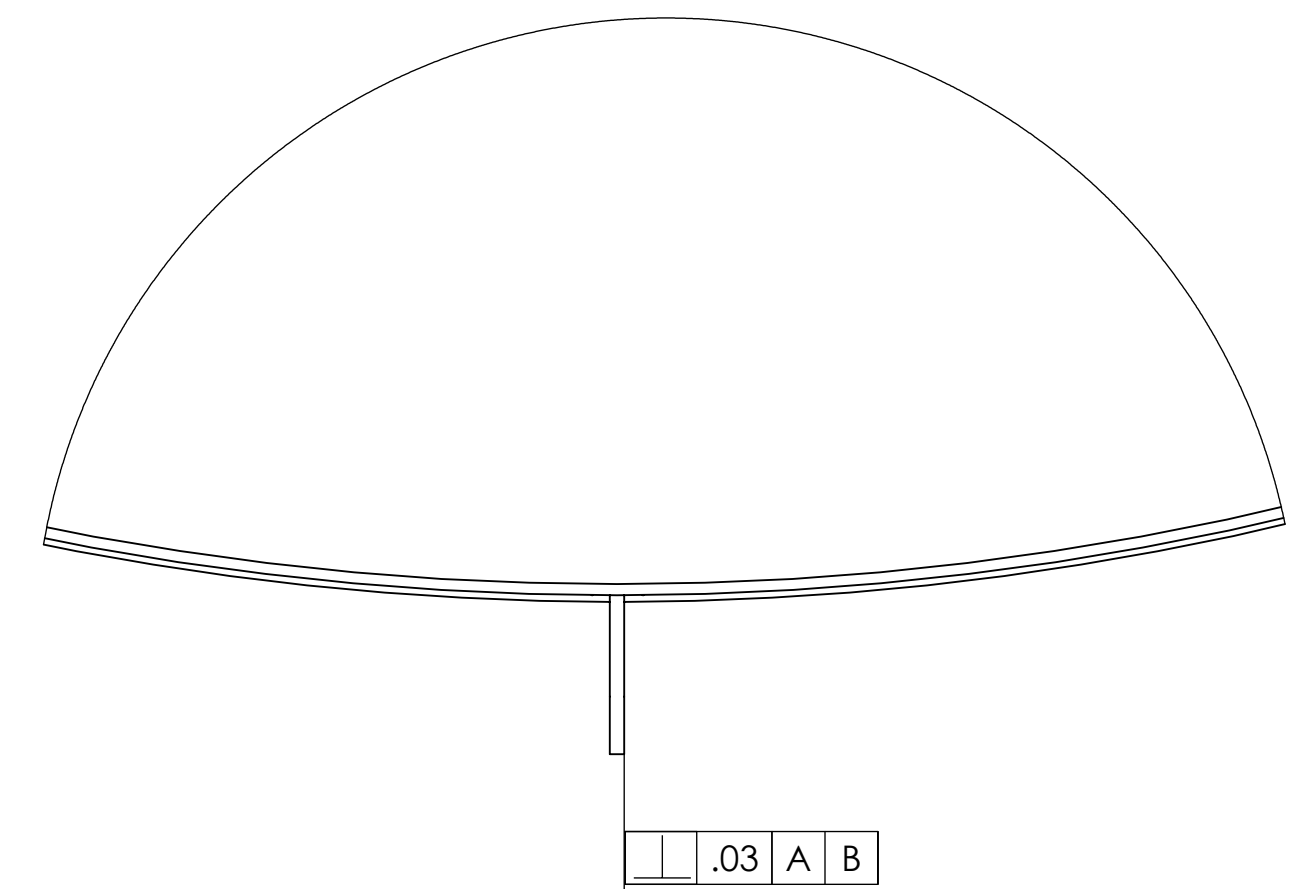
REV.	DATE	DCN #	DRAWING TREE #
v1	20 MAY 2010	E1000360	E1000367
v2	11 MAY 2011	E1000360-v2	-
v3	3 OCT 2011	E1000360-v3	-



FOR QUOTE ONLY



GENERAL VIEW FOR REFERENCE ONLY NO SCALE



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ	SPARE	TOTAL
3	D1000570	MANIFOLD-CRYO BAFFLE CYLINDER	18 GAUGE 304 SSSL	1		1
2	D1000536	BAFFLE BRACE BRACKET	14 GAUGE 304 SSSL	3		3
1	D1001018	ELLIPSE SCRAPER BLADE	18 GAUGE 304 SSSL	1		1

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)

- INTERPRET DRAWING PER ASME Y14.5-1994.
- REMOVE ALL SHARP EDGES .005-.015 ON ALL EDGES AND HOLES.
- DO NOT SCALE FROM DRAWING.
- ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

TOLERANCES:  
 .X ± .1  
 .XX ± .06  
 .XXX ± .010

ANGULAR ± 1.0°

MATERIAL: N/A      FINISH: N/A

SYSTEM: ADVANCED LIGO      SUB-SYSTEM: AOS

NEXT ASSY: D1101398, D1003183, D1003221

PART NAME: MANIFOLD-CRYO BAFFLE CYLINDER-SCRAPER ASSEMBLY

DESIGNER: H. KELMAN      25 MAY 2010      SIZE: D      DWG. NO.: D1001348      REV.: v3

DRAFTER: TQ. NGUYEN      07 SEP 2010

CHECKER: M. SMITH      27 JUL 2011

APPROVAL: D. COYNE

SCALE: 1:6      PROJECTION:      SHEET 1 OF 1

D:\001348\_d\UGO\_Manifold\_Cryo\_Baffle\_Cyl\_Scraper Assy.PART.PDM.REV.X-045.DRAWING.PDM.REV.X-029

NOTES CONTINUED:  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK OR MECHANICALLY STAMP (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR 'TYPE' IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX

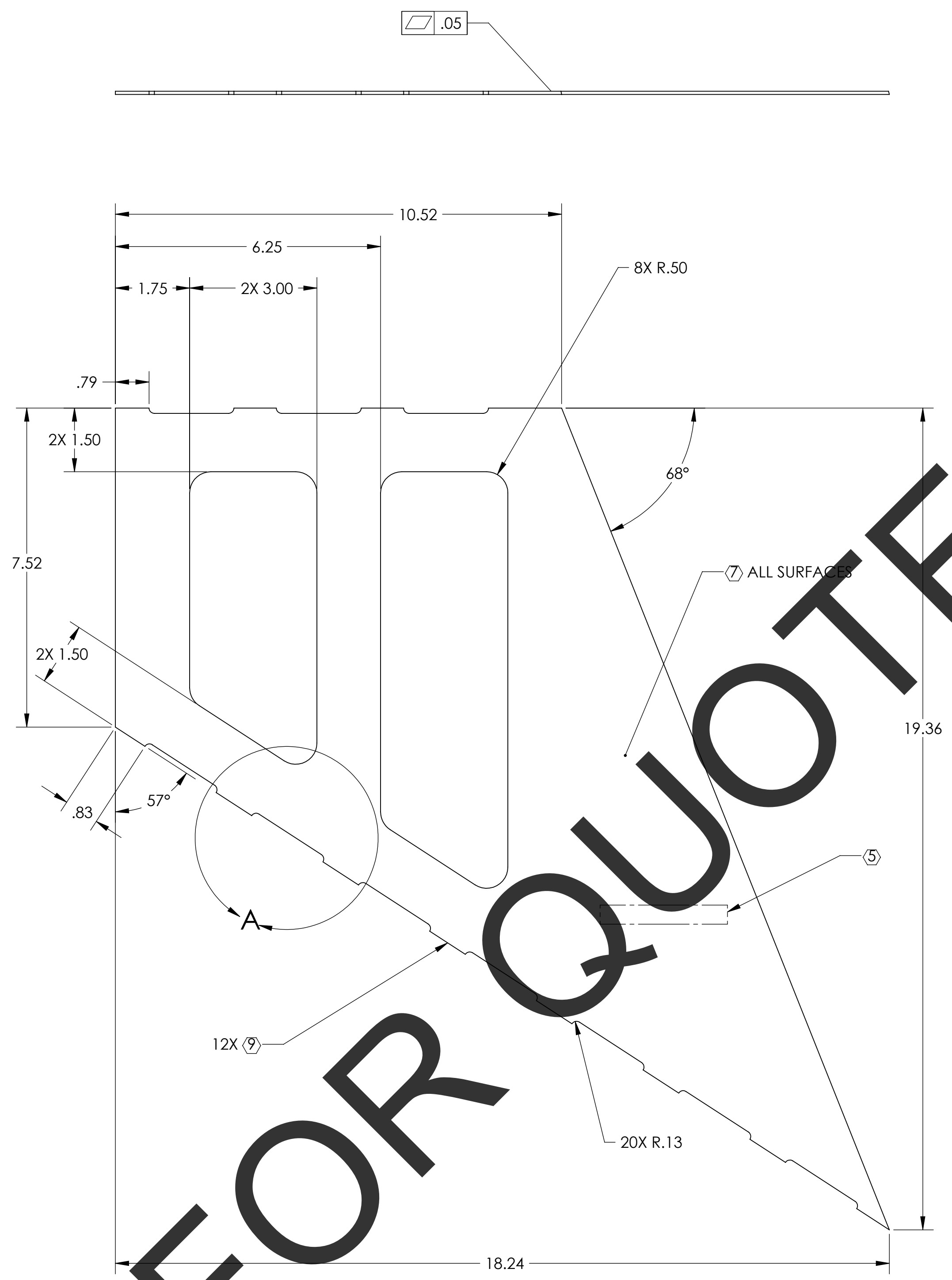
6. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364 AND E1100842.

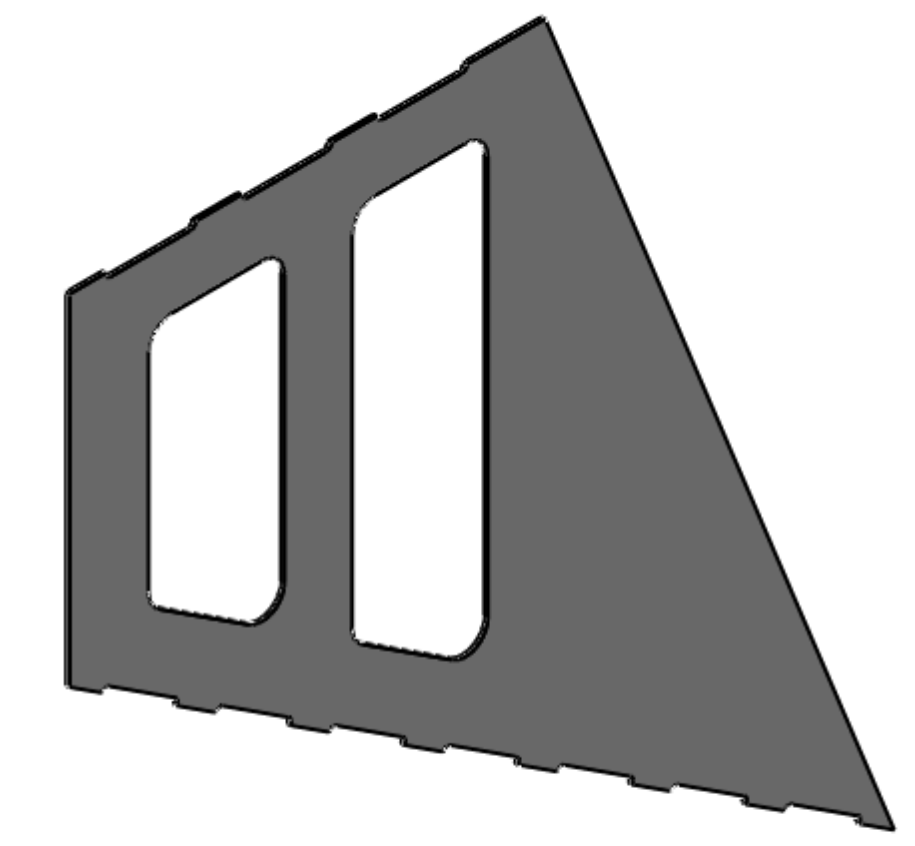
8. SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

9. CASTELLATION ON MATERIAL EDGES ARE FOR WELD PURPOSES IN ASSEMBLIES (D0902654, D0902655, D0902656).

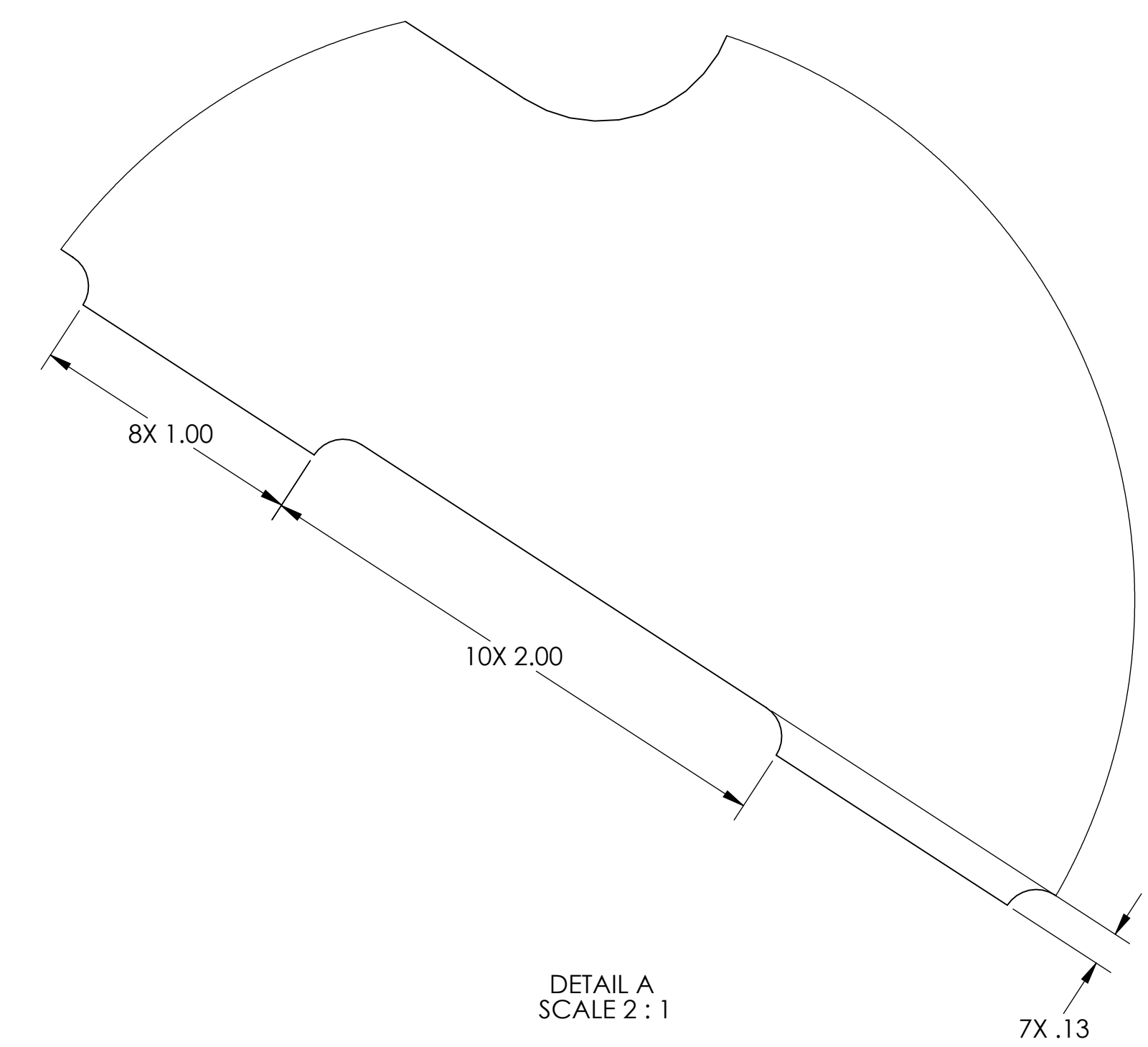
REV.	DATE	DCN #	DRAWING TREE #
v1	2 OCT 2010	E1000360	E1000085-v1
v2	12 MAY 2011	E1000360-v2	E1000090-v1
v3	4 OCT 2011	E1000360-v3	E1000091-v1



FOR QUOTE ONLY



GENERAL VIEW FOR REFERENCE ONLY NO SCALE



DETAIL A SCALE 2:1

THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE NEXT ASSEMBLY FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDING.

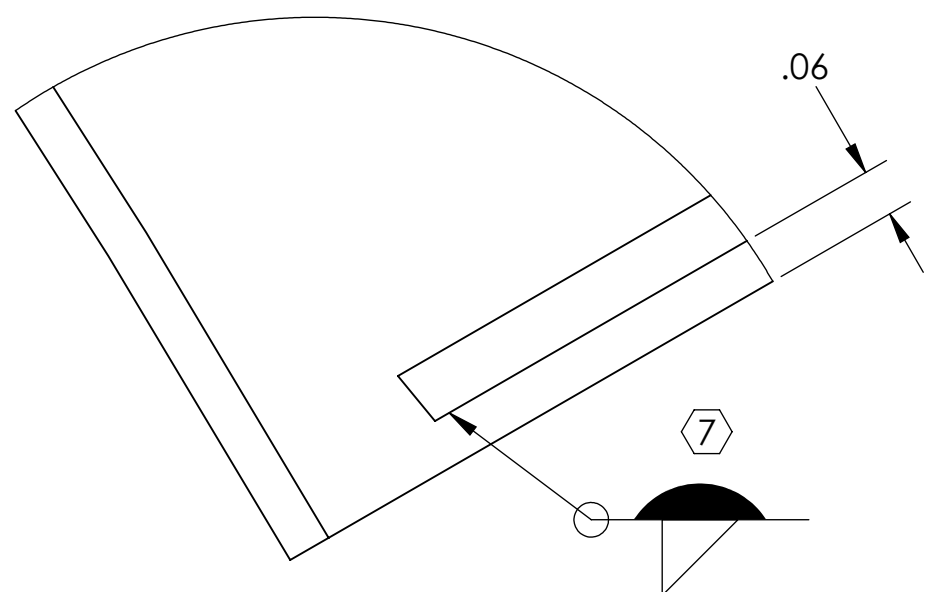
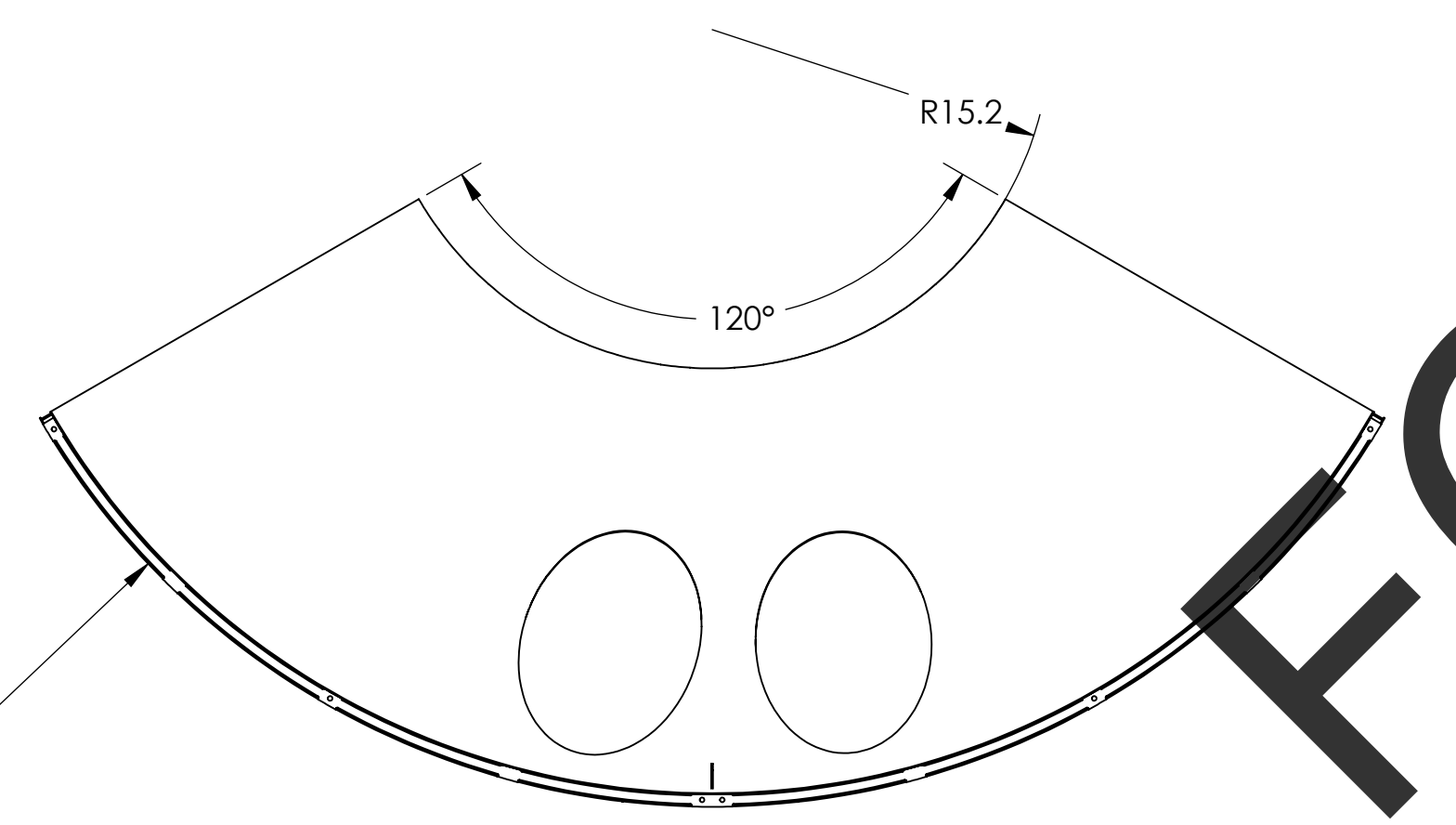
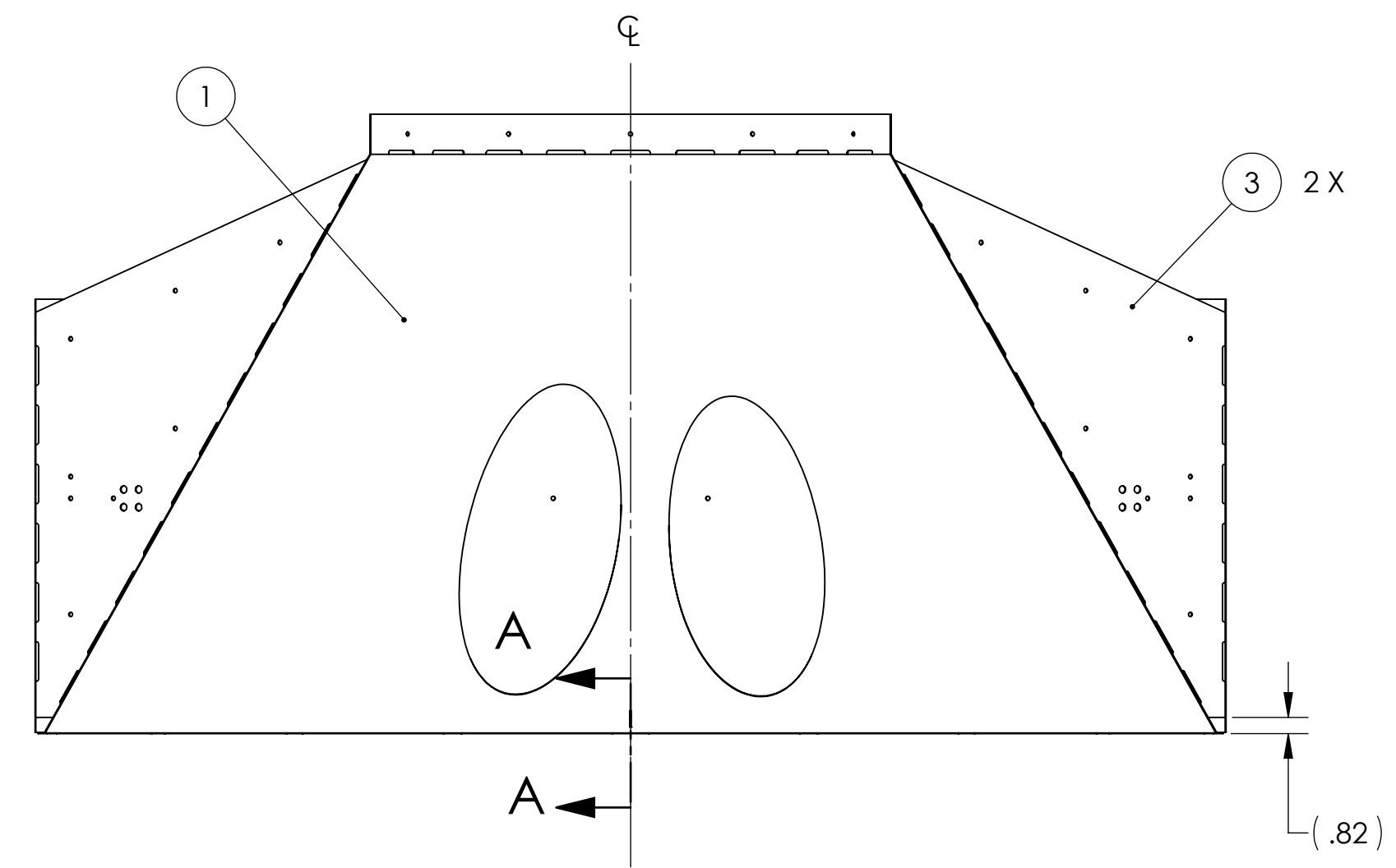
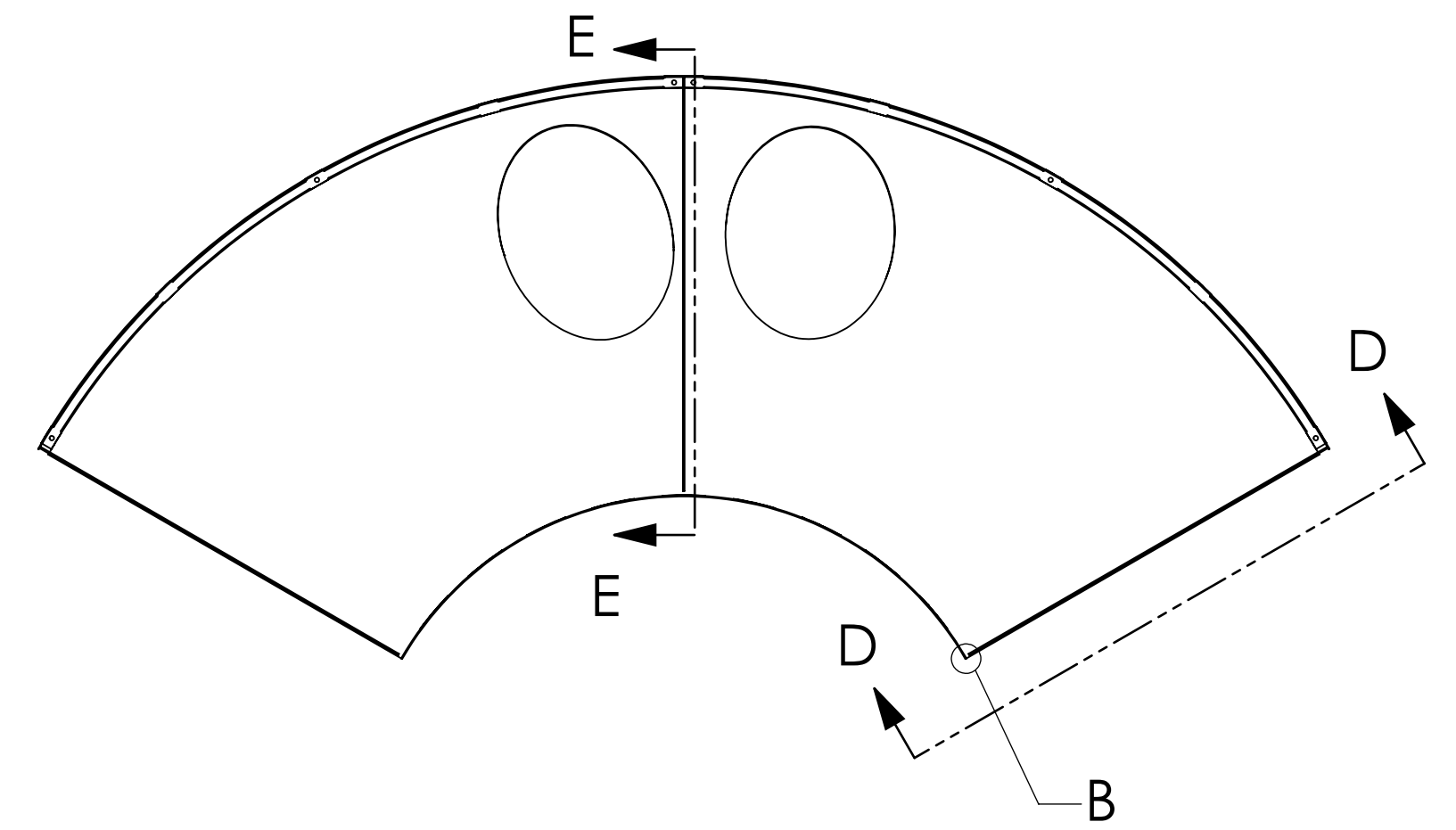
NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)		LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME			
DIMENSIONS ARE IN INCHES		SYSTEM ADVANCED LIGO NEXT ASSY VARIOUS		SUB-SYSTEM AOS		MANIFOLD CRYO BAFFLE WELDMENT BRACE	
TOLERANCES: .XX ± .06 .XXX ± .010 ANGULAR ± 1.0°						DESIGNER H. KELMAN 27 OCT 2010	SIZE D
MATERIAL 14 GAUGE 304 SSSL		FINISH 8		DRAFTER TQ. NGUYEN 2 OCT 2010	SCALE: 1:2		PROJECTION:
				CHECKER M. SMITH 27 SEP 2011	SHEET 1 OF 1		
				APPROVAL D. COYNE			

D1002849.dwg; Manifold\_Cryo\_Baffle\_Weldment\_Brace; PART PDM REV: X-024; DRAWING PDM REV: X-016

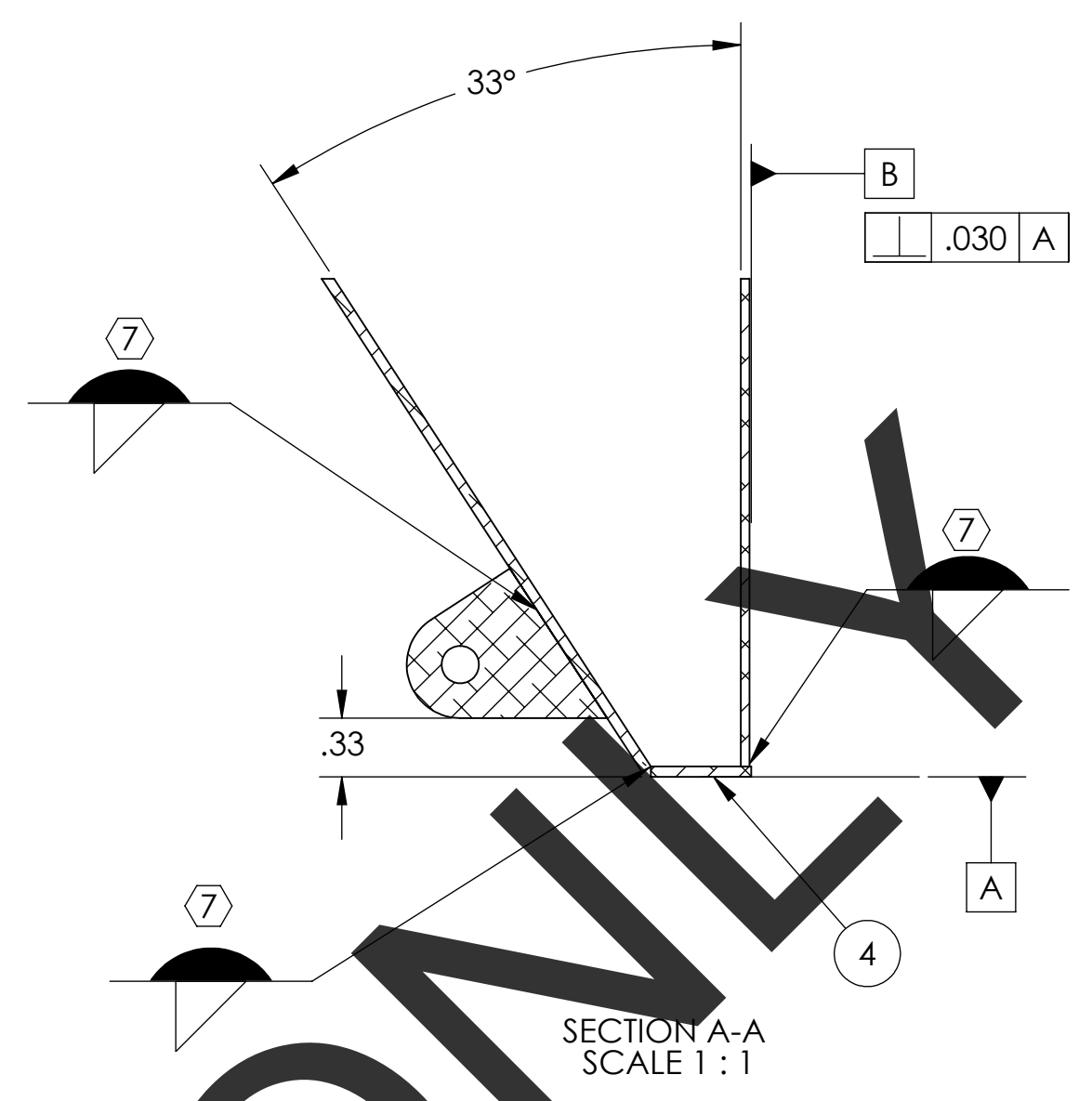
NOTES CONTINUED:  
 ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS.  
 EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX  
 DO NOT APPLY MARK ON SUPER #8 SIDE

6. ASSEMBLY TO BE OXIDIZED AFTER WELDMENT IS COMPLETED PER SPECIFICATION E1100842.

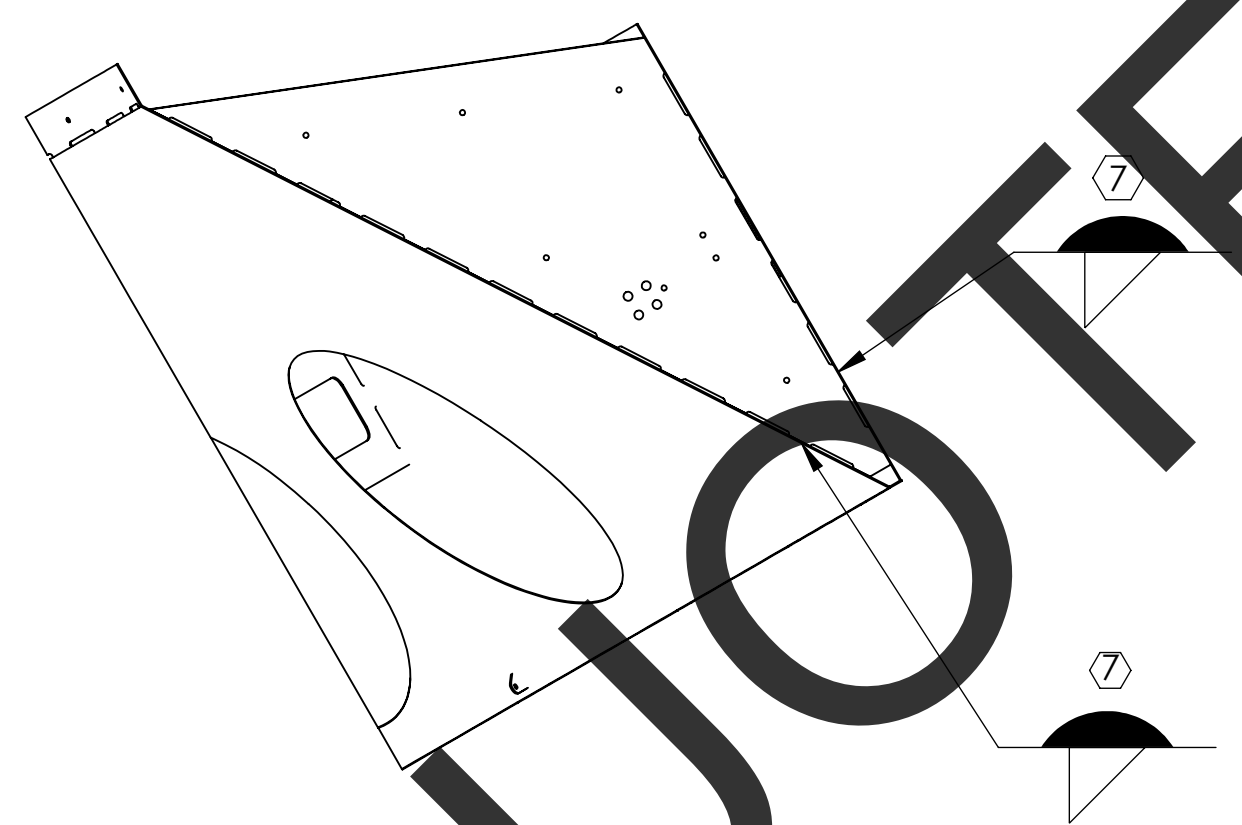
⑦ FILLET WELDS WHERE ITEMS ① & ③, ① & ⑤, ② & ③, ① & ④ MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048



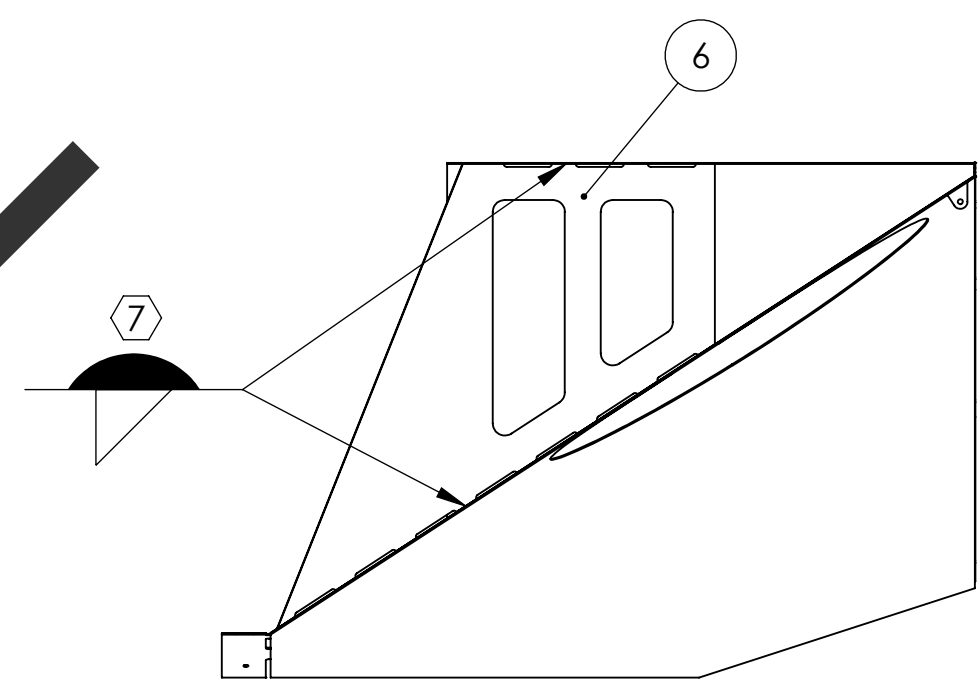
DETAIL B  
SCALE 4 : 1



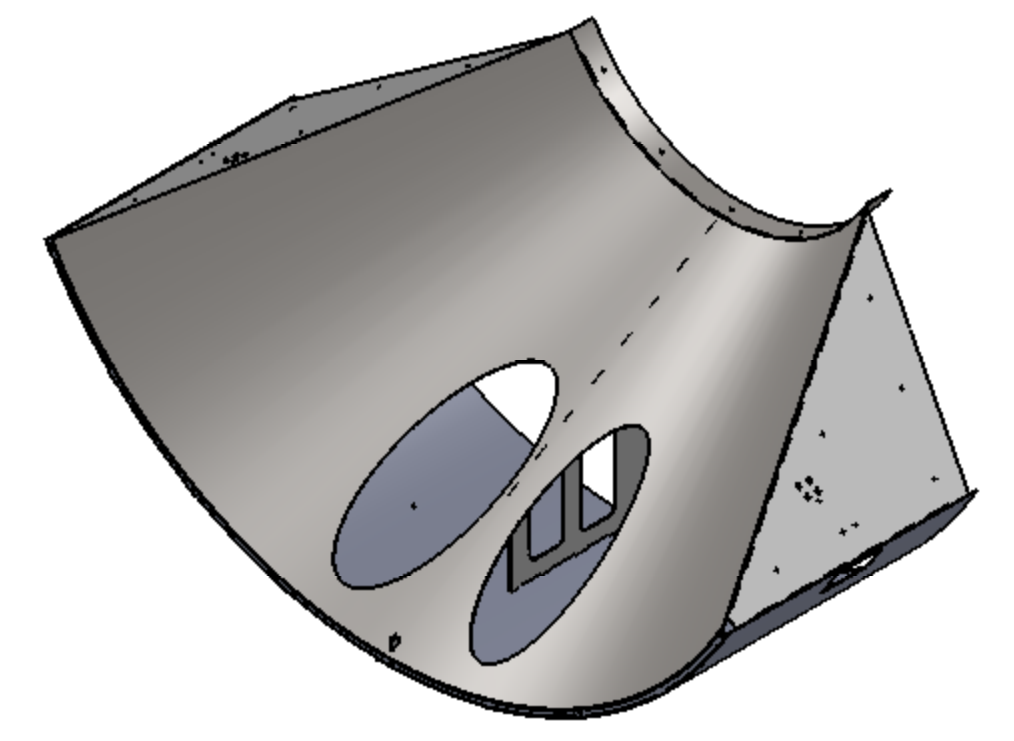
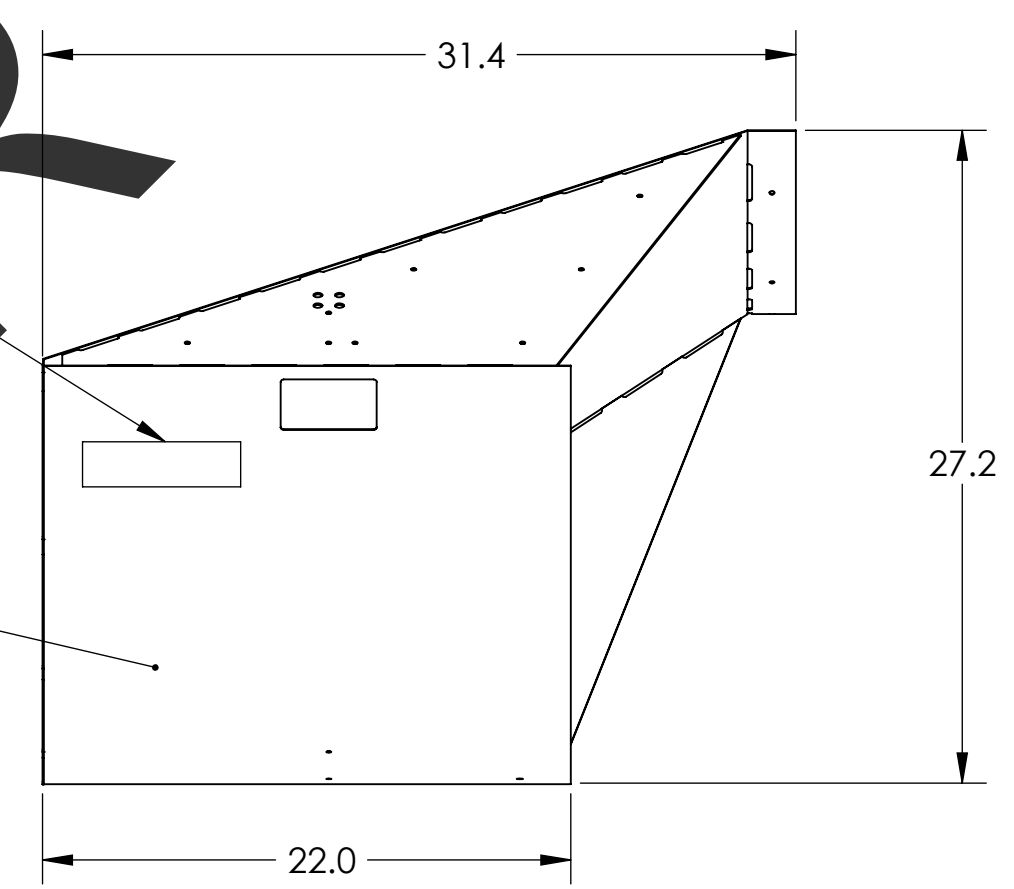
SECTION A-A  
SCALE 1 : 1



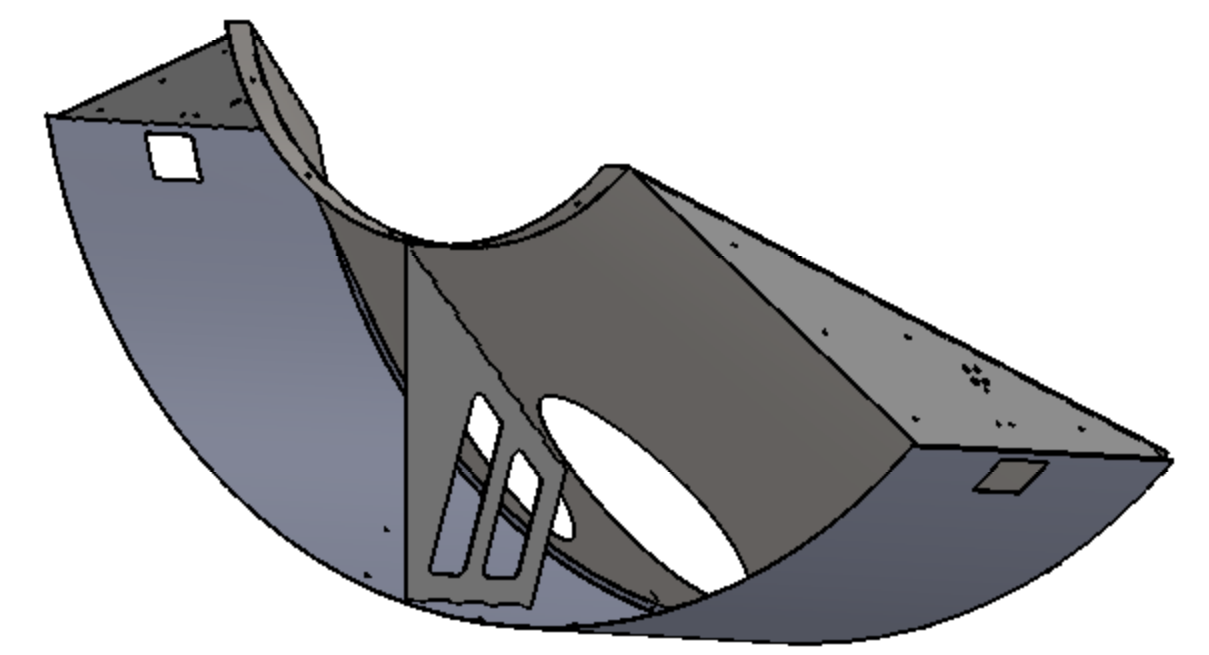
SECTION D-D



SECTION E-E



GENERAL VIEW  
FOR REFERENCE ONLY  
NO SCALE



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ	SPARE	TOTAL
6	D1002849	MANIFOLD CRYO BAFFLE WELDMENT BRACE	14 GAUGE 304 SSSL	1		1
5	D1000536	BAFFLE BRACE BRACKET	14 GAUGE 304 SSSL	1		1
4	D1001073	RADIAL ATTACHMENT NUT PLATE	14 GAUGE 304 SSSL	1		1
3	D0902621	MANIFOLD CRYO BAFFLE BRACKET	14 GAUGE 304 SSSL	2		2
2	D0902620	RADIAL SEGMENT, BOTTOM	18 GAUGE 304 SSSL	1		1
1	D1003185	MANIFOLD-CRYO BAFFLE INNER SEGMENT, ETMX H1 BOTTOM	18 GAUGE 304 SSSL	1		1

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)  
 1. INTERPRET DRAWING PER ASME Y14.5-1994.  
 2. REMOVE ALL SHARP EDGES, .005-.015 ON ALL EDGES AND HOLES.  
 3. DO NOT SCALE FROM DRAWING.  
 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

DIMENSIONS ARE IN INCHES  
 TOLERANCES:  
 .X ± .1  
 .XX ± .06  
 .XXX ± .010  
 ANGULAR ± 1.0°

MATERIAL: A424 TYPE I STEEL  
 FINISH: N/A

**LIGO** CALIFORNIA INSTITUTE OF TECHNOLOGY  
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO  
 SUB-SYSTEM: AOS  
 NEXT ASSY: D1003183

PART NAME: MANIFOLD -CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMX H1, BOTTOM

DESIGNER: H. KELMAN 17 MAR 2010  
 DRAFTER: TQ. NGUYEN 3 SEP 2010  
 CHECKER: M. SMITH  
 APPROVAL: D. COYNE

SIZE: D  
 DWG. NO.: D1003184  
 REV.: v2

SCALE: 1:8  
 PROJECTION:

SHEET 1 OF 1

D1003184.dwg\_Monolithic\_Cryo\_Baffle\_Segment\_Subassembly\_Weldment - PART PDM REV-X-017, DRAWING PDM REV. X-003

NOTES CONTINUED:  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR TYPE IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE

6. CONE AND LIP TO BE WELDED WHERE PIECES MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048.

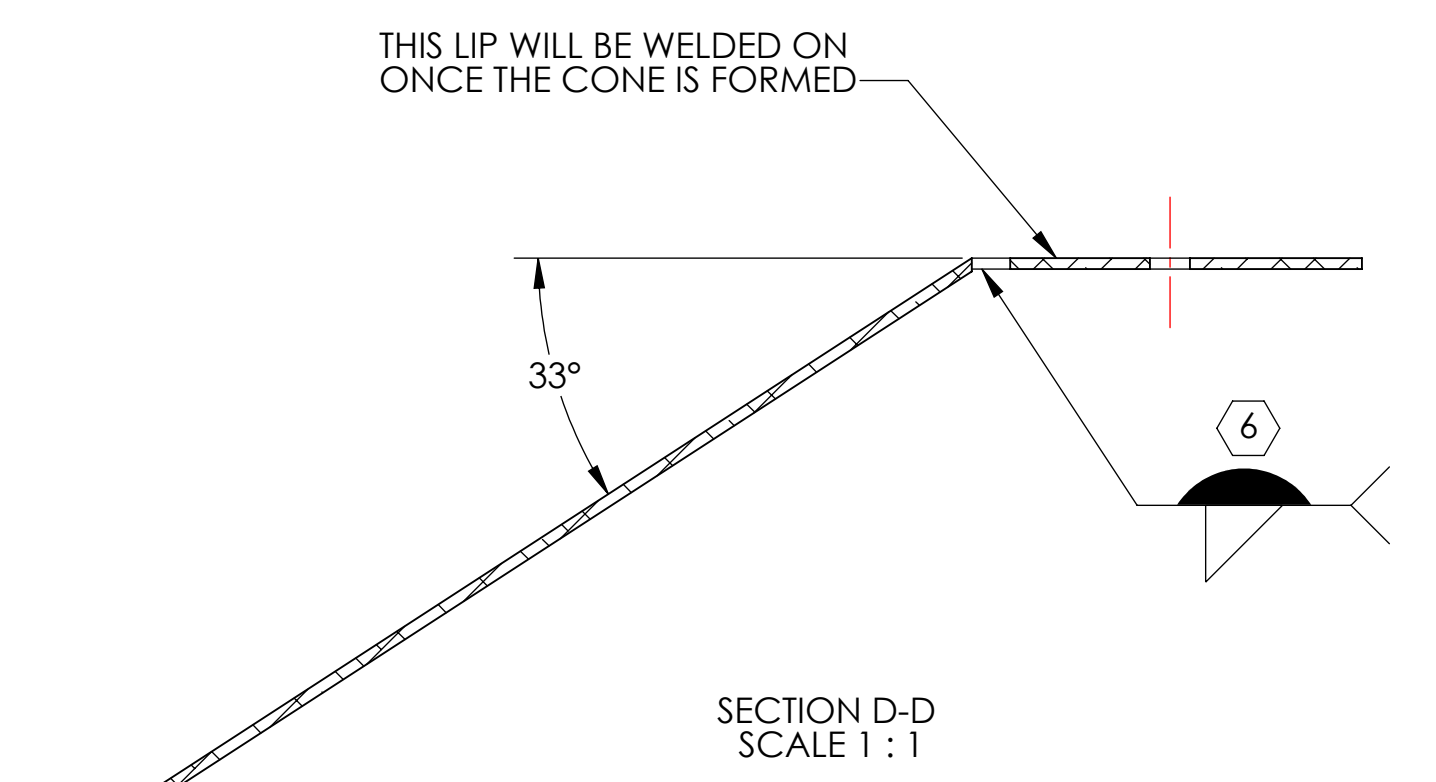
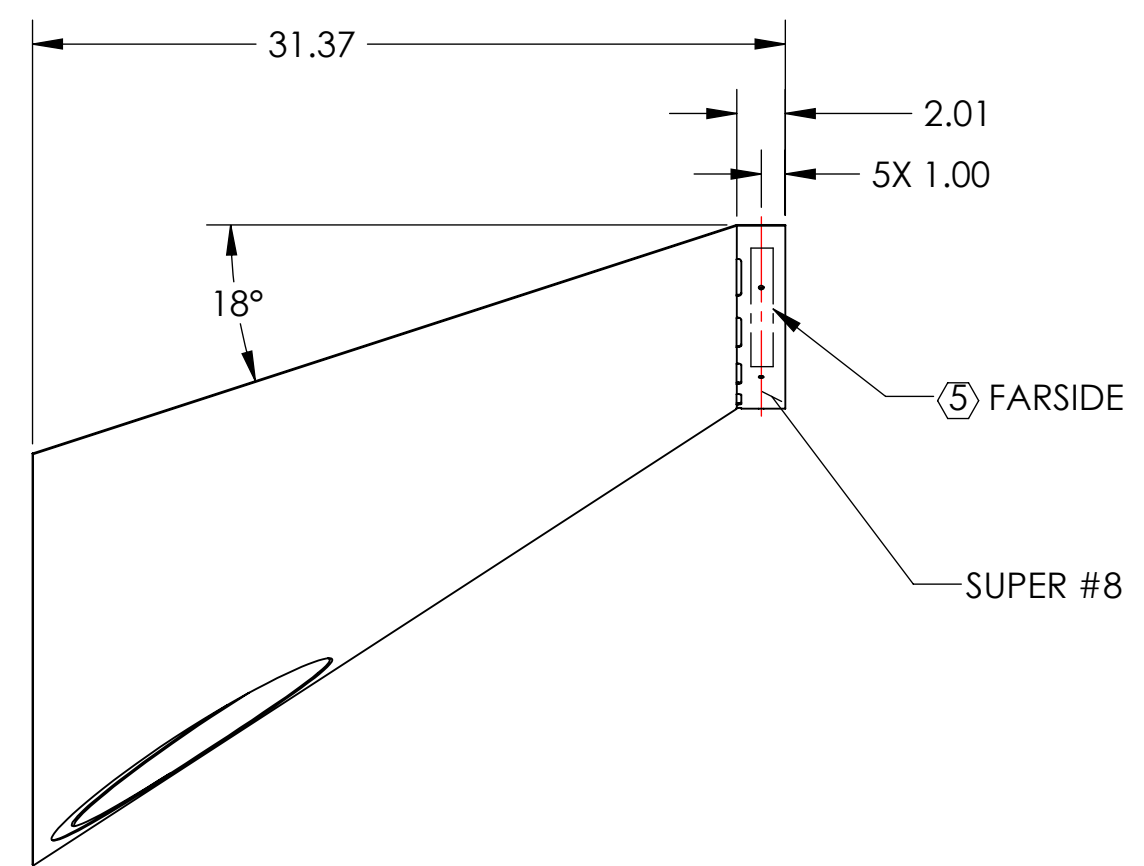
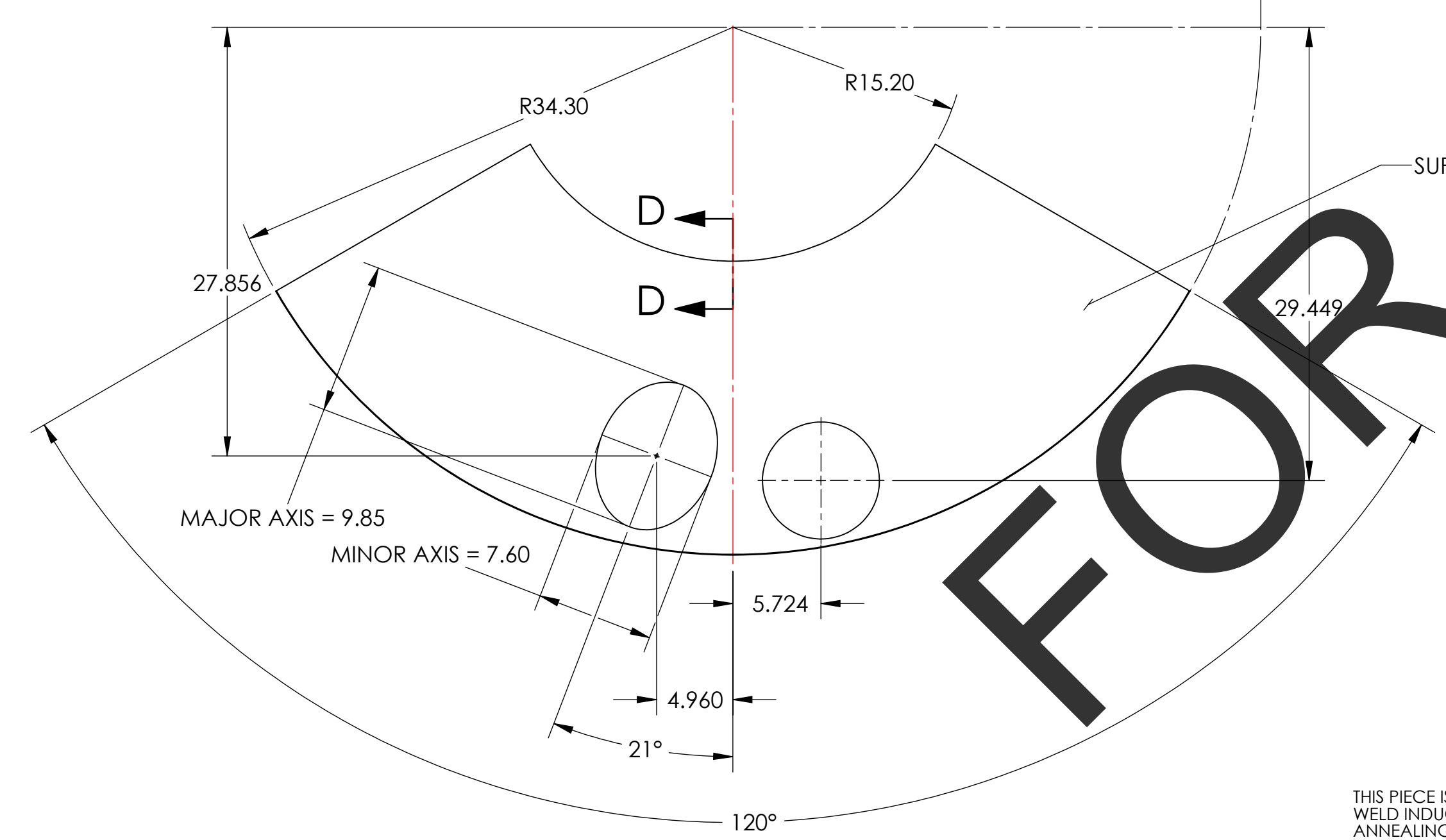
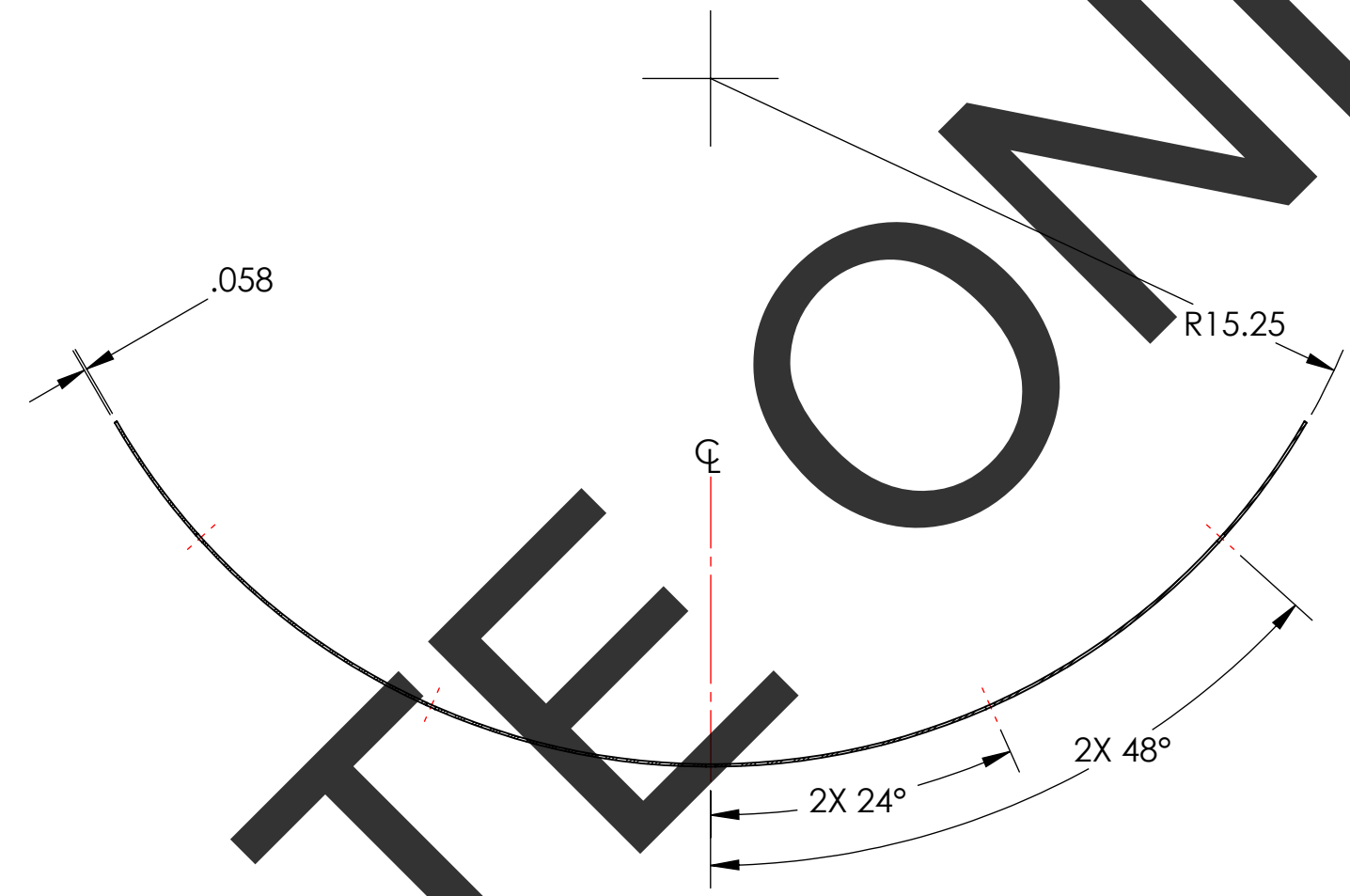
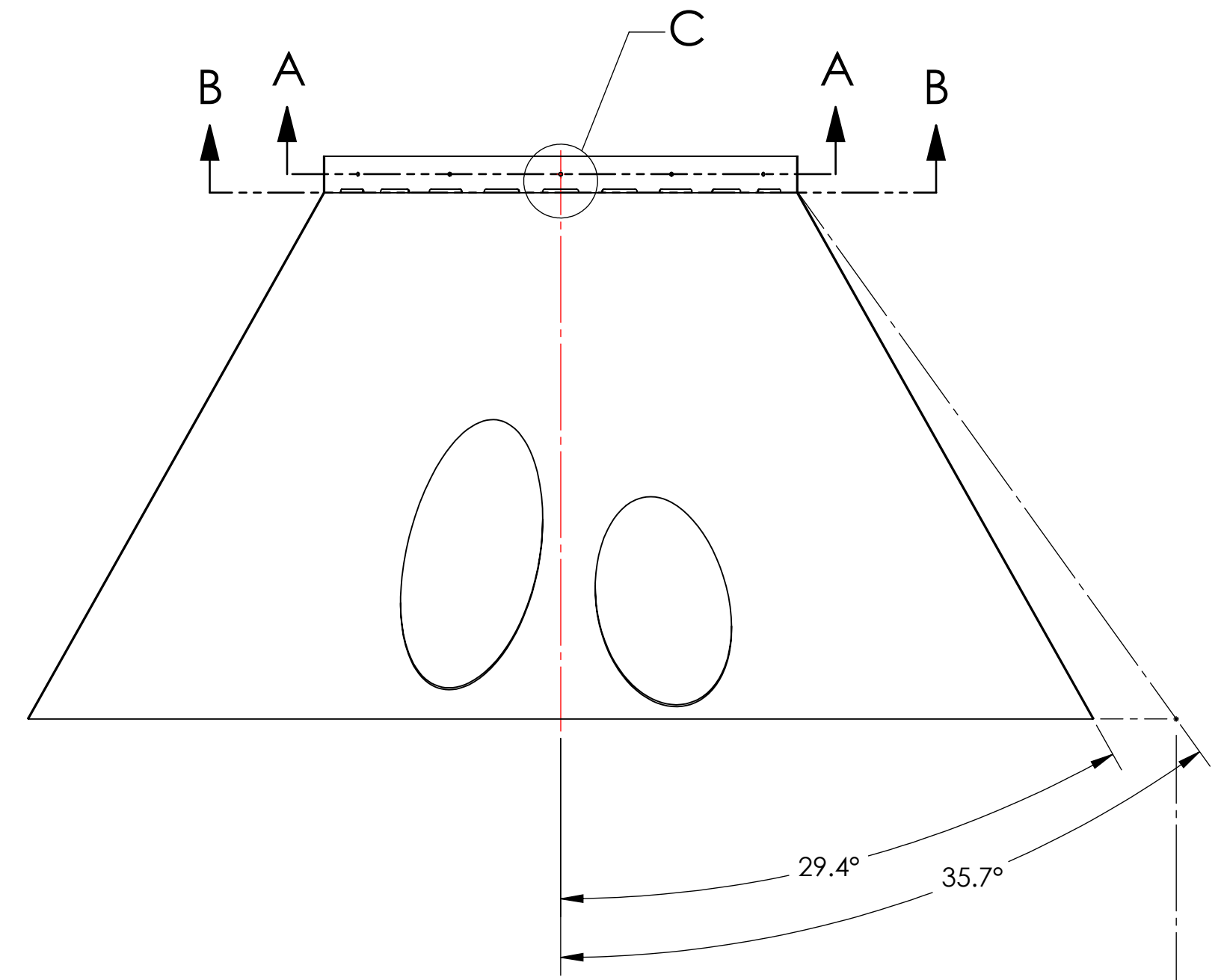
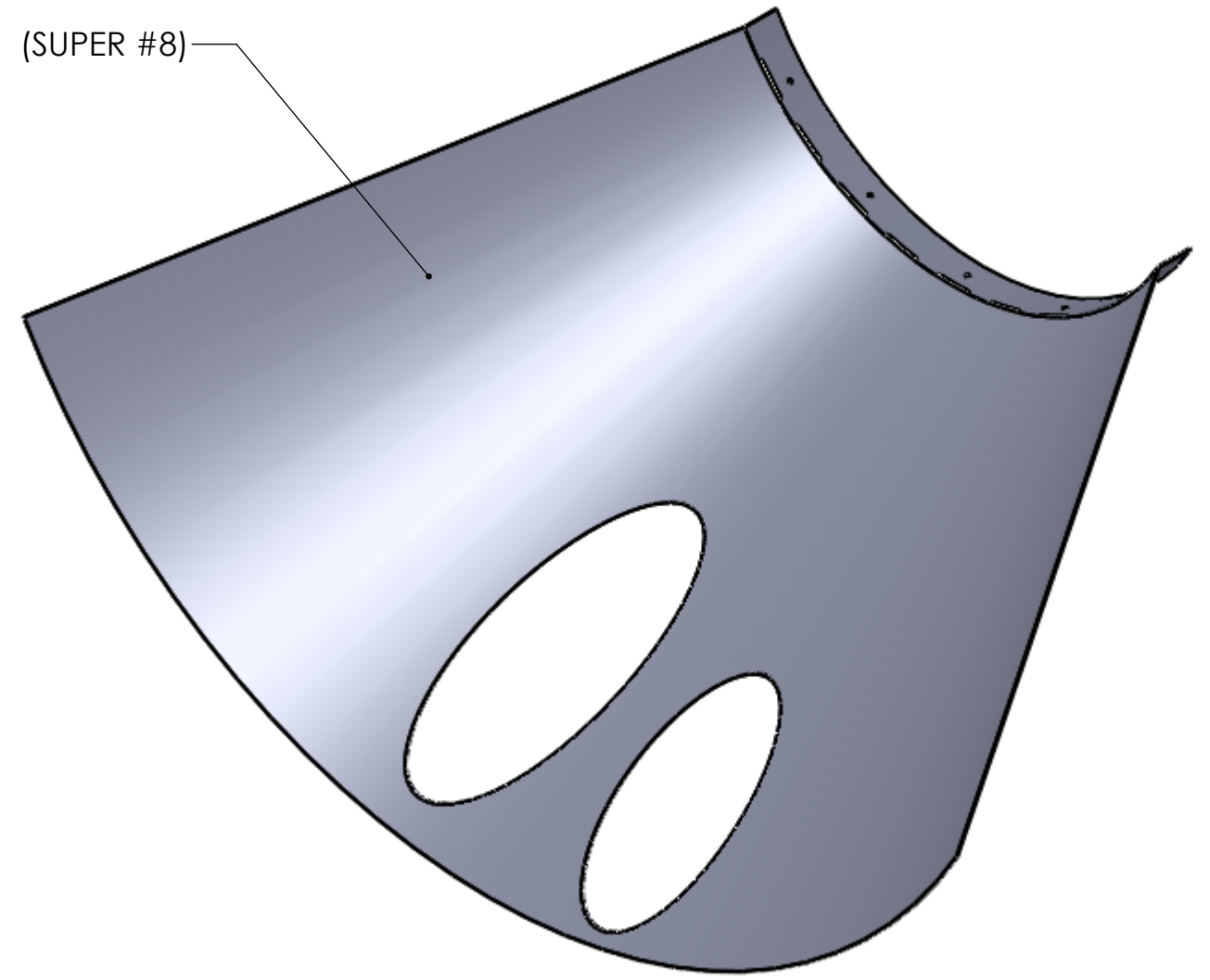
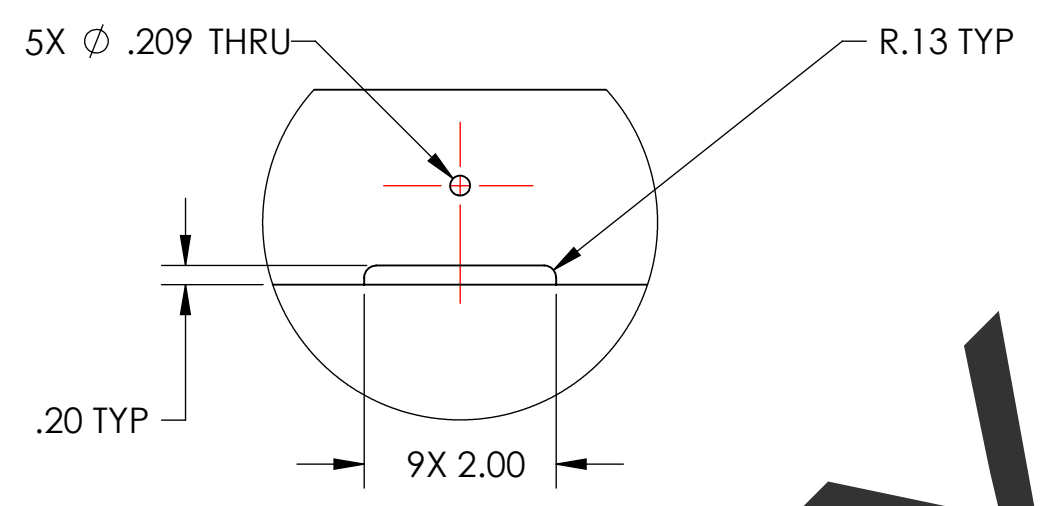
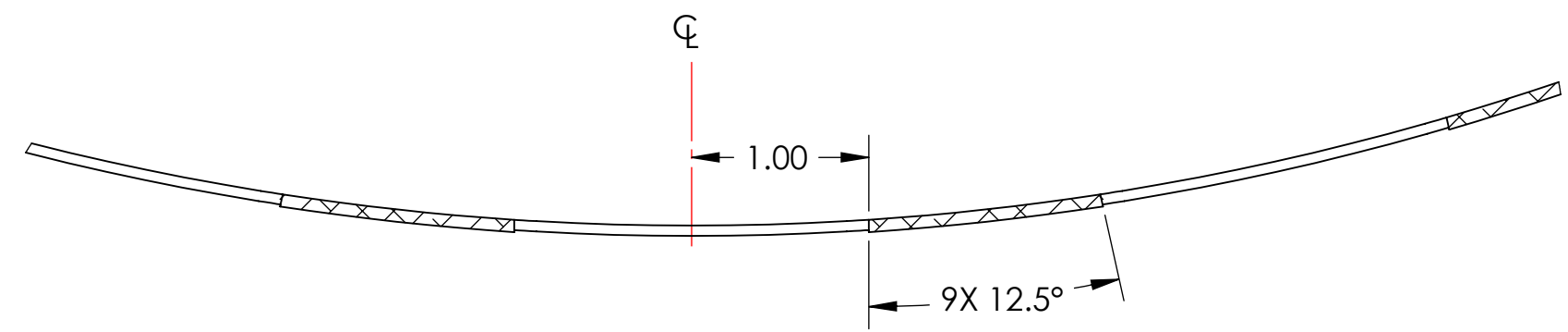
7. DELETED

8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

9. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

10. SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

REV.	DATE	DCN #	DRAWING TREE #
v1	28 JUL 2011	E1000360-v2	-
v2	20 OCT 2011	E1000360-v3	-
v3	31 OCT 2012	-	-



10 PLS

FOR QUOTE ONLY

THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D0902655 FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.

DIMENSIONS ARE IN INCHES		NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
TOLERANCES: .XX ± .06 .XXX ± .010		1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015 ON ALL EDGES AND HOLES. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.	
MATERIAL	FINISH	NEXT ASSY	SYSTEM
18 GAUGE 304 SSTL	10 SUPER #8	D1003184	ADVANCED LIGO AOS
ANGULAR ± 0.1°			

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
DESIGNER	TQ. NGUYEN 6 DEC 2010
DRAFTER	TQ. NGUYEN 6 DEC 2010
CHECKER	M. SMITH 27 JAN 2012
APPROVAL	D. COYNE 27 JAN 2012

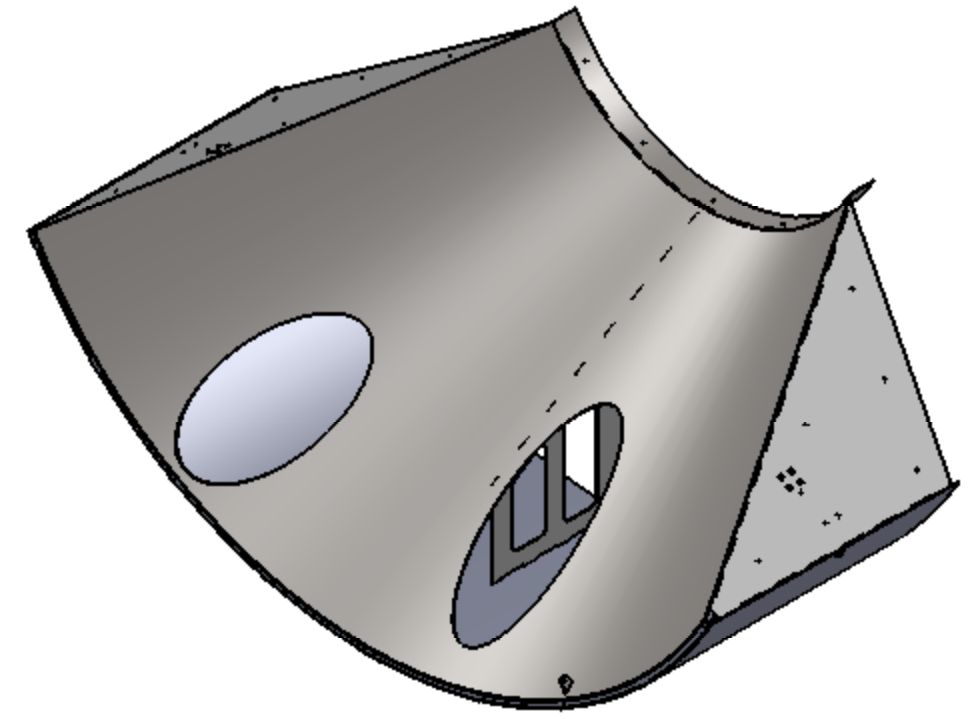
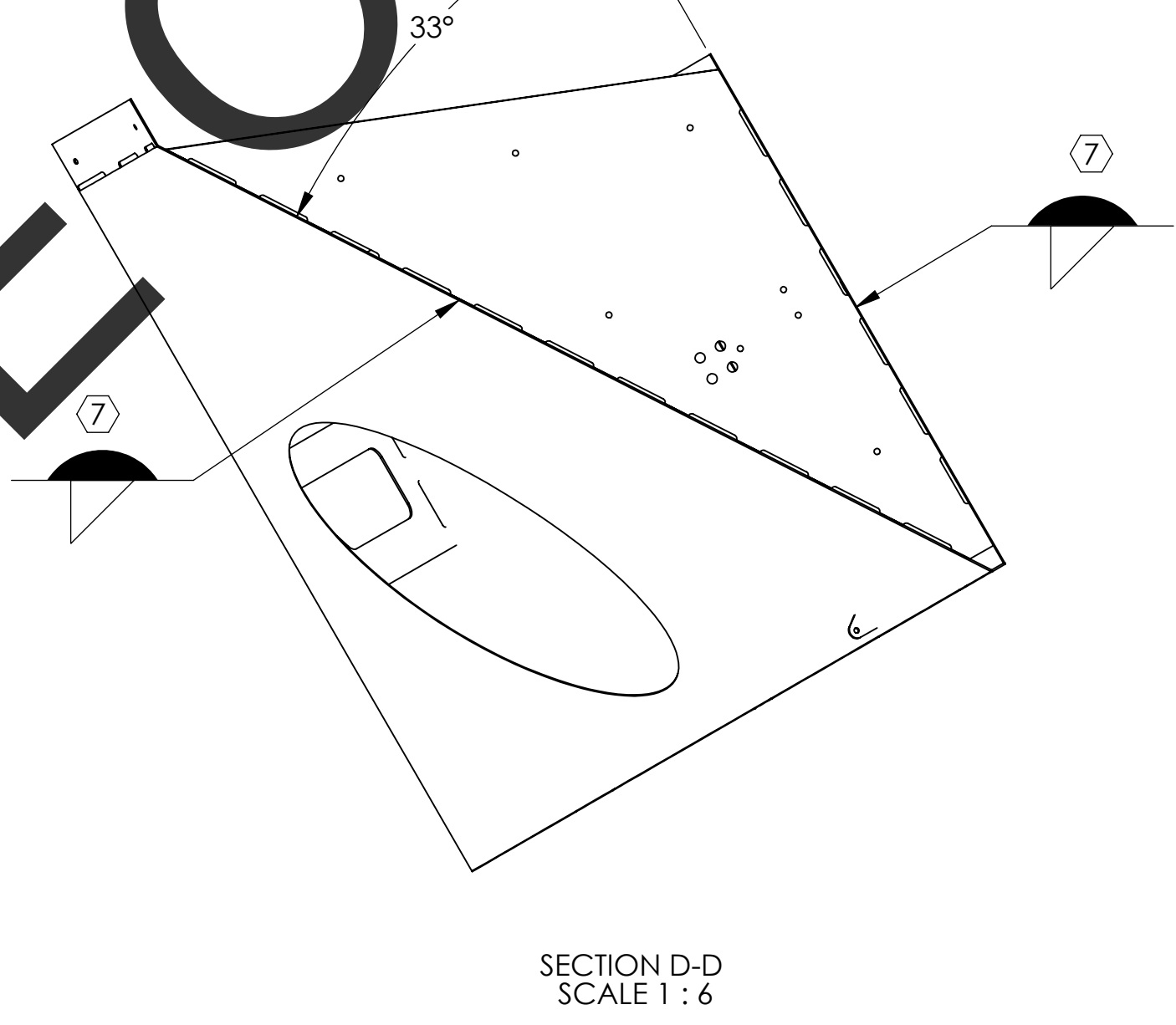
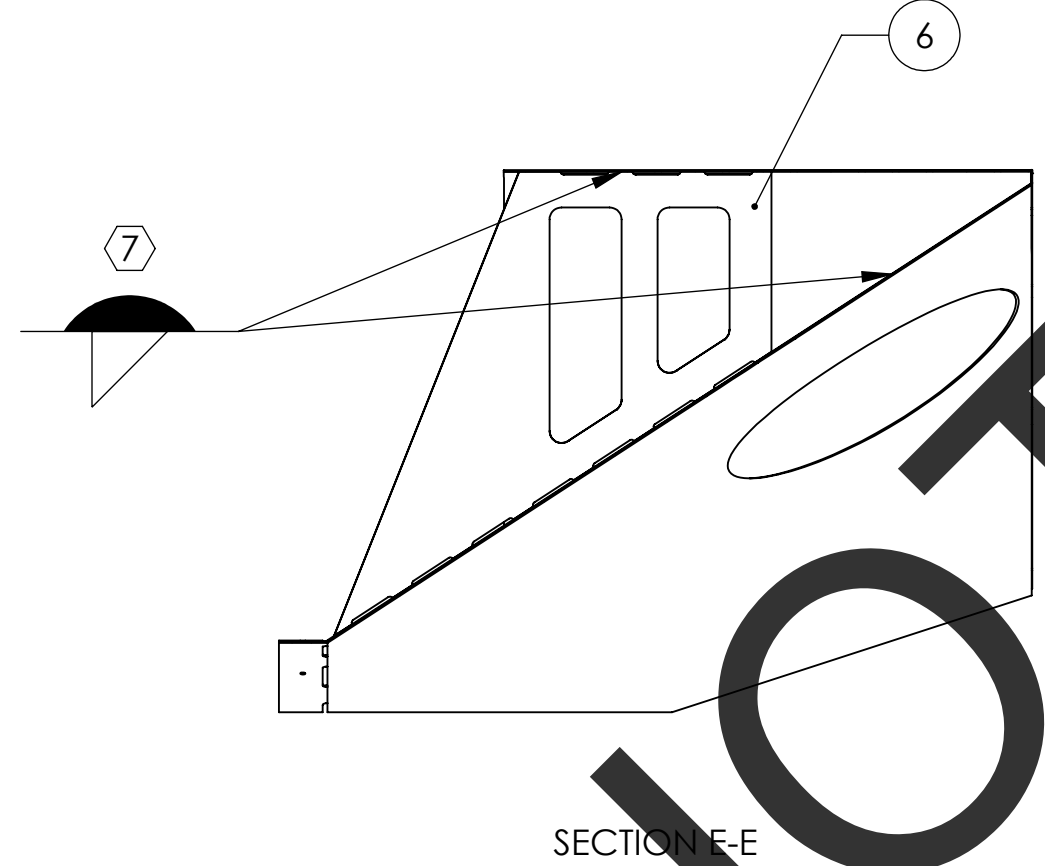
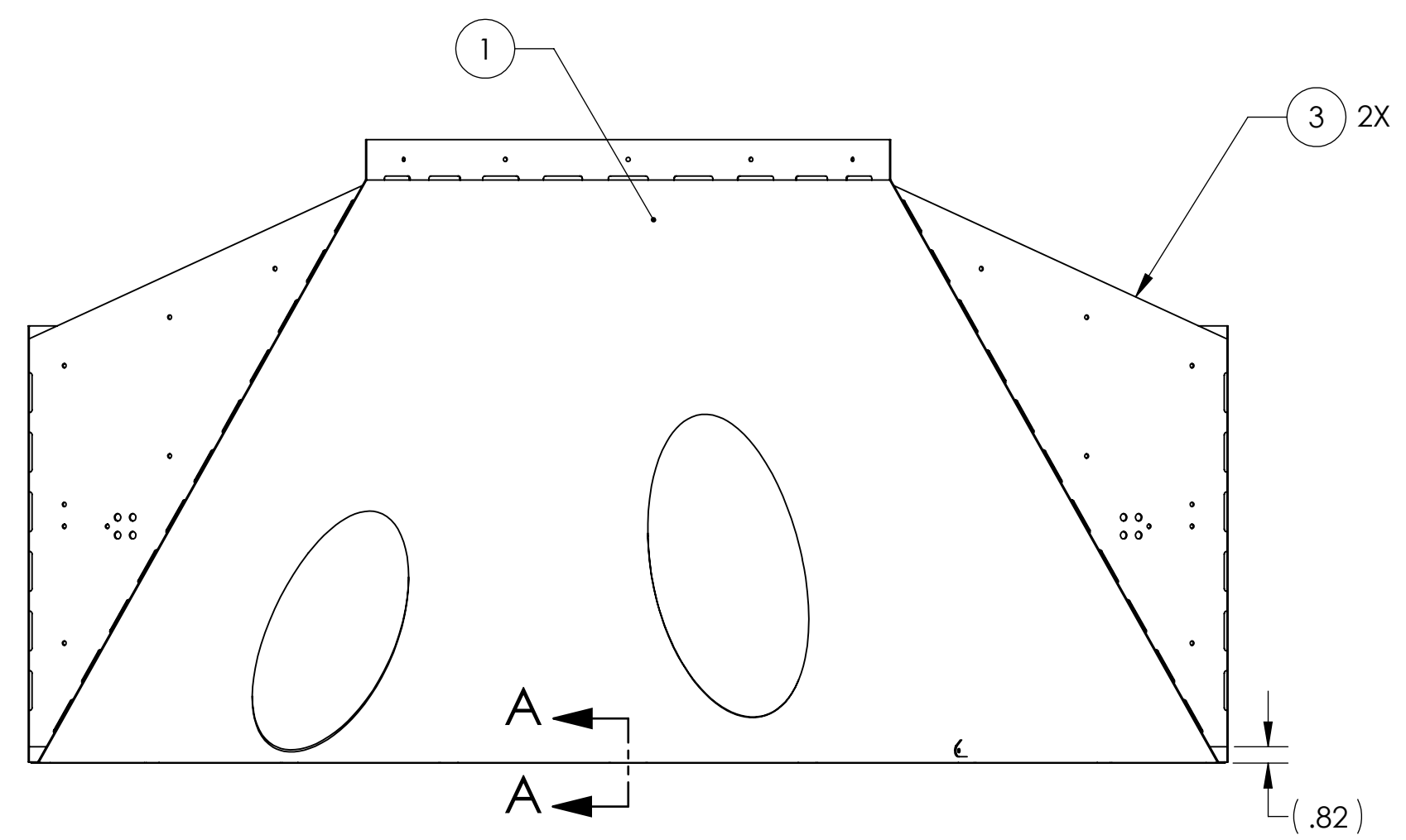
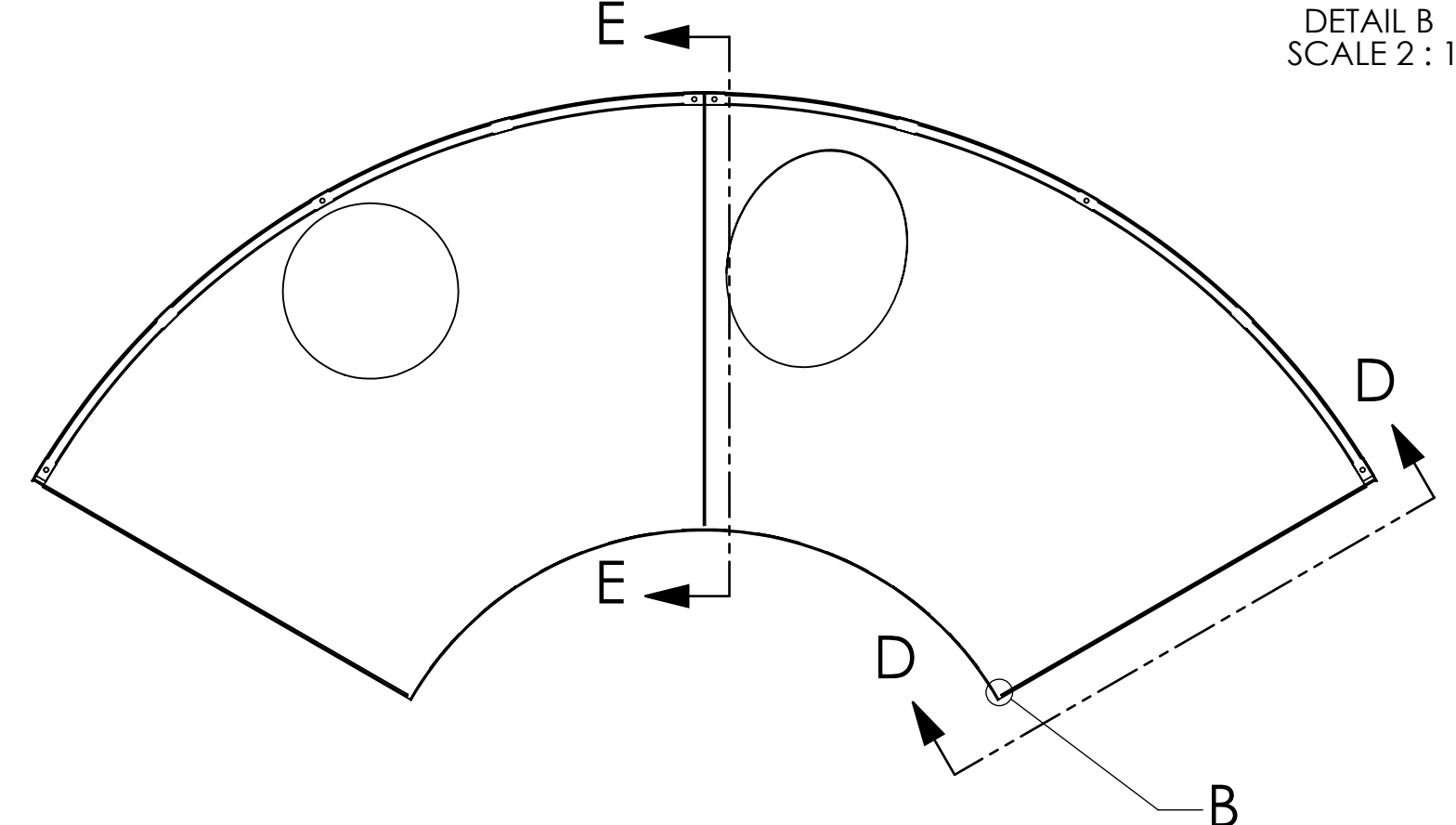
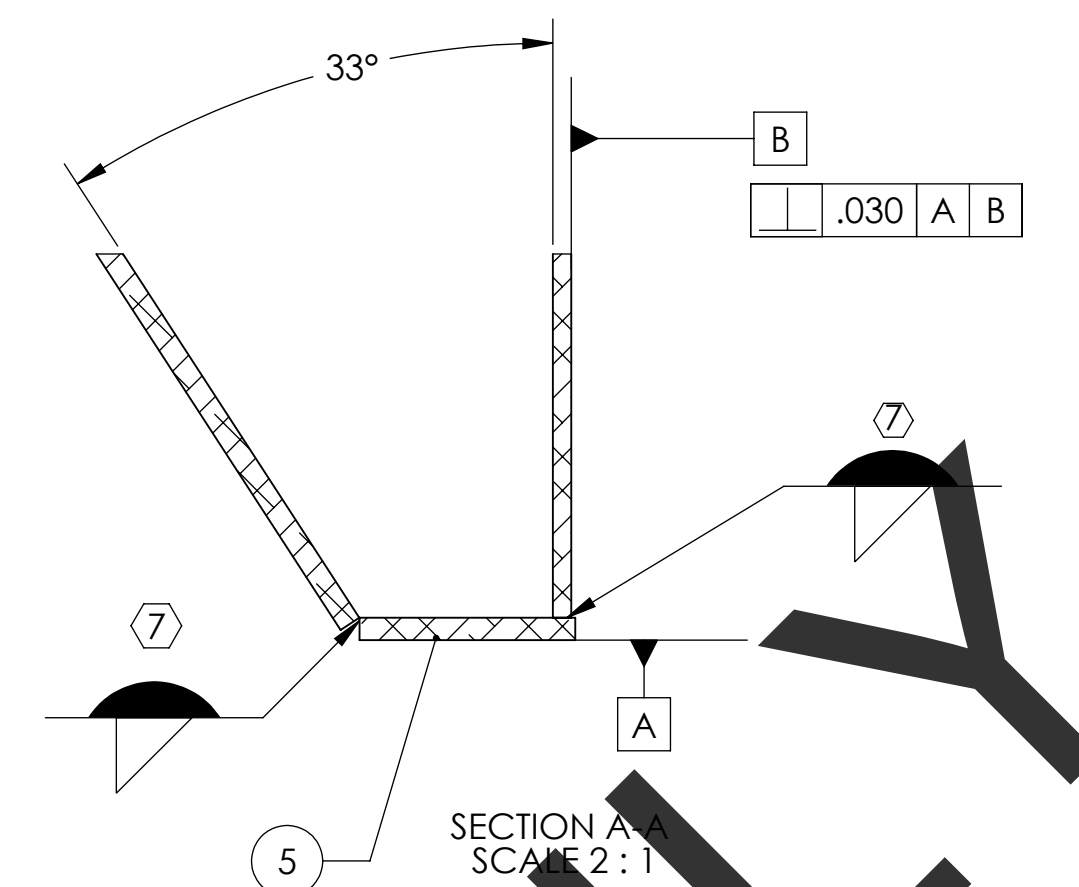
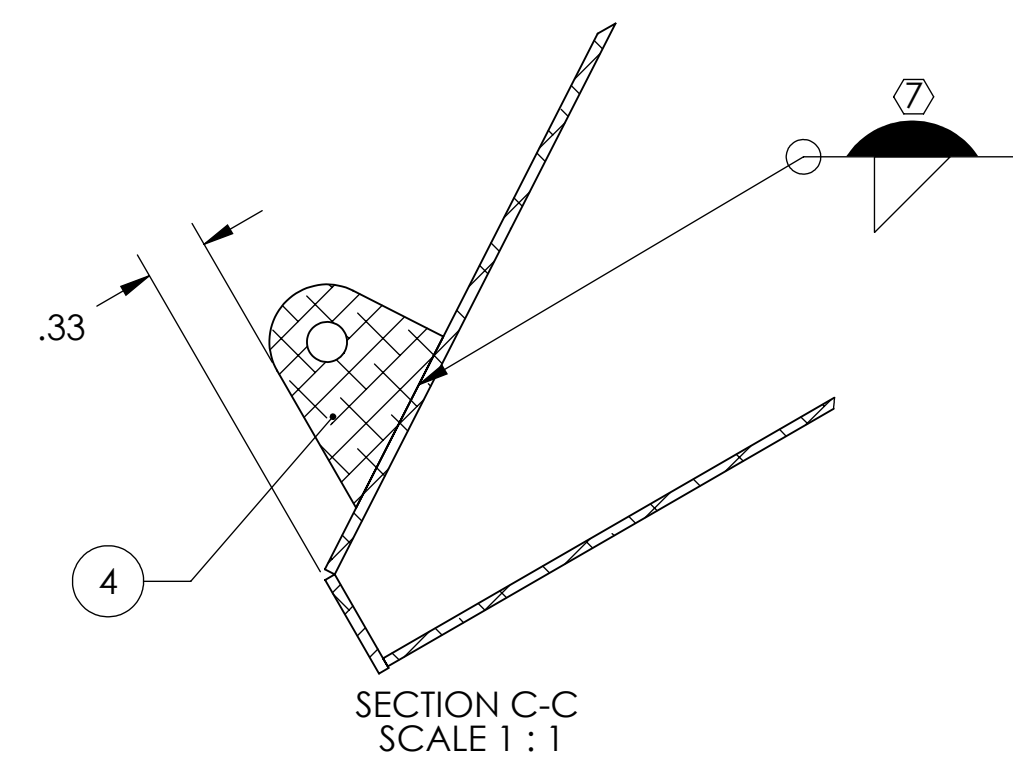
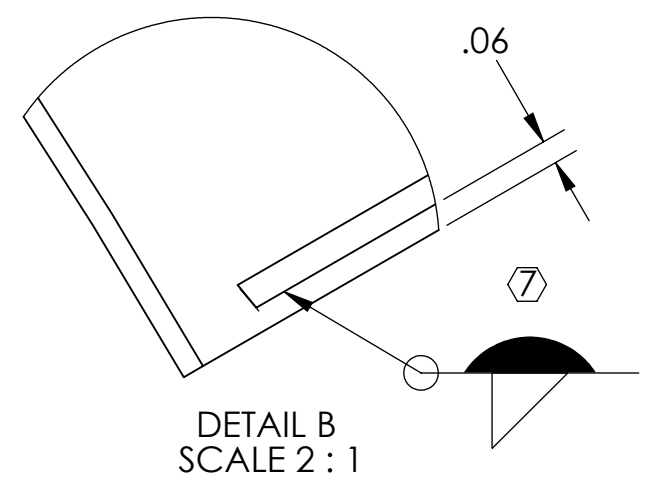
PART NAME		MANIFOLD-CRYO BAFFLE INNER SEGMENT, ETMX H1 BOTTOM	
DESIGNER	TQ. NGUYEN 6 DEC 2010	SIZE	DWG. NO.
DRAFTER	TQ. NGUYEN 6 DEC 2010	D	D1003185
CHECKER	M. SMITH 27 JAN 2012	REV.	v3
APPROVAL	D. COYNE 27 JAN 2012	SCALE:	1:8
PROJECTION:		SHEET 1 OF 1	

NOTES CONTINUED:  
 ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR TYPE IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXXX DO NOT APPLY MARK ON SUPER #8 SIDE

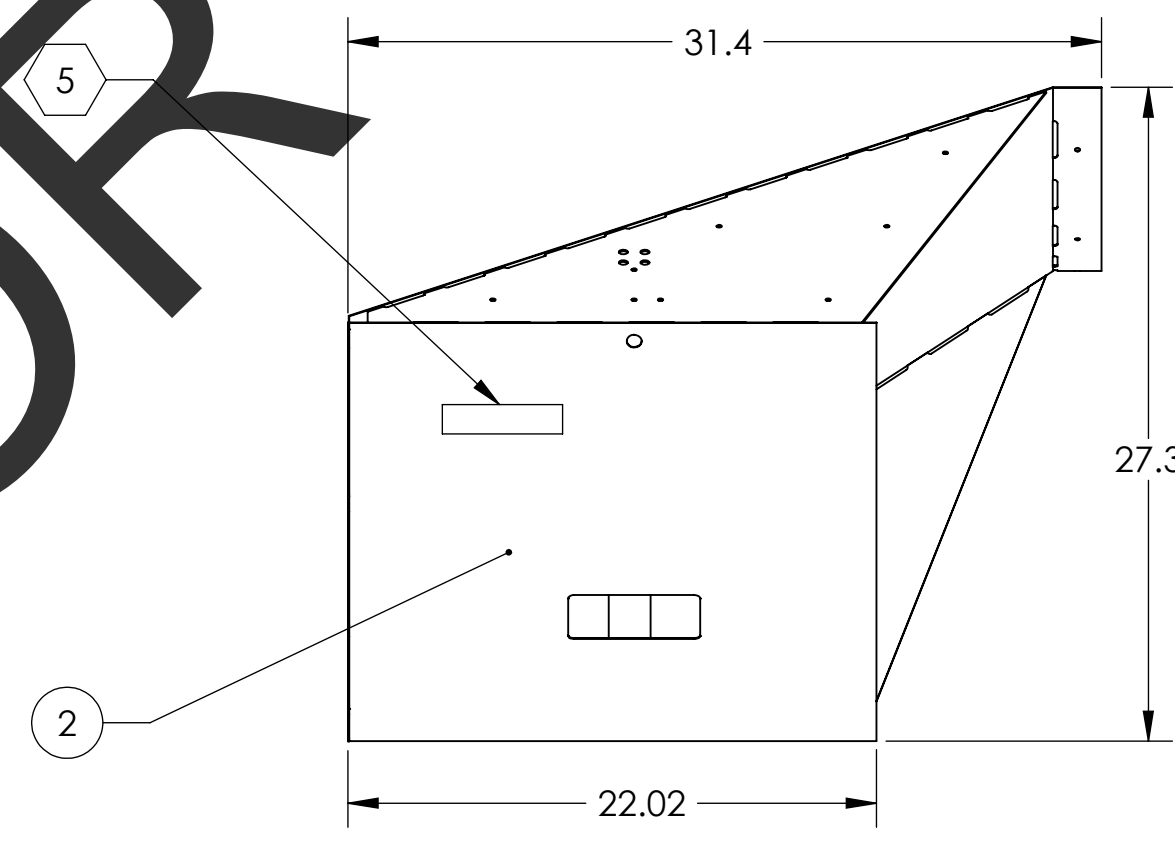
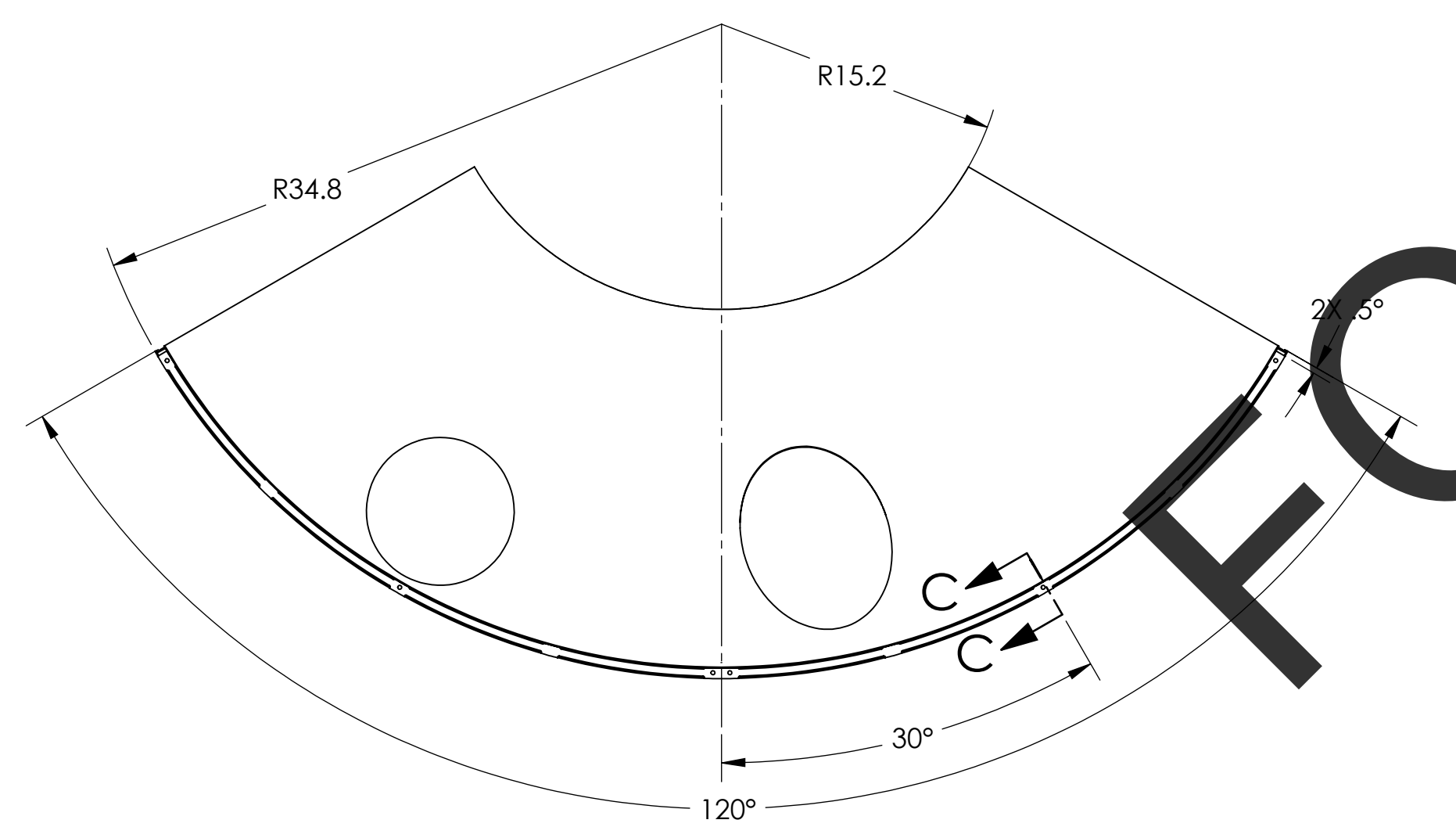
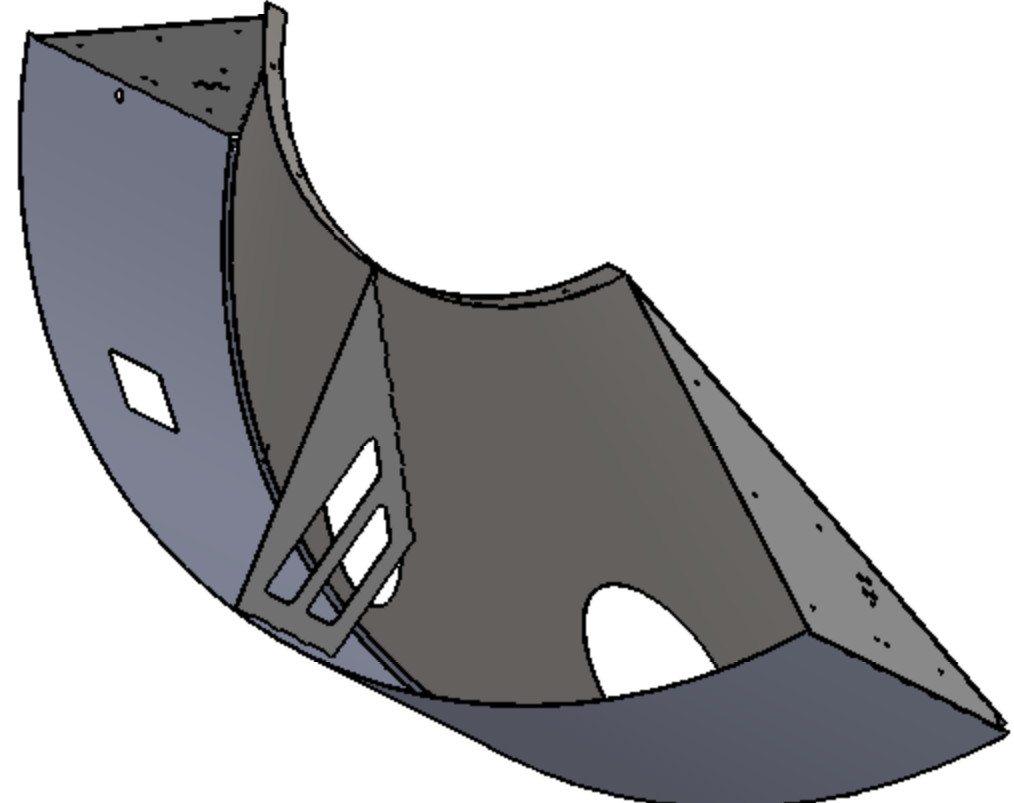
6. ASSEMBLY TO BE OXIDIZED AFTER WELDMENT IS COMPLETED PER SPECIFICATION E1100842.

⑦ FILLET WELDS WHERE ITEMS ① & ③, ① & ⑤, & ① & ④ MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048

REV.	DATE	DCN #	DRAWING TREE #
v1	1 OCT 2010	E1000360-v2	E1000091
v2	20 OCT 2010	E1000360-v3	



GENERAL VIEW FOR REFERENCE ONLY NO SCALE



FOR QUOTE ONLY

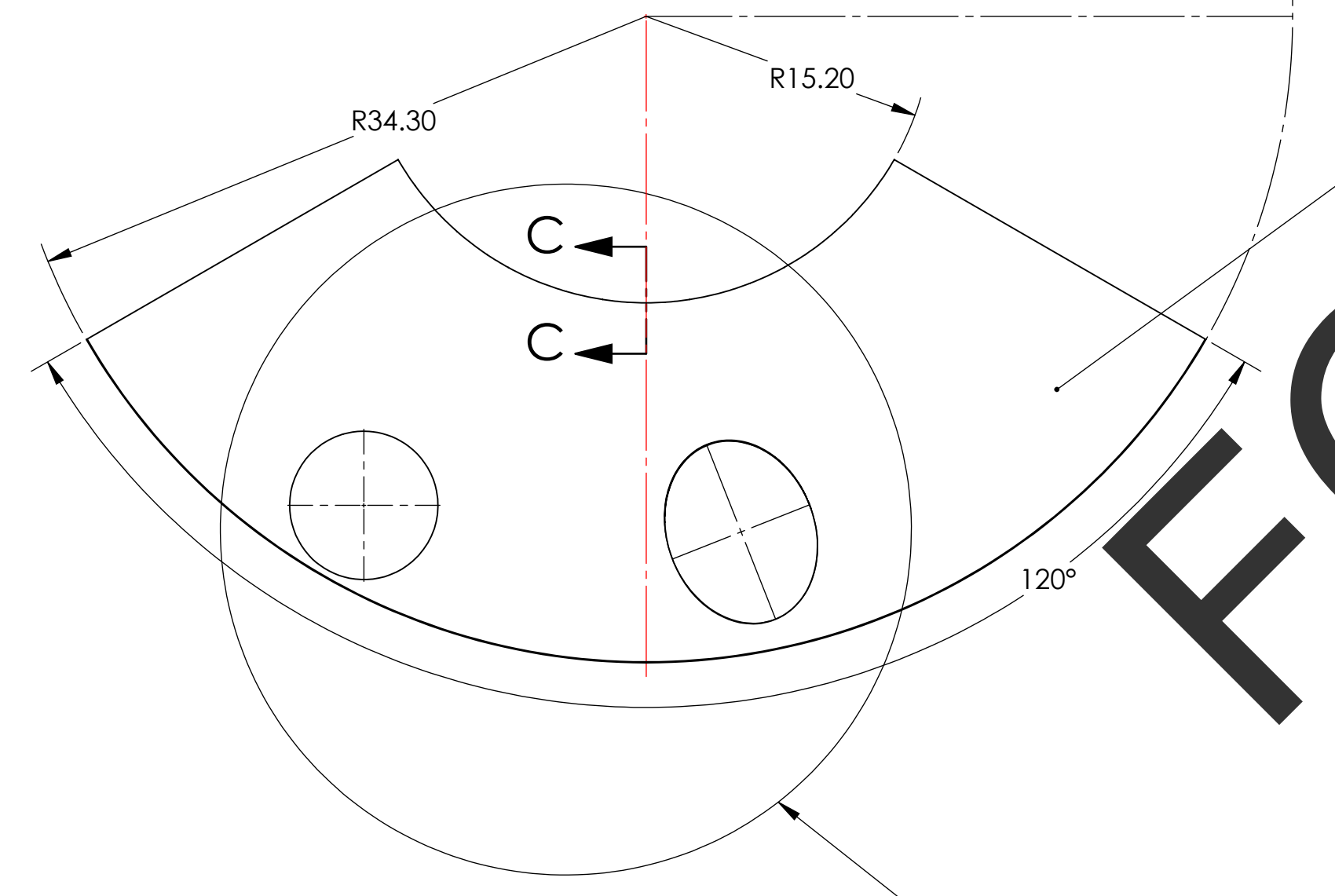
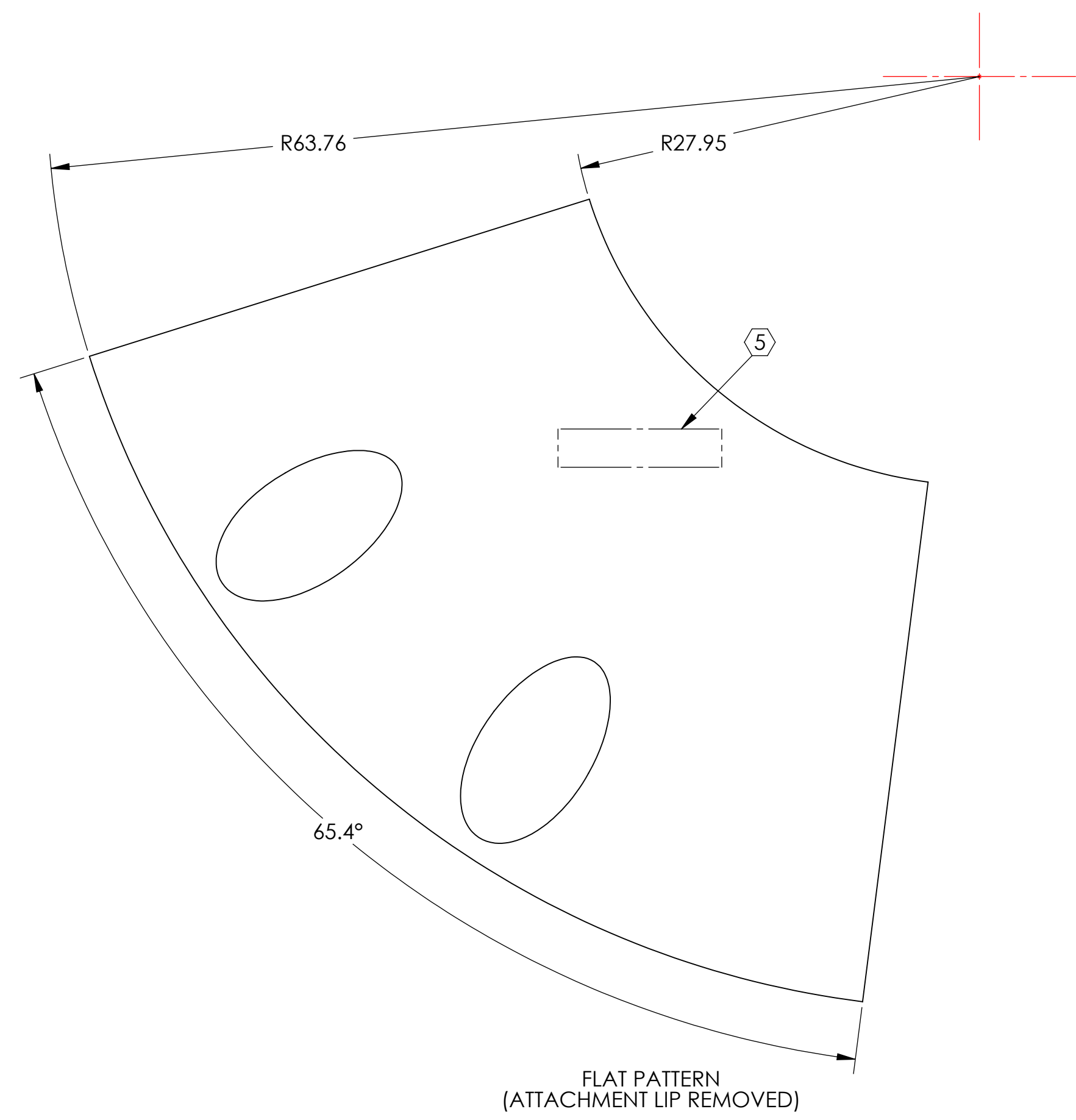
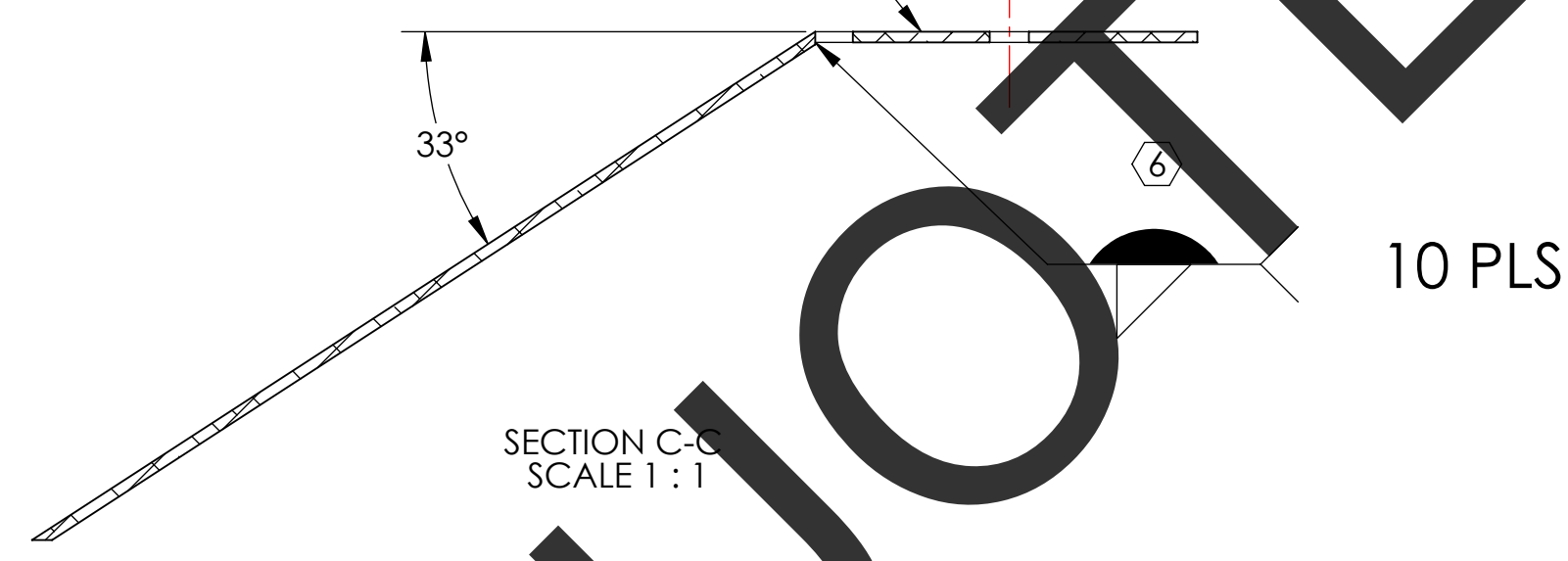
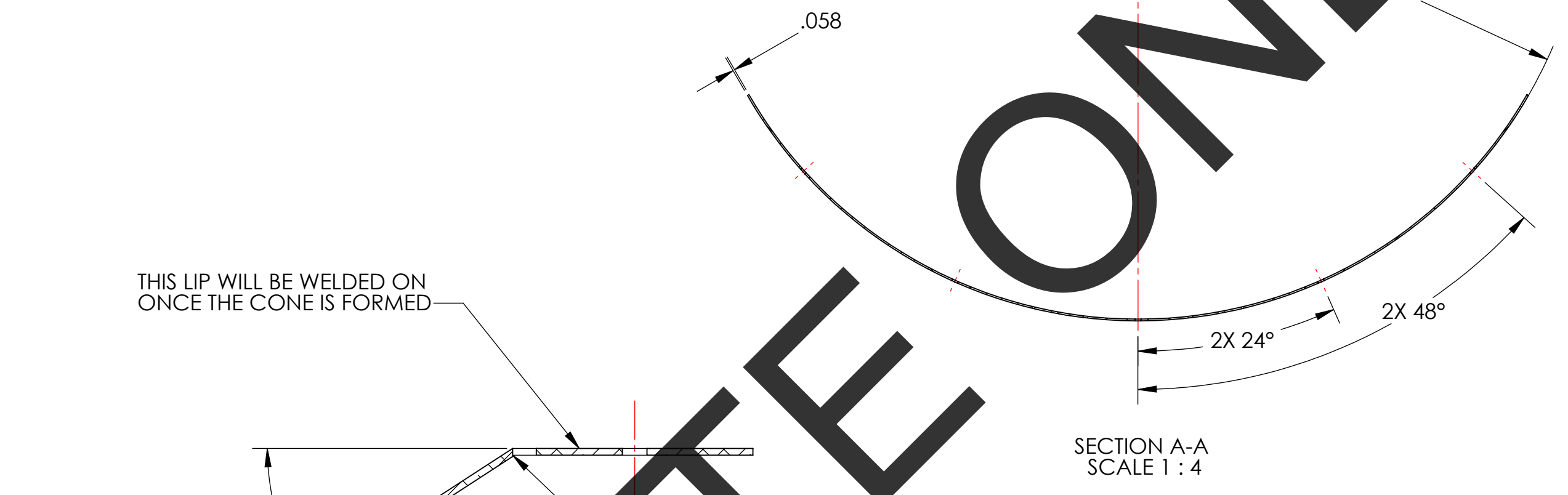
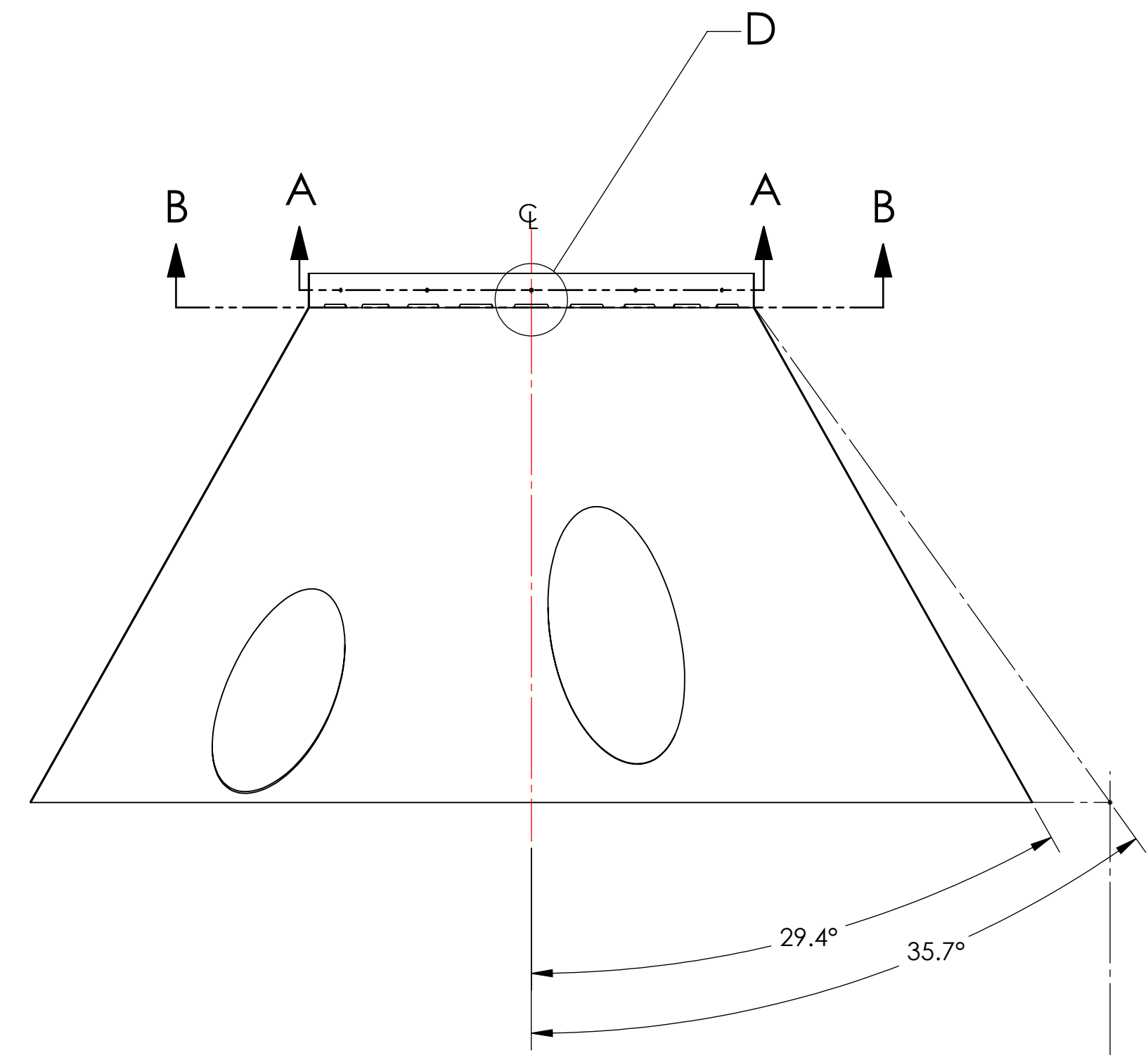
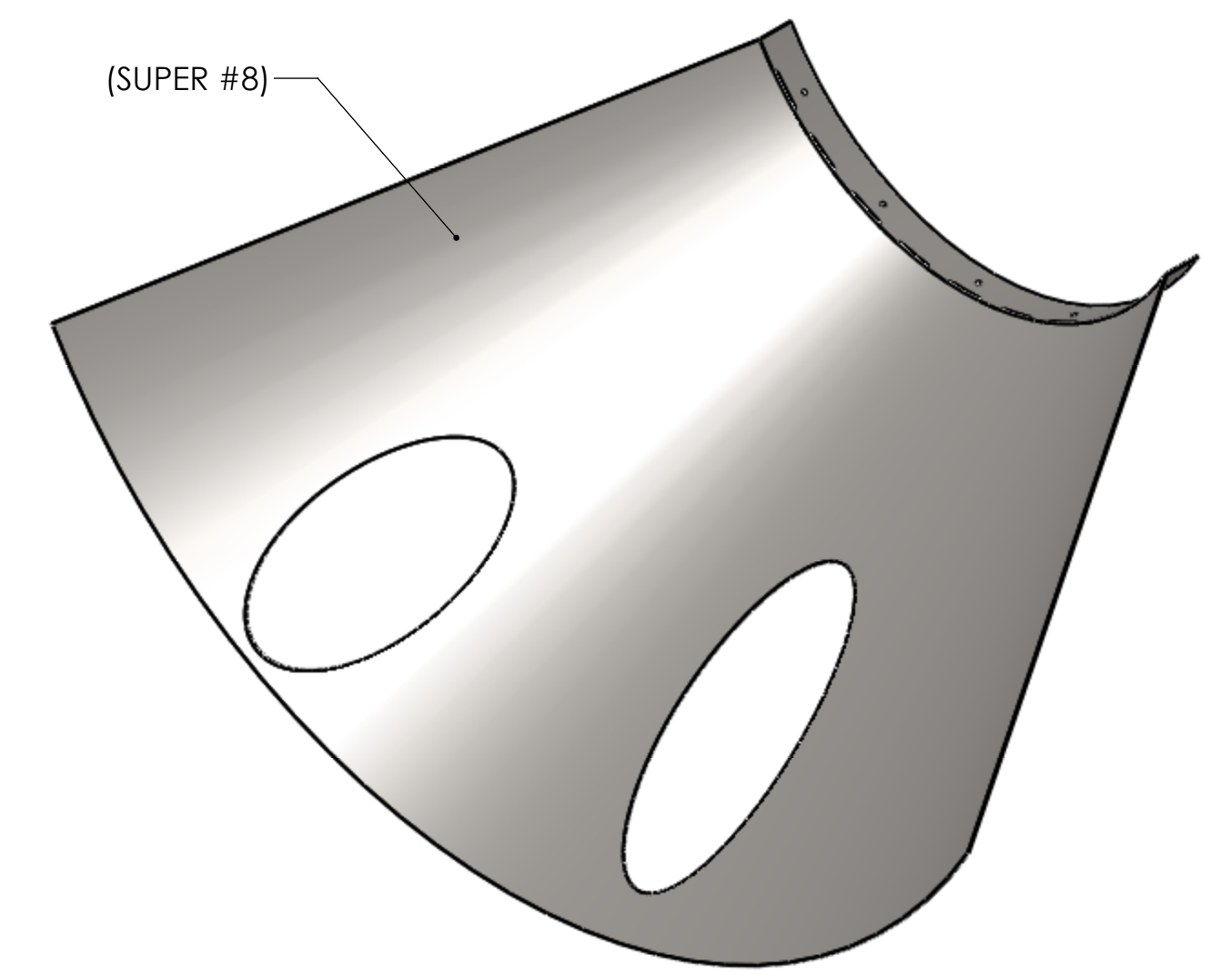
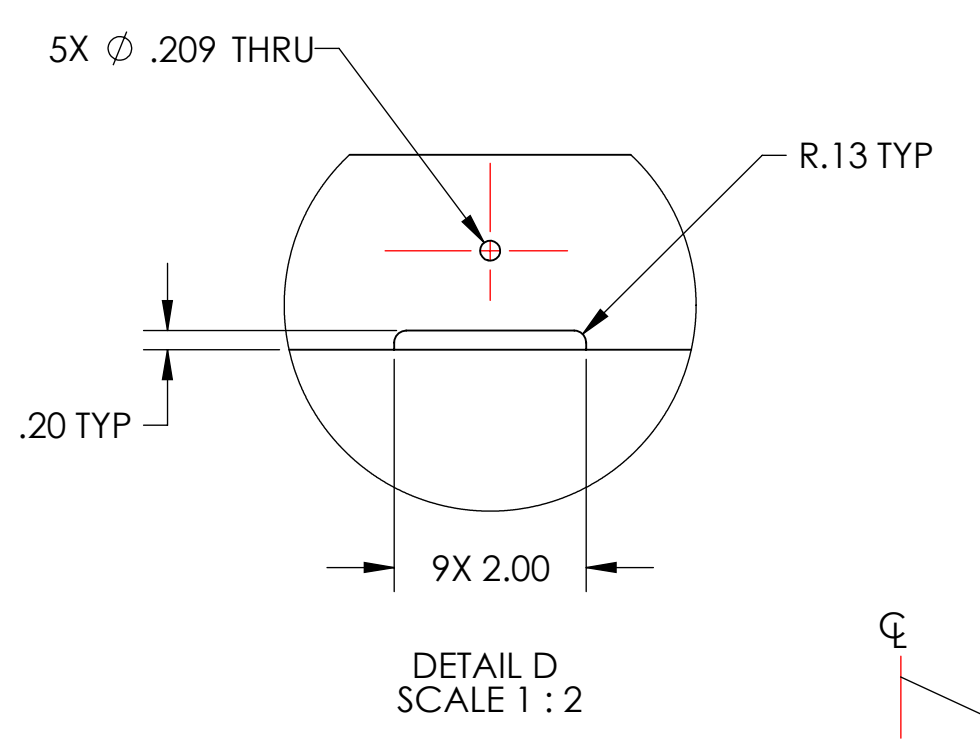
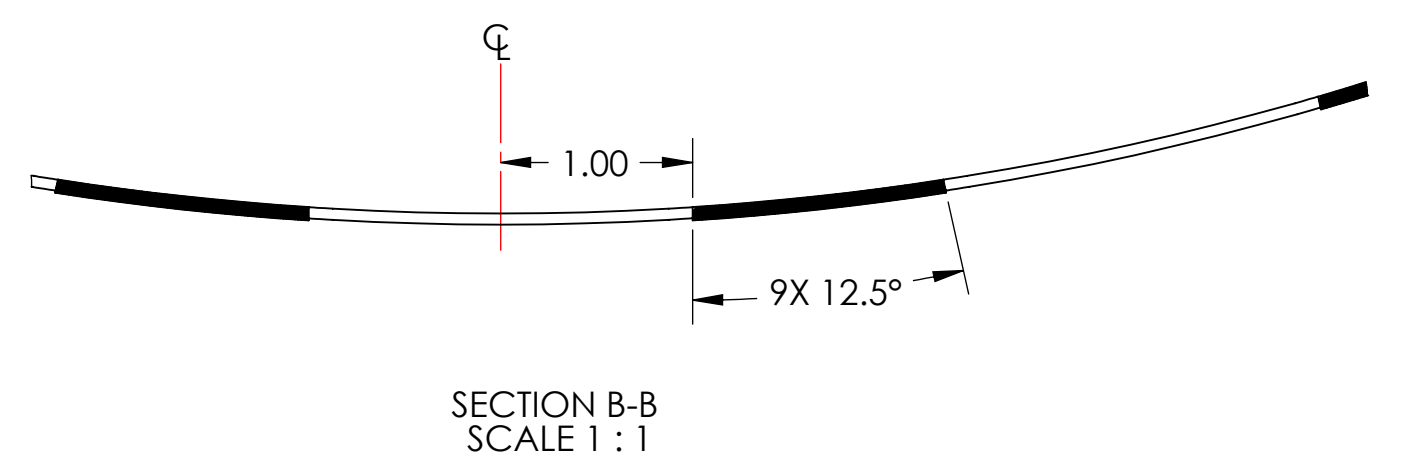
ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	QTY.	SPARE	TOTAL
6	D1002849	MANIFOLD CRYO BAFFLE WELDMENT BRACE	14 GAUGE 304 SSSL	1		0
5	D1000559	RADIAL SEGMENT, RIGHT	18 GAUGE 304 SSSL	1		0
4	D1001073	RADIAL ATTACHMENT NUT PLATE	14 GAUGE 304 SSSL	1		0
3	D1000536	BAFFLE BRACE BRACKET	14 GAUGE 304 SSSL	1		0
2	D0902621	MANIFOLD CRYO BAFFLE BRACKET	14 GAUGE 304 SSSL	2		0
1	D1003187	MANIFOLD-CRYO BAFFLE INNER SEGMENT WELDMENT, ETMX H1, RIGHT	18 GAUGE 304 SSSL	1		0

DIMENSIONS ARE IN INCHES		NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)		CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
TOLERANCES: .X ± .1 .XX ± .06 .XXX ± .010		1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015 ON ALL EDGES AND HOLES. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		SYSTEM <b>ADVANCED LIGO</b>		SUB-SYSTEM <b>AOS</b>	
ANGULAR ± 1.0°		MATERIAL N/A		FINISH N/A		PART NAME <b>MANIFOLD CRYO BAFFLE SEGMENT          SUBASSEMBLY WELDMENT, ETMX H1, RIGHT</b>	
		NEXT ASSY D1003183		DESIGNER H. KELMAN 20 MAY 2010		SIZE DWG. NO. <b>D D1003186</b>	
				DRAFTER TQ. NGUYEN 07 SEP 2010		REV. <b>v2</b>	
				CHECKER M. SMITH		SCALE: 1:8 PROJECTION:	
				APPROVAL D. COYNE		SHEET 1 OF 1	

D1003186 - d:\lco\_Monolith\_Cryo\_Baffle\_Segment\_Subassembly\_Weldment\_ETMX\_H1\_Right\_PART.PDM REV: X-0103.DRAWING.PDM REV: X-003

- NOTES CONTINUED:**
- ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE
  - ⑥ CONE AND LIP TO BE WELDED WHERE PIECES MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048.
  - 7. DELETED
  - 8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
  - 9. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.
  - ⑩ SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

REV.	DATE	DCN #	DRAWING TREE #
v1	28 JUL 2011	E1000360-v1	-
v2	20 OCT 2011	E1000360-v3	-
-	-	-	-



THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D0902654 FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.

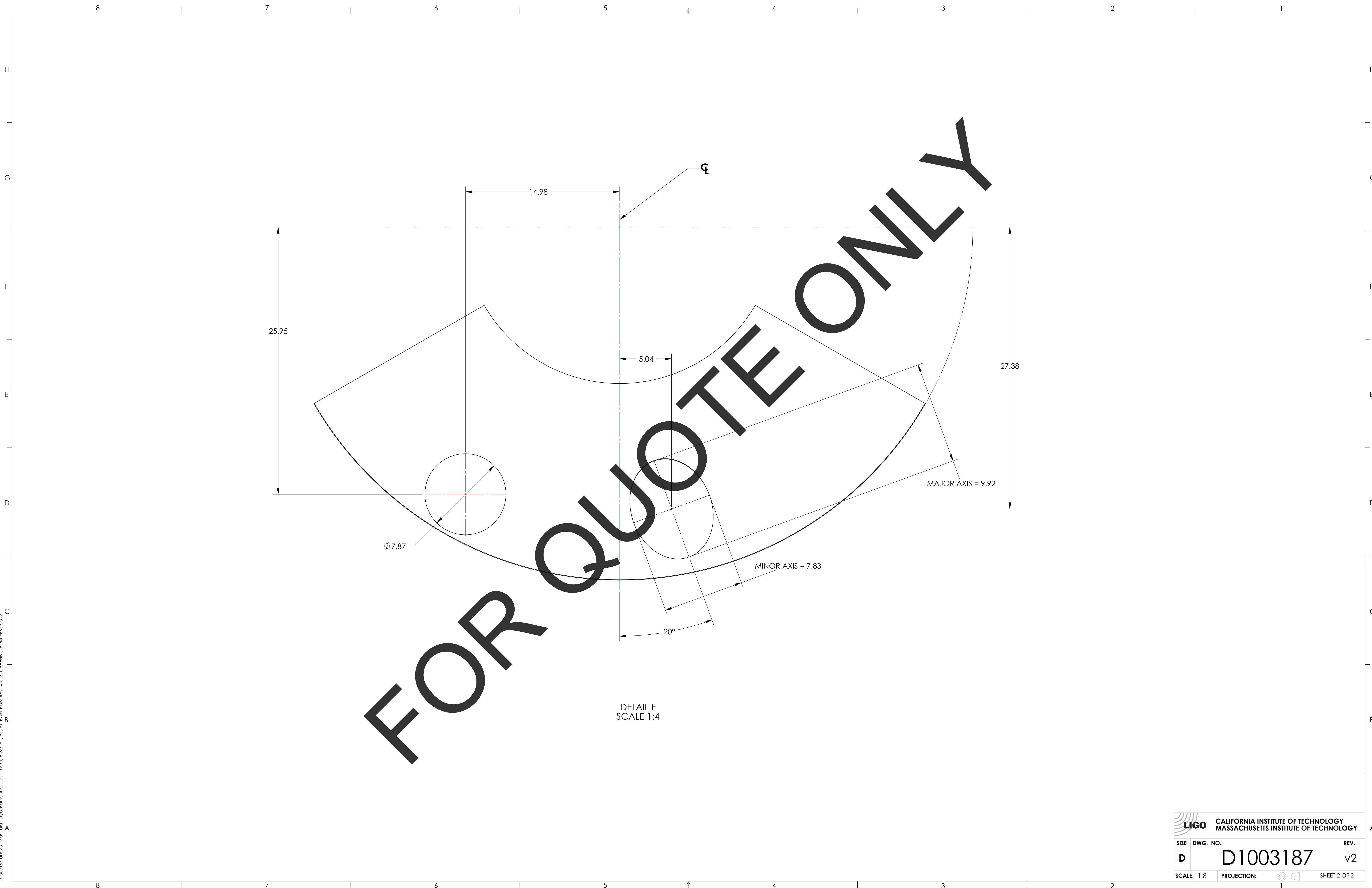
SEE DETAIL F ON NEXT SHEET

FOR QUOTE ONLY

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
1. INTERPRET DRAWING PER ASME Y14.5-1994.	
2. REMOVE ALL SHARP EDGES, .005-.015 ON ALL EDGES AND HOLES.	
3. DO NOT SCALE FROM DRAWING.	
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.	
DIMENSIONS ARE IN INCHES	
TOLERANCES:	
.XX ± .06	
.XXX ± .010	
ANGULAR ± 0.5°	
MATERIAL	18 GAUGE 304 SSTL
FINISH	⑩ SUPER #8

<b>LIGO</b> CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	SYSTEM	ADVANCED LIGO	SUB-SYSTEM	AOS
NEXT ASSY		D1003186		

PART NAME		MANIFOLD-CRYO BAFFLE INNER SEGMENT WELDMENT, ETMX H1, RIGHT		
DESIGNER	TQ. NGUYEN	6 DEC 2010	SIZE	DWG. NO.
DRAFTER	TQ. NGUYEN	7 DEC 2010		
CHECKER	M. SMITH			
APPROVAL	D. COYNE			
SCALE: 1:8		PROJECTION:		SHEET 1 OF 2
REV.		D1003187		v2



DETAIL F  
SCALE 1:4

		CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
SIZE	DWG. NO.	REV.	
D	D1003187	v2	
SCALE: 1:8	PROJECTION:	SHEET 2 OF 2	

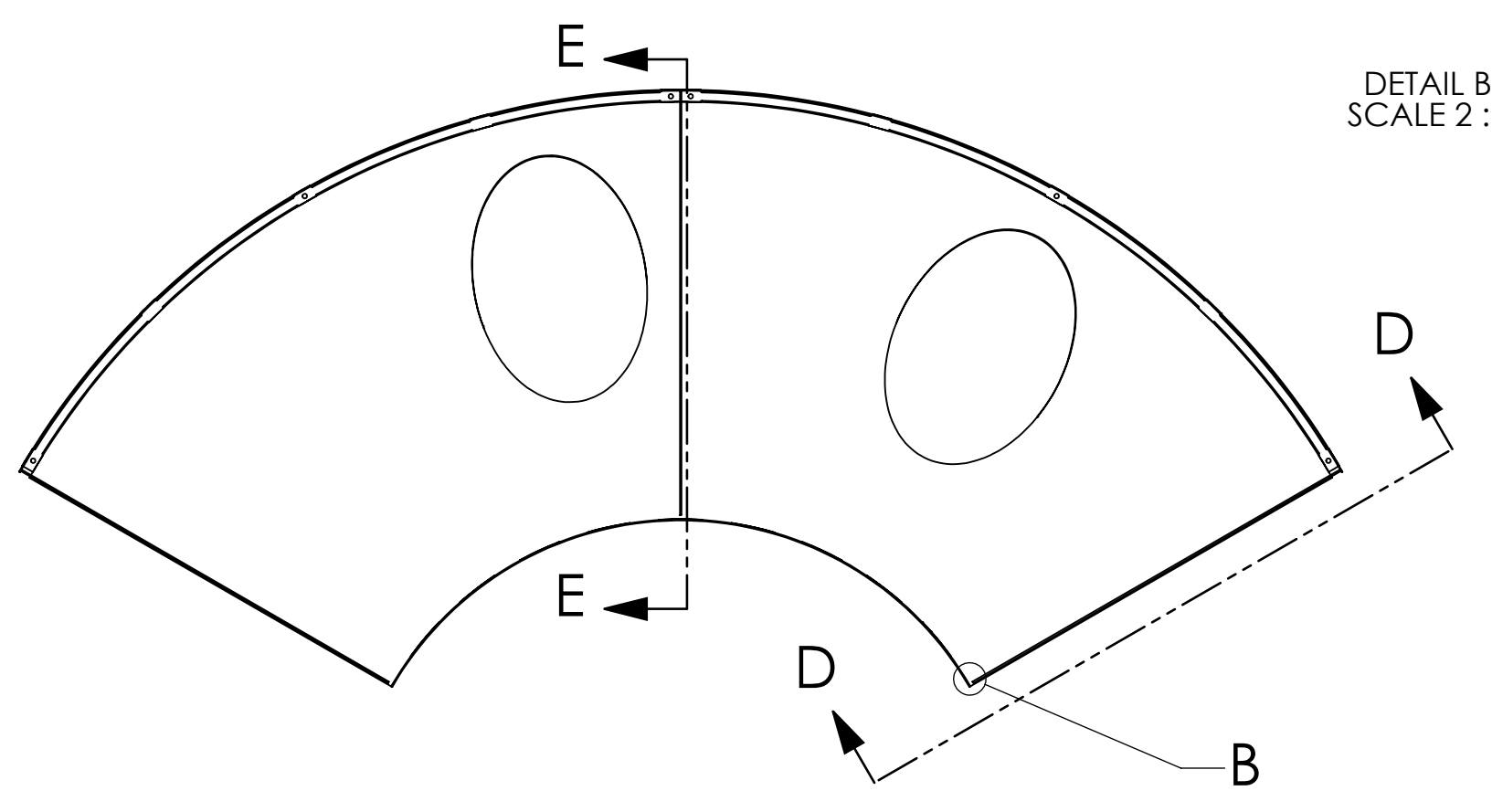
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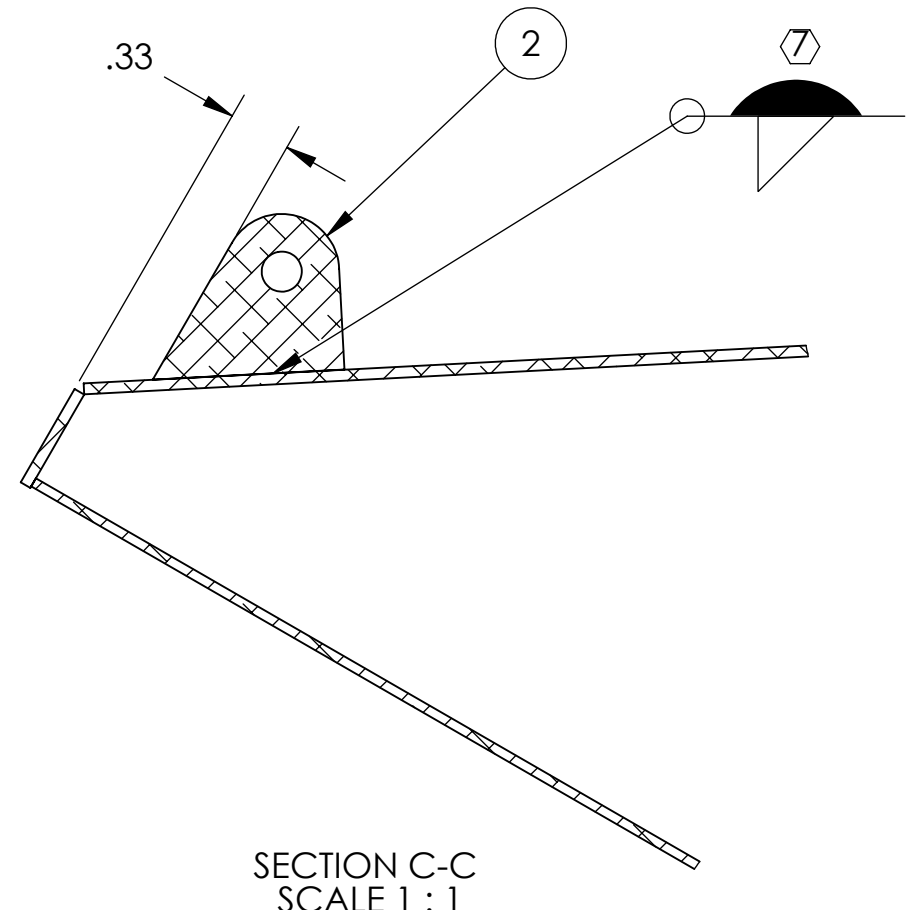
**NOTES CONTINUED:**  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS.  
 EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX  
 DO NOT APPLY MARK ON SUPER #8 SIDE

6. ASSEMBLY TO BE OXIDIZED AFTER WELDMENT IS COMPLETED PER SPECIFICATION E1100842.  
 7. FILLET WELDS WHERE ITEMS MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048.

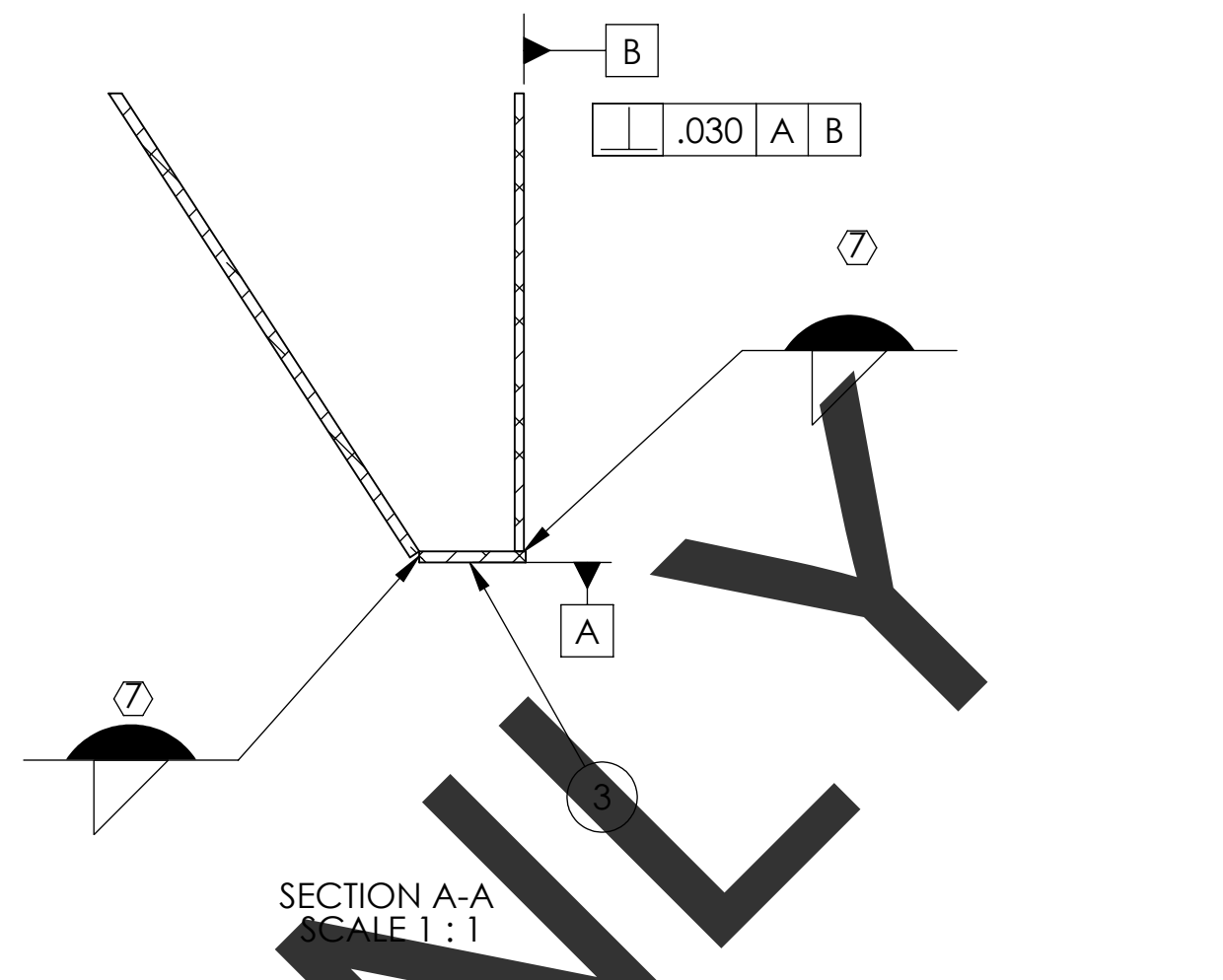
REV.	DATE	DCN #	DRAWING TREE #
v1	28 JUL 2011	E1000360-v2	-
v2	20 OCT 2011	E1000360-v3	-
-	-	-	-



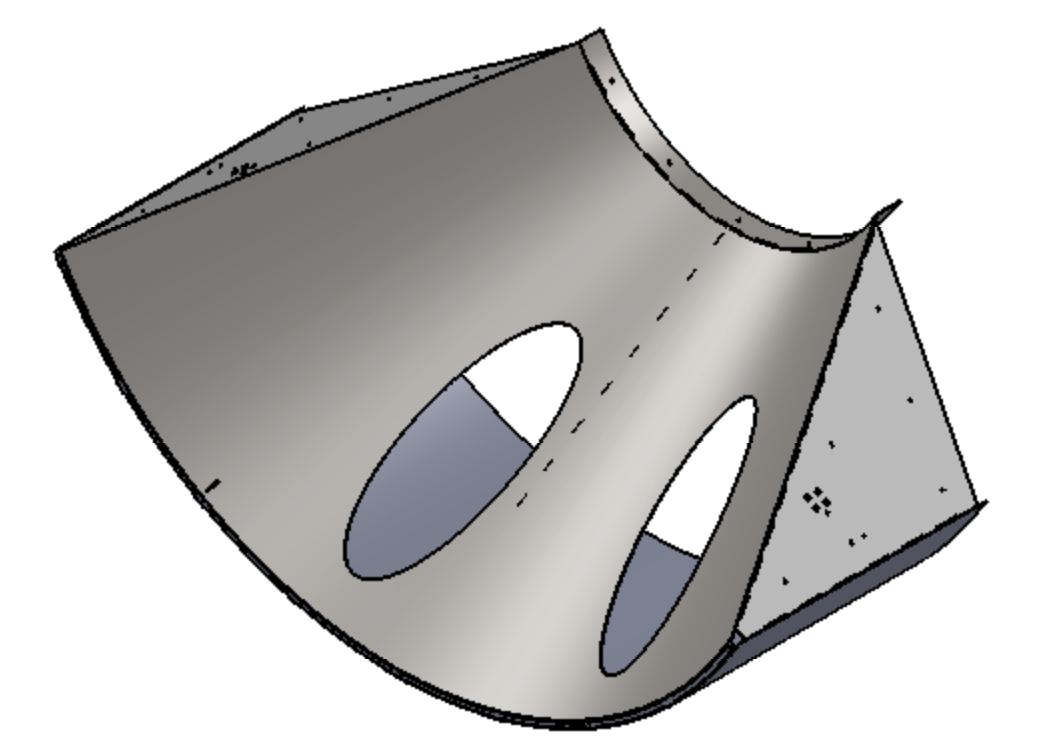
DETAIL B  
SCALE 2 : 1



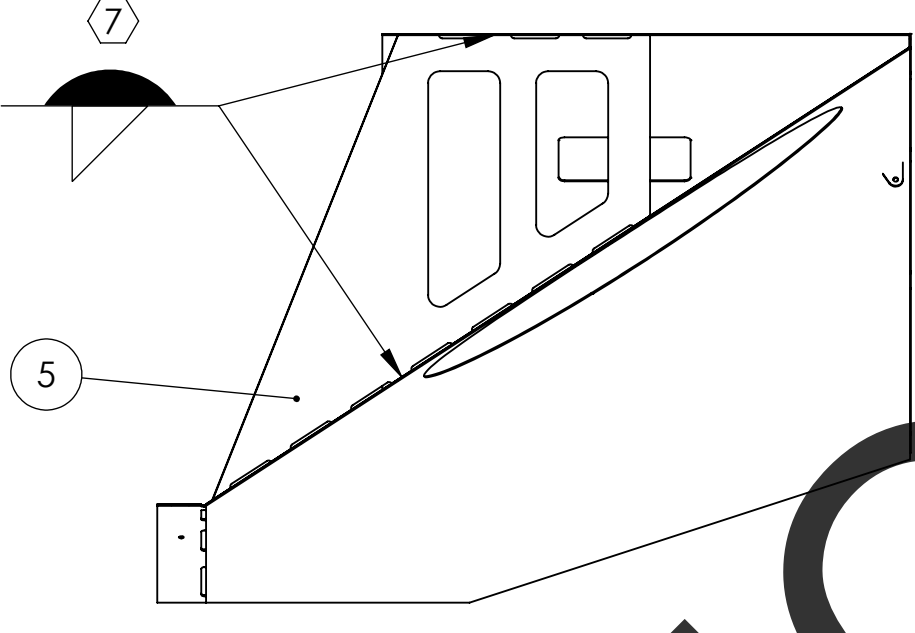
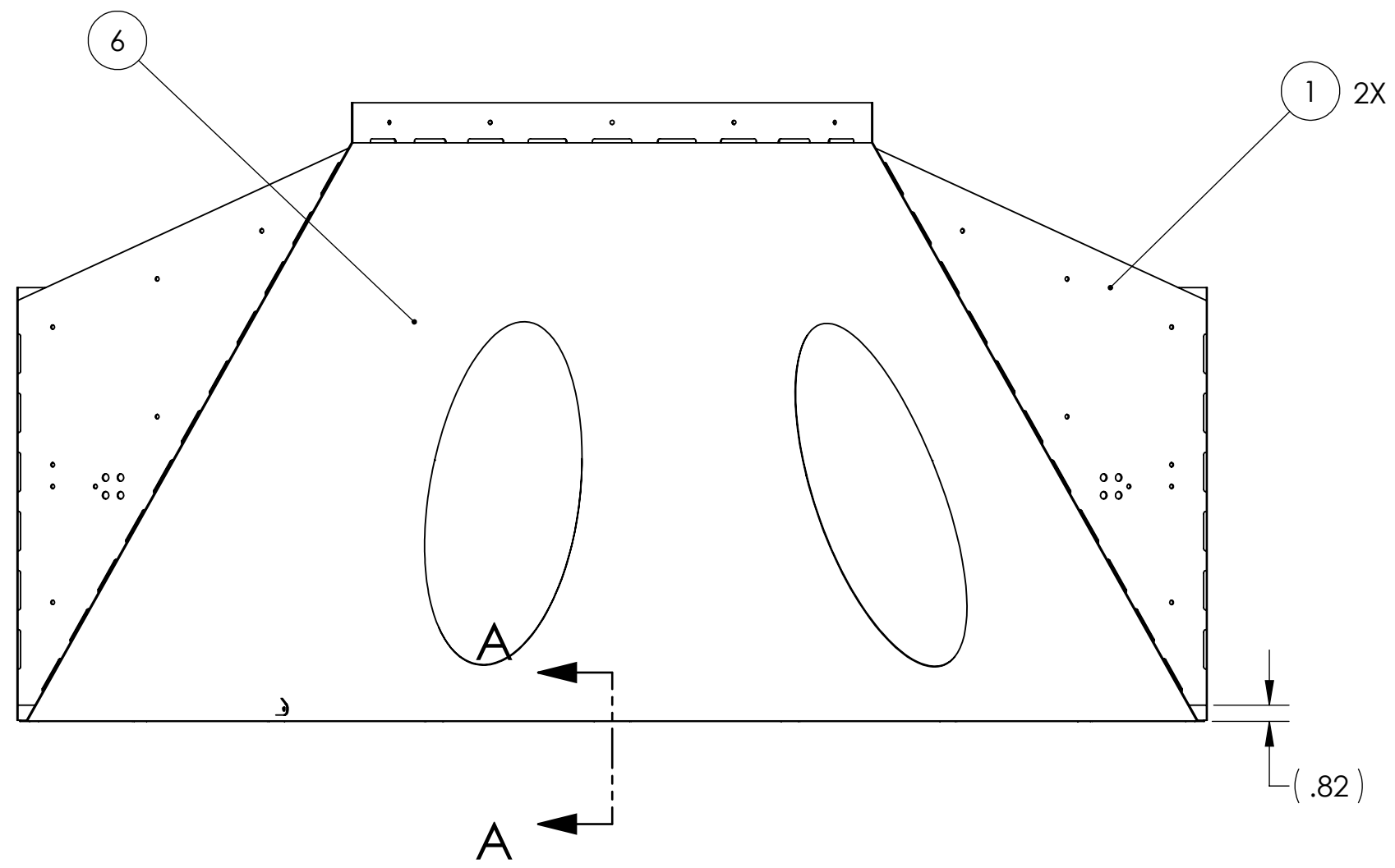
SECTION C-C  
SCALE 1 : 1



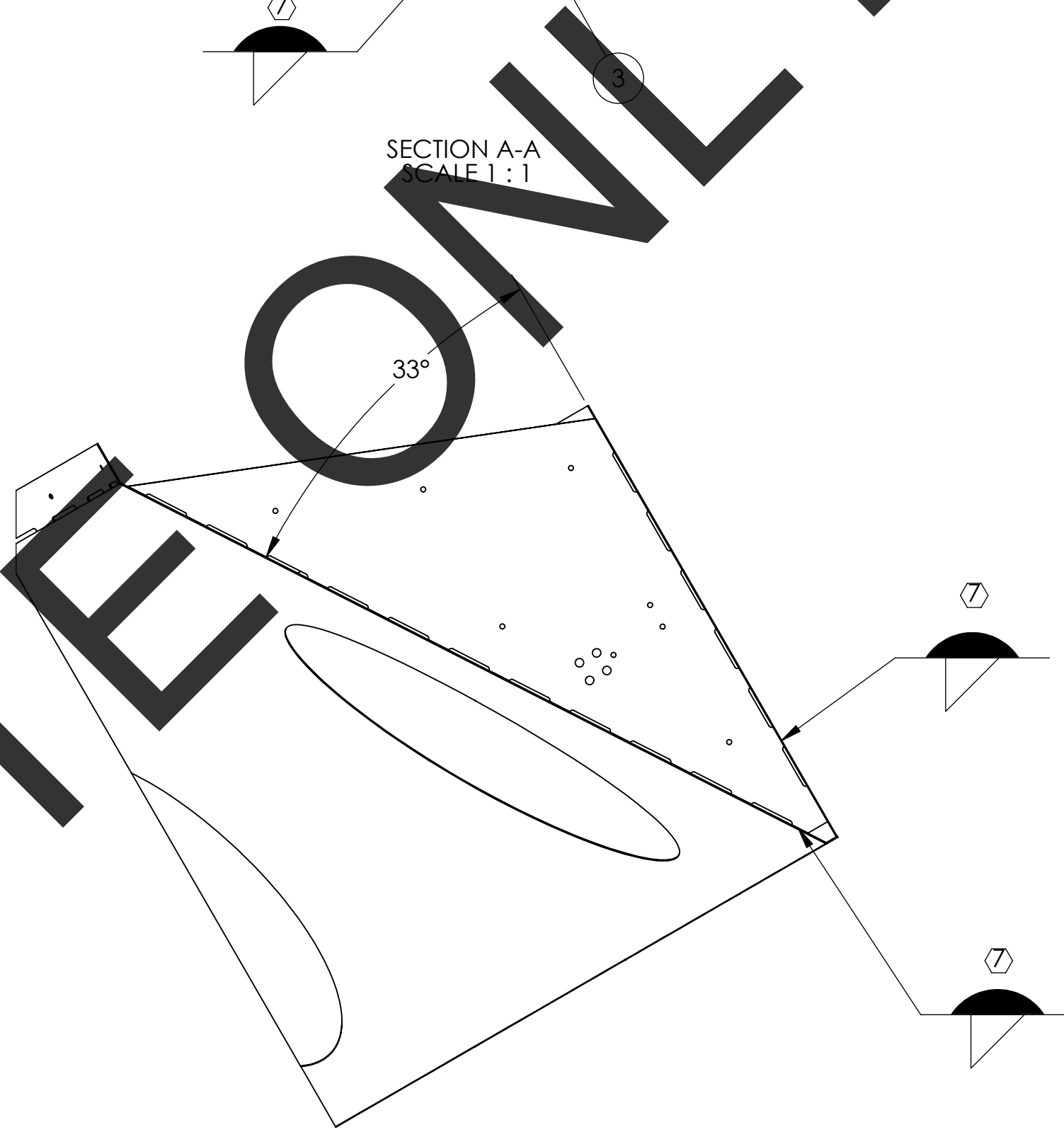
SECTION A-A  
SCALE 1 : 1



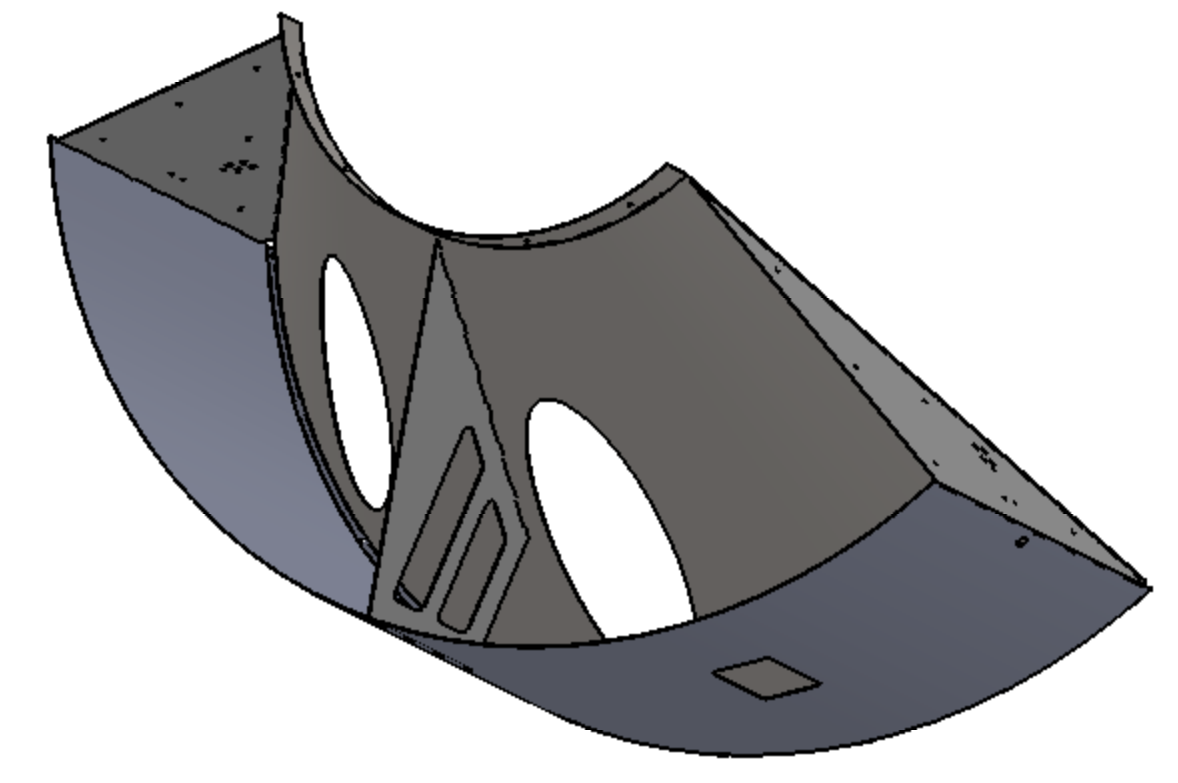
GENERAL VIEW  
FOR REFERENCE ONLY  
NO SCALE



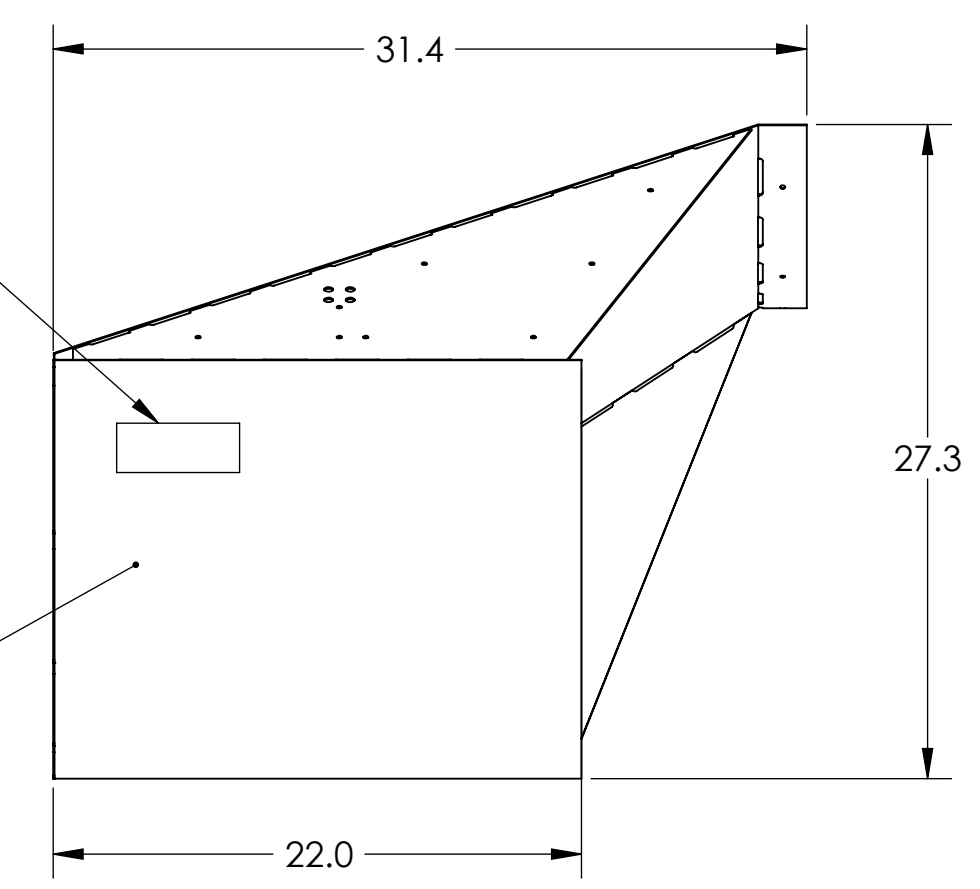
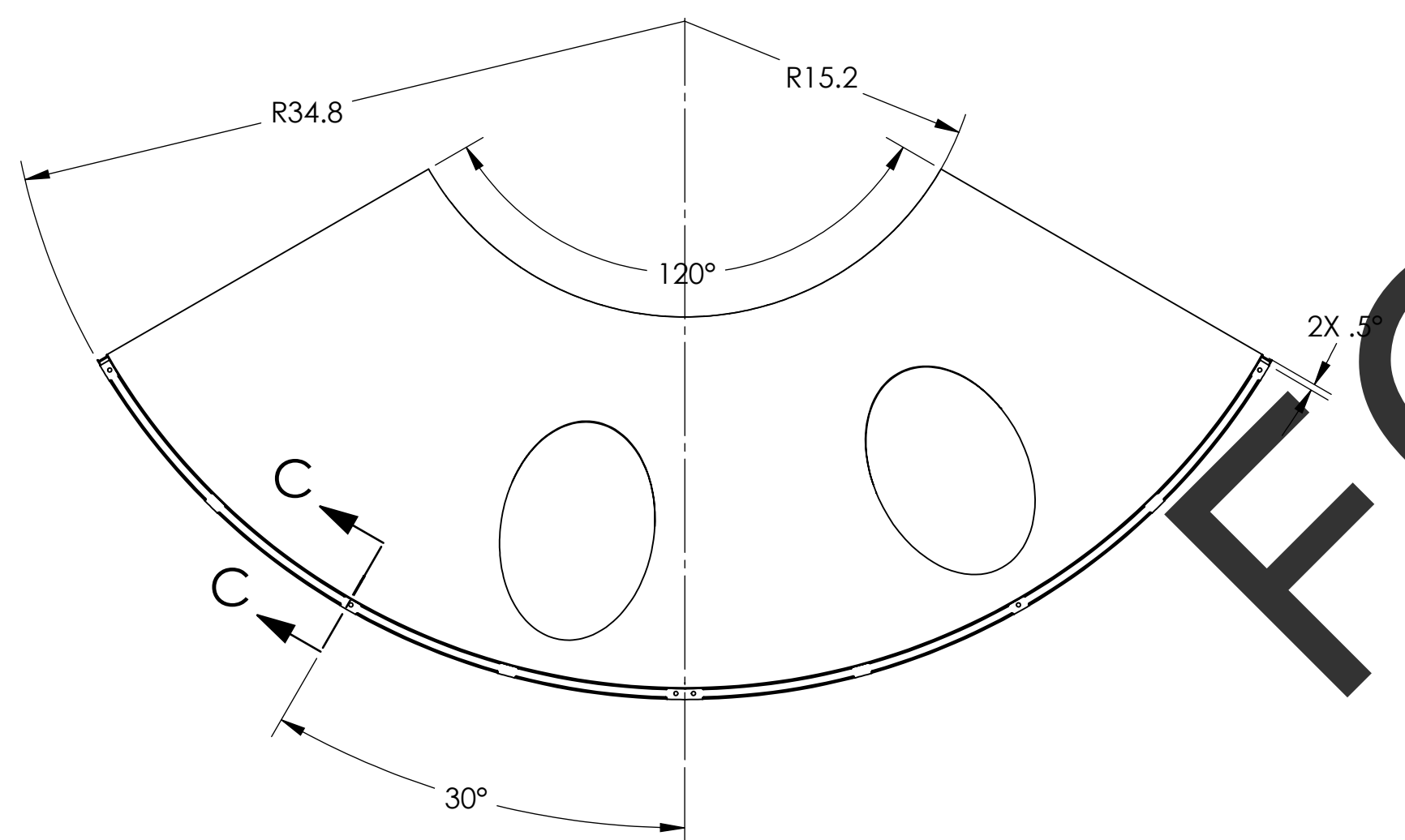
SECTION E-E



SECTION D-D  
SCALE 1 : 6



GENERAL VIEW  
FOR REFERENCE ONLY  
NO SCALE



4

FOR QUOTE ONLY

ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ	SPARE	TOTAL
6	D1003191	MANIFOLD-CRYO BAFFLE INNER SEGMENT WELDMENT, ETMX H1, LEFT	18 GAUGE 304 SSSL	1		1
5	D1002849	MANIFOLD CRYO BAFFLE WELDMENT BRACE	14 GAUGE 304 SSSL	1		1
4	D1000558	RADIAL SEGMENT, LEFT	18 GAUGE 304 SSSL	1		1
3	D1001073	RADIAL ATTACHMENT NUT PLATE	14 GAUGE 304 SSSL	1		1
2	D1000536	BAFFLE BRACE BRACKET	14 GAUGE 304 SSSL	1		1
1	D0902621	MANIFOLD CRYO BAFFLE BRACKET	14 GAUGE 304 SSSL	2		2

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
1. INTERPRET DRAWING PER ASME Y14.5-1994.	
2. REMOVE ALL SHARP EDGES, R.02 MIN.	
3. DO NOT SCALE FROM DRAWING.	
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.	
MATERIAL	N/A
FINISH	N/A
ANGULAR ± 1.0°	

**LIGO** CALIFORNIA INSTITUTE OF TECHNOLOGY  
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO SUB-SYSTEM: AOS

NEXT ASSY: D1003183

PART NAME: MANIFOLD-CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMX H1, LEFT

DESIGNER: H. KELMAN 20 MAY 2010 SIZE: D DWG. NO.: D1003188 REV.: v2

DRAFTER: TQ. NGUYEN 07 SEP 2010

CHECKER: M. SMITH

APPROVAL: D. COYNE

SCALE: 1:8 PROJECTION: SHEET 1 OF 1

D1003188.dwg: Manifold\_Cryo\_Baffle\_Segment\_Subassembly\_Weldment\_ETMX\_H1\_Left\_PART\_PDM\_REV:K011\_DRAWING\_PDM\_REV:K004

**NOTES CONTINUED:**  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS.  
 EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX  
 DO NOT APPLY MARK ON SUPER #8 SIDE

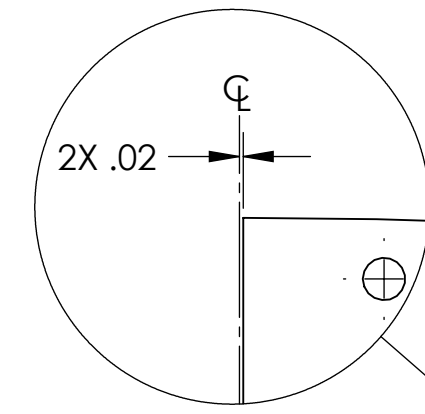
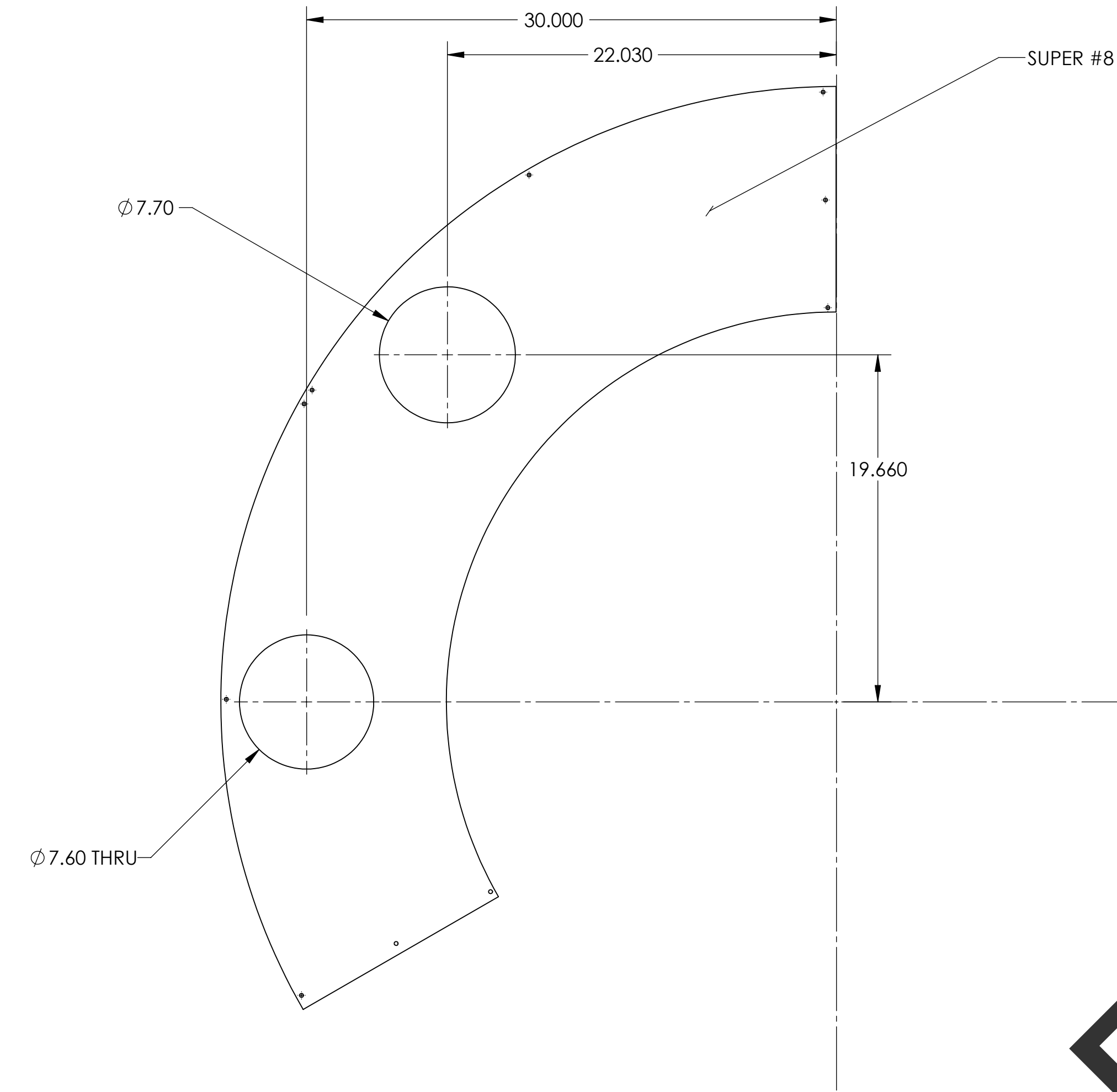
6. APPROXIMATE WEIGHT = 11.072 LBS.

7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (I.E. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

9. PART TO BE OXIDIZED PER LIGO SPECIFICATION E1100842.

REV.	DATE	DCN #	DRAWING TREE #
v1	17 MAY 2011	E1000360-v2	-
v2	31 OCT 2012	E1000360-v3	-
-	-	-	-



DETAIL A  
SCALE 1 : 1

10X  $\phi .221$  THRU  
 $\oplus .014$  A B C

$\oplus .014$  A B C

2X 6.10

(R22.09)

(11.03)

(17.41)

(19.14)

(30.20)

R22.34 B.C.

R34.55 B.C.

R34.86

120°

89.75°

60.75°

59.25°

30.25°

1.25°

12.77

118.75°

5

12.77

12.77

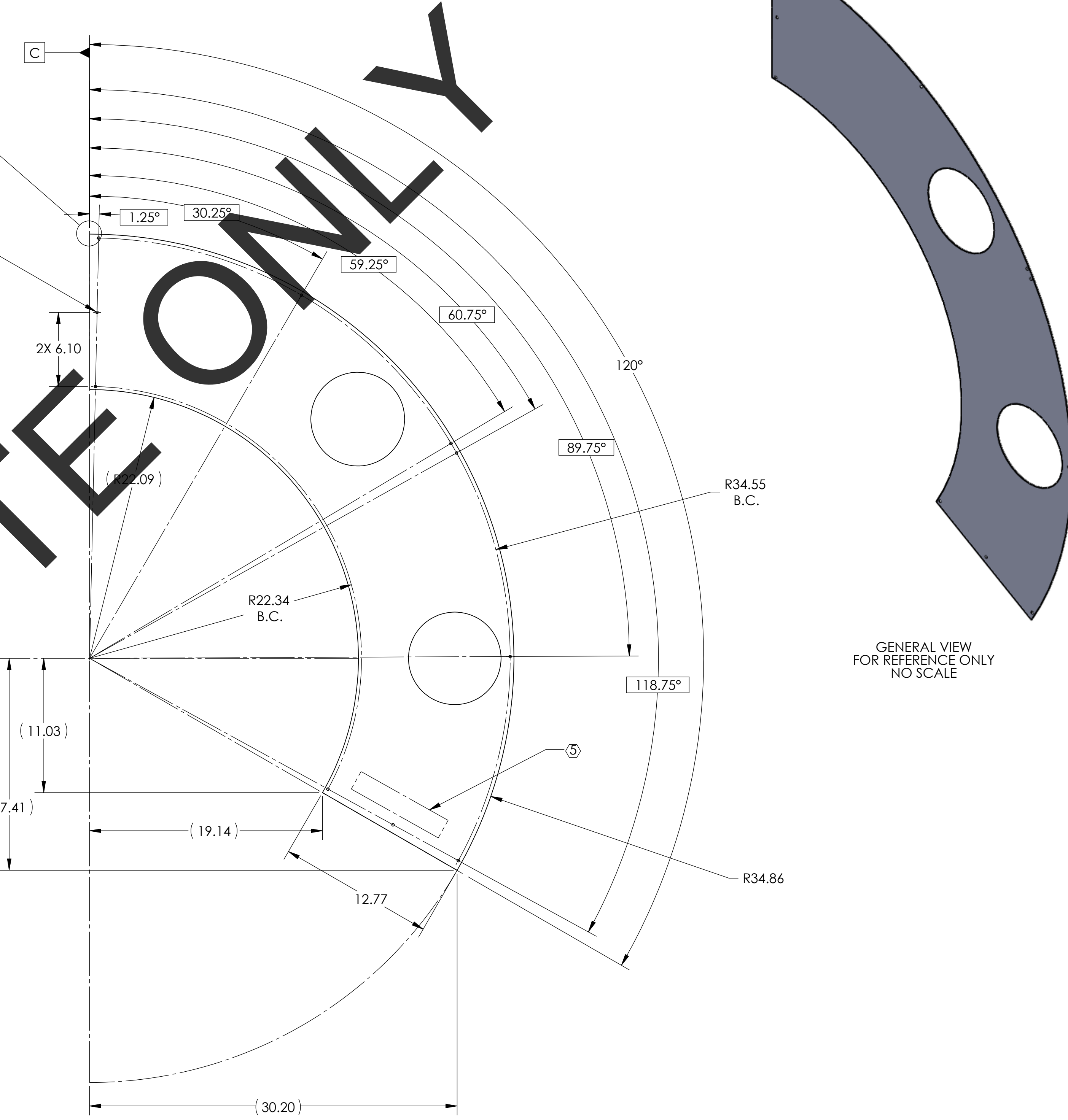
12.77

12.77

12.77

12.77

12.77



GENERAL VIEW  
FOR REFERENCE ONLY  
NO SCALE

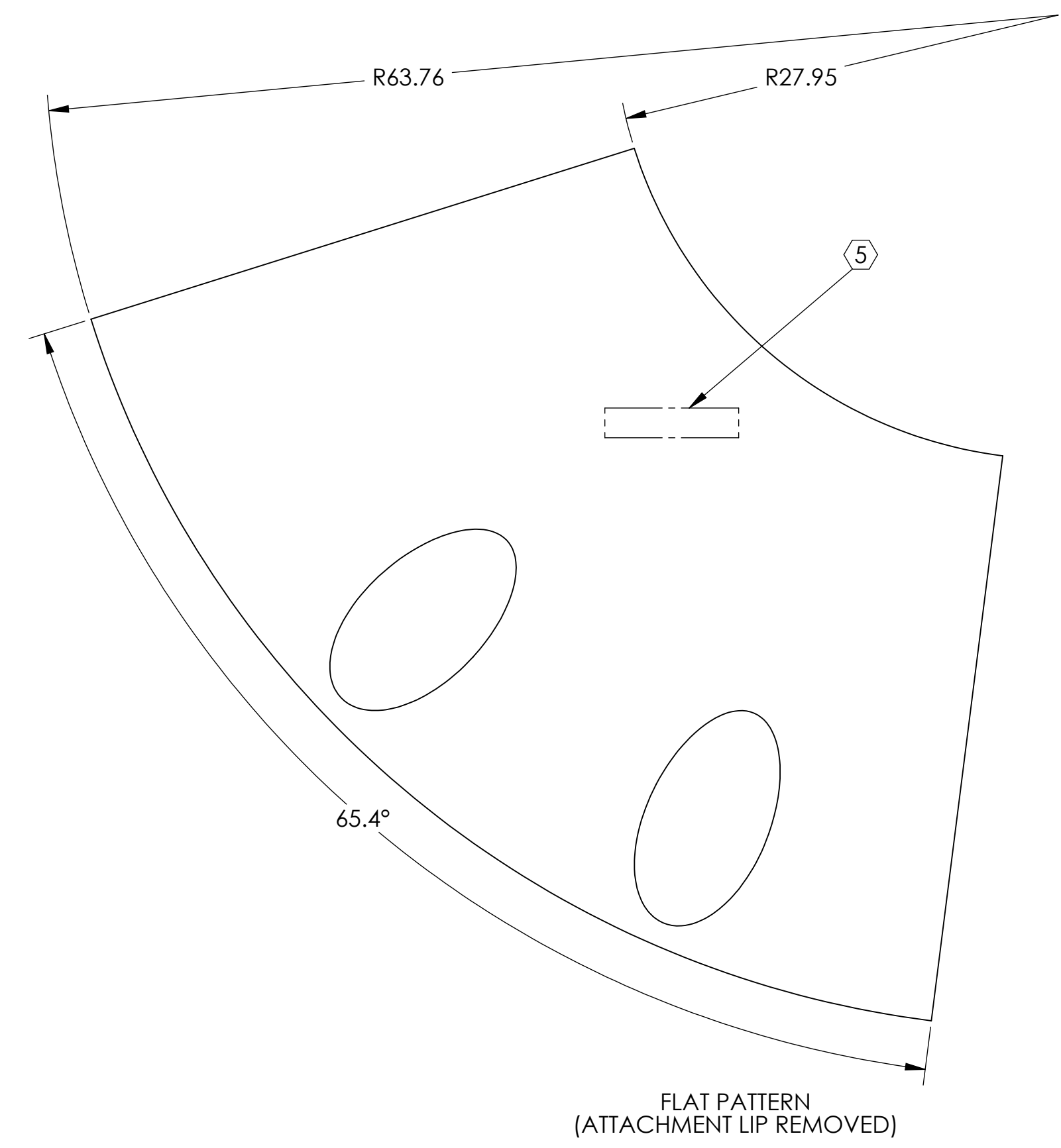
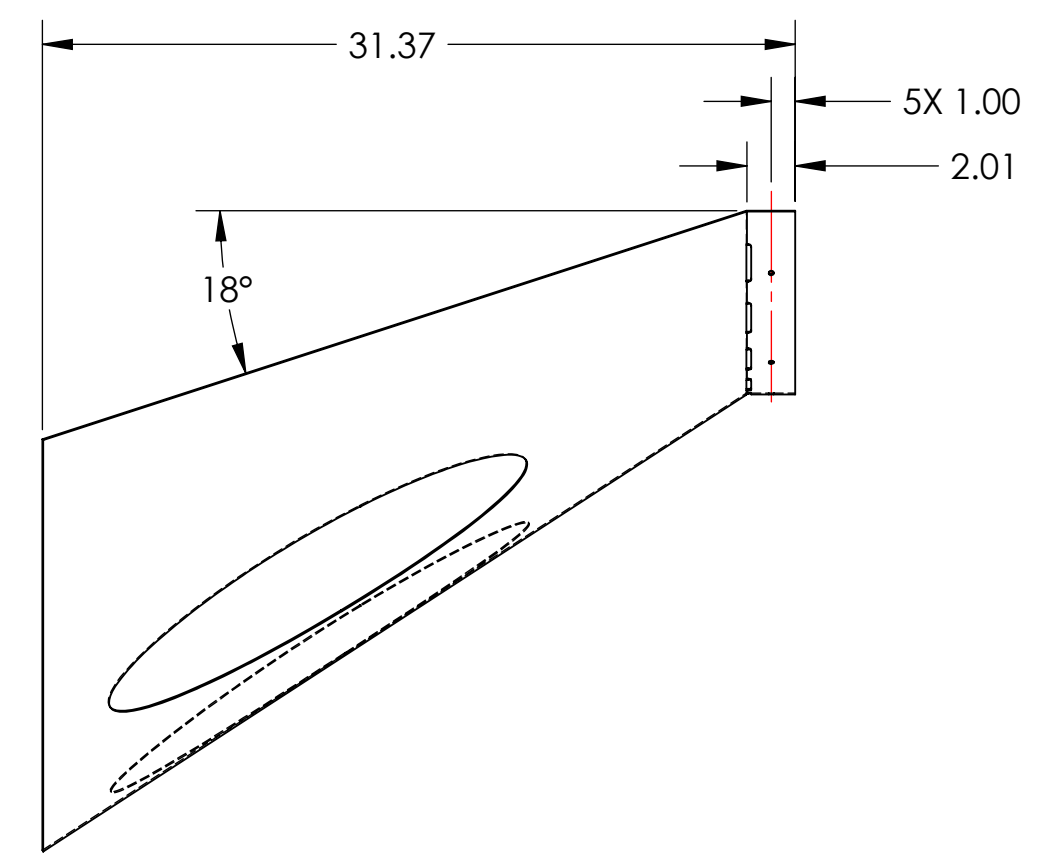
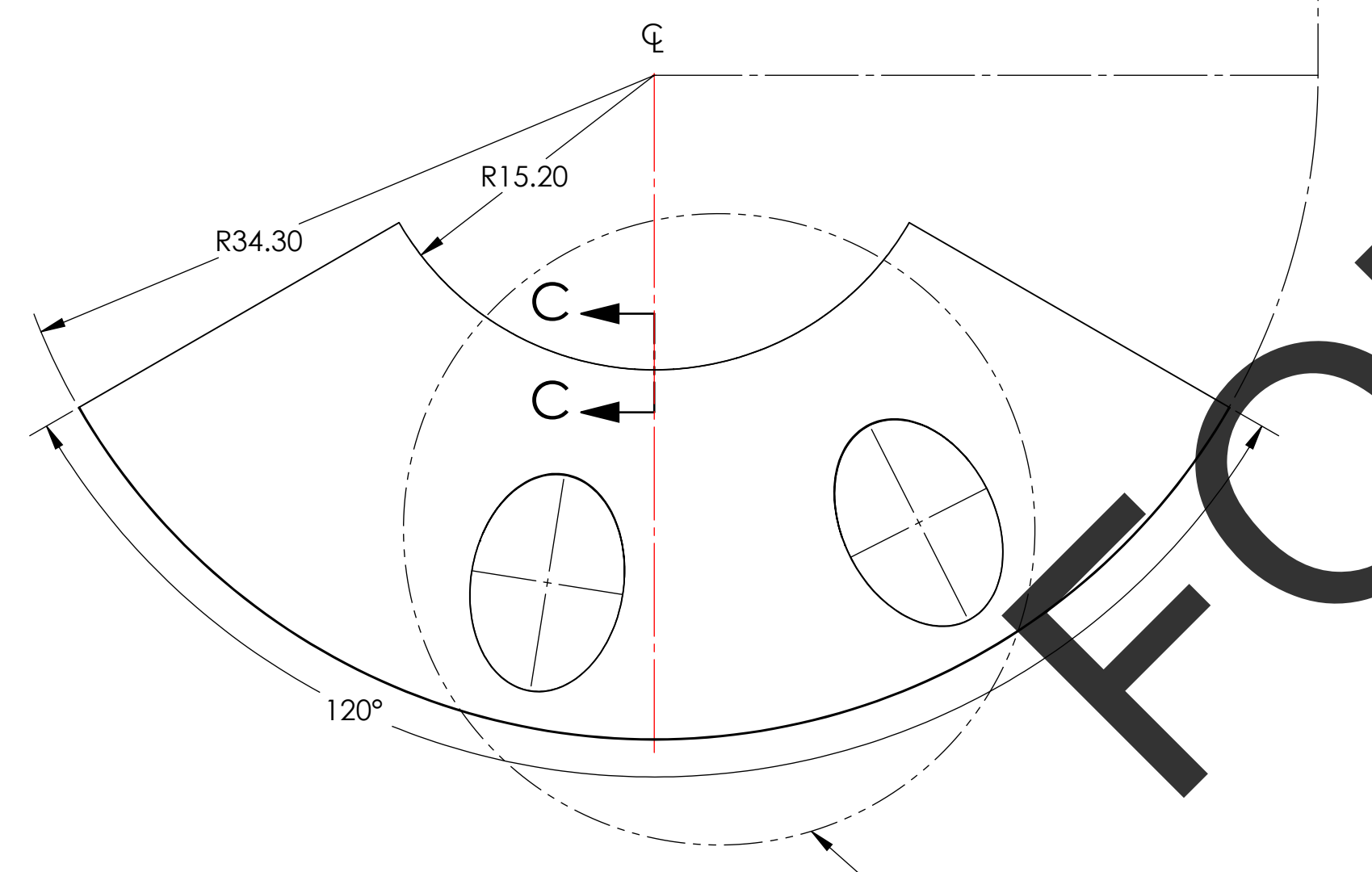
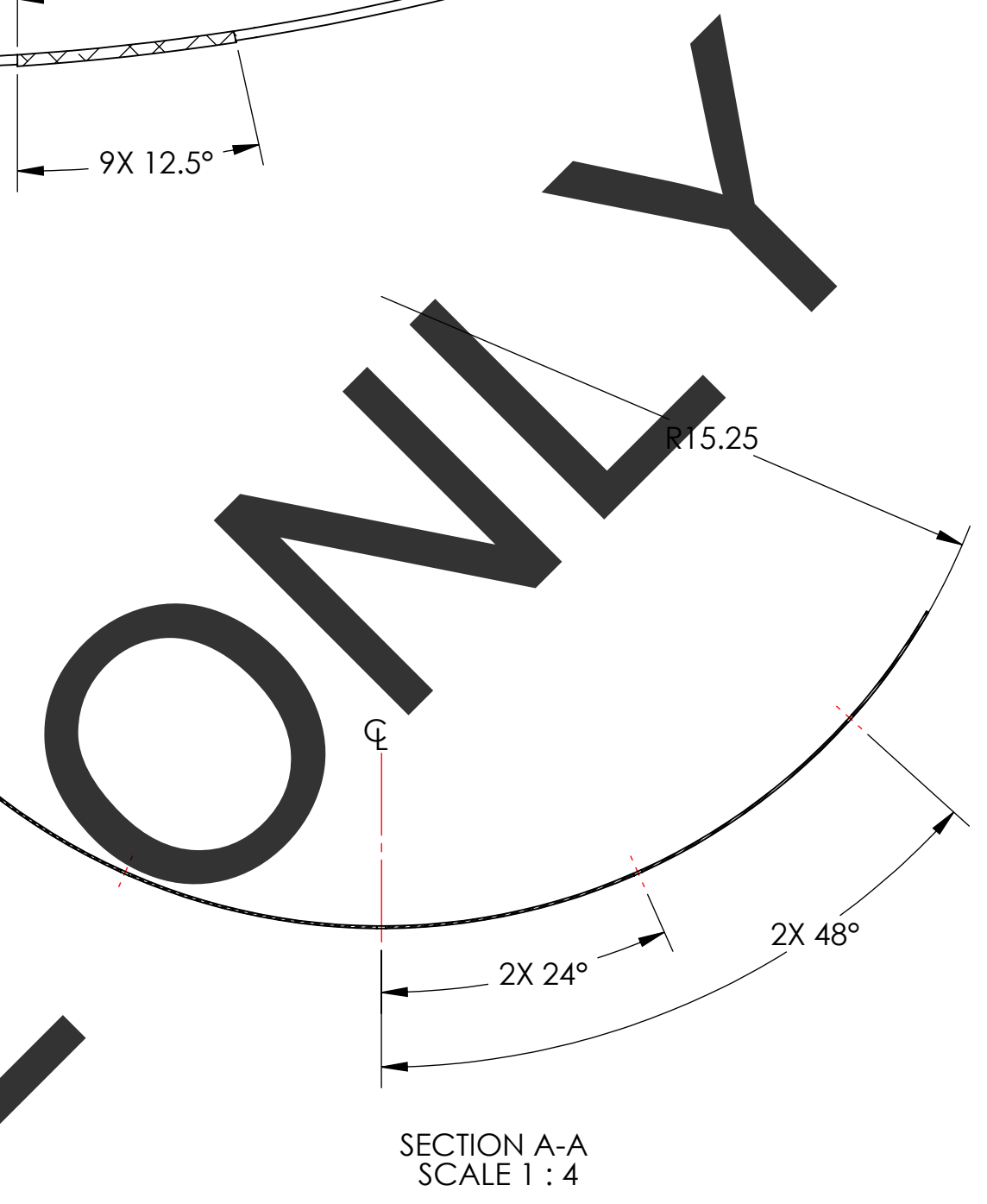
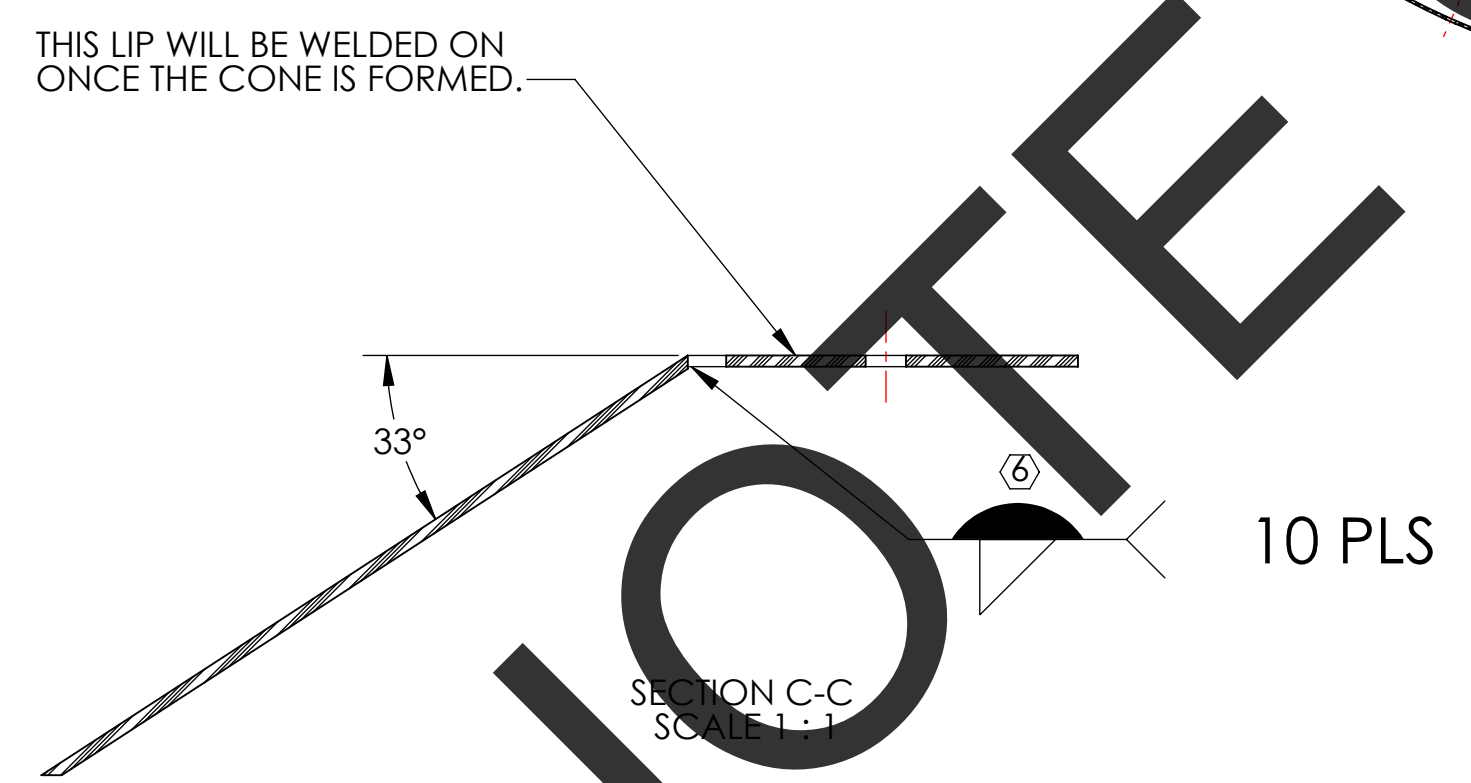
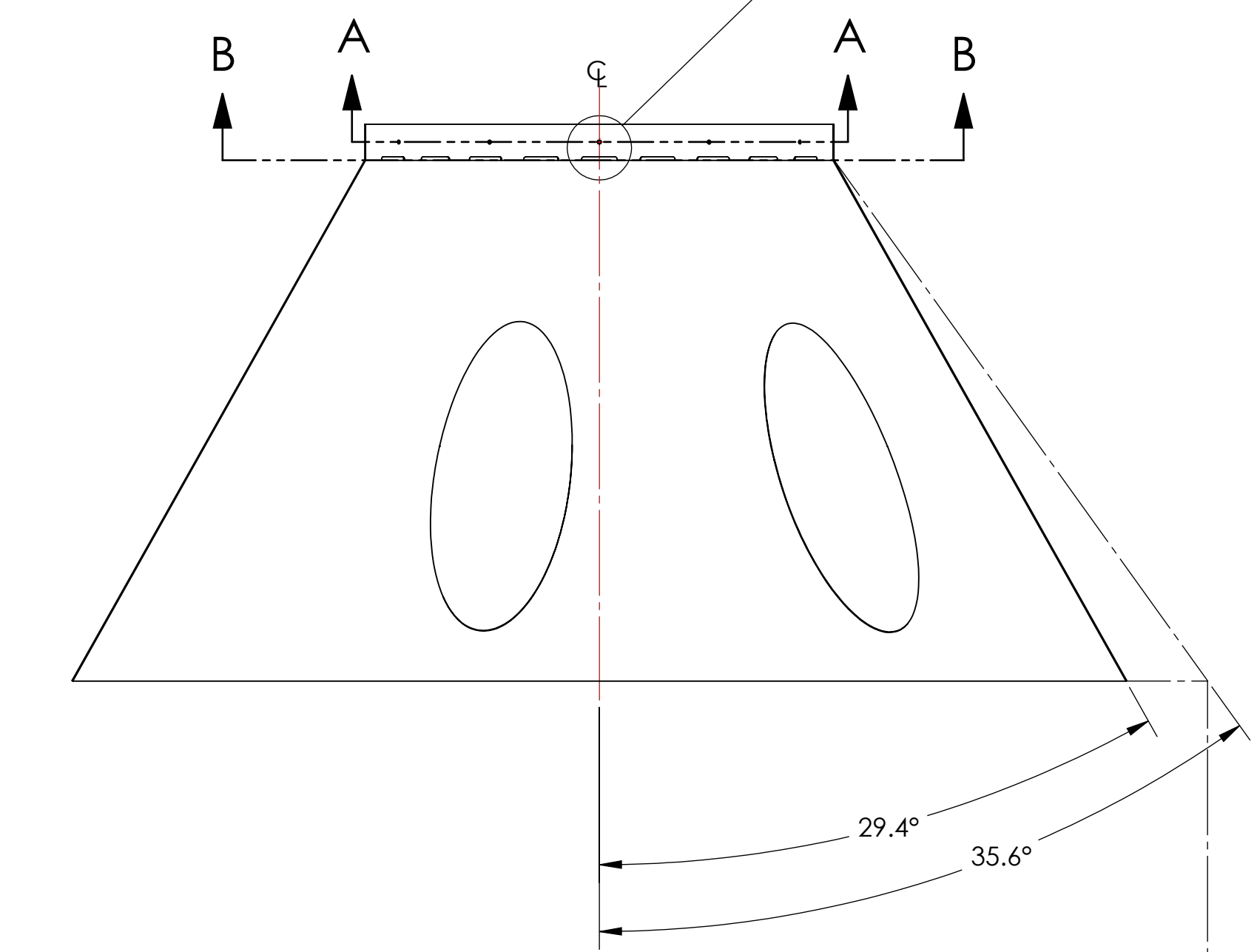
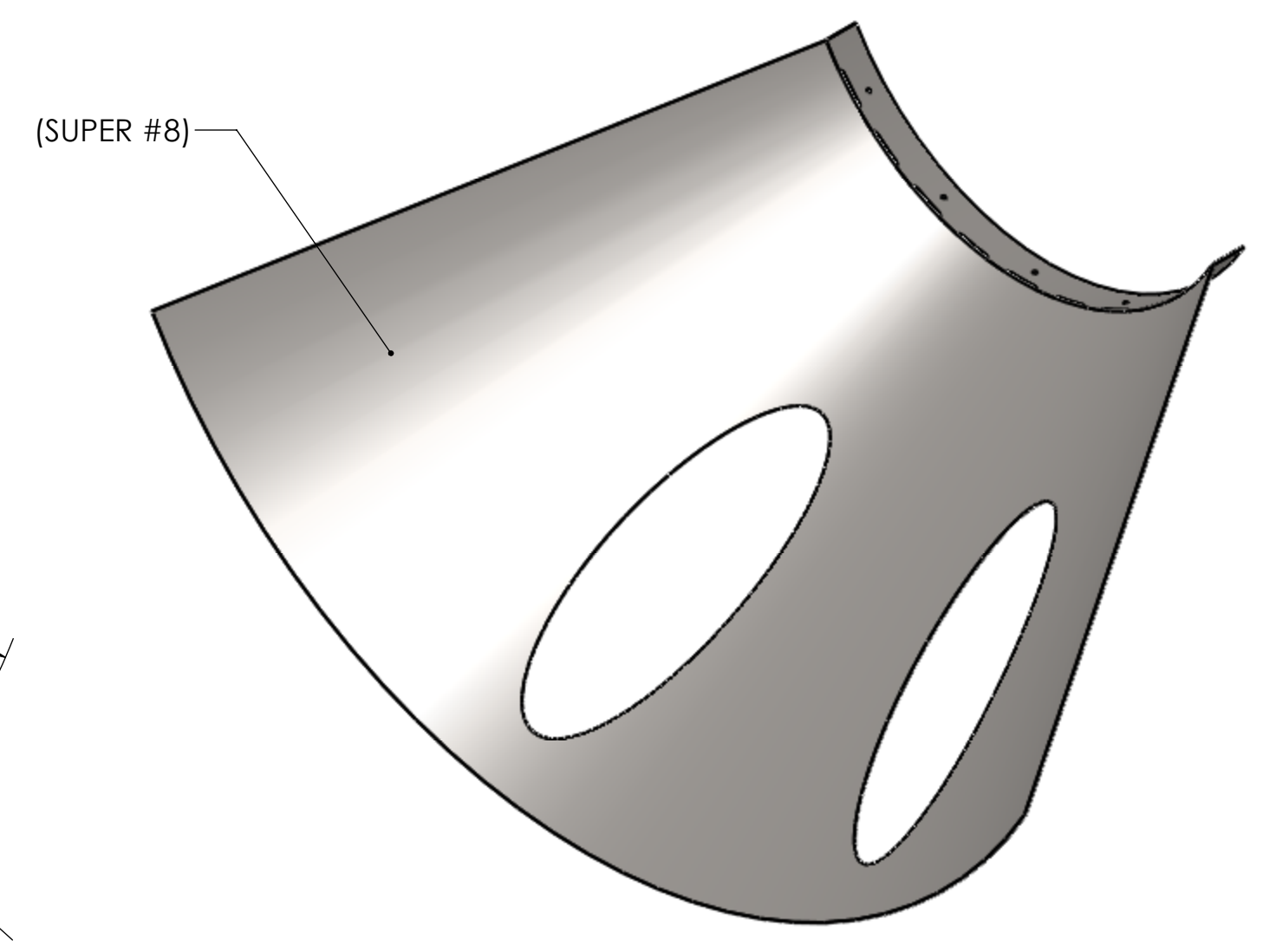
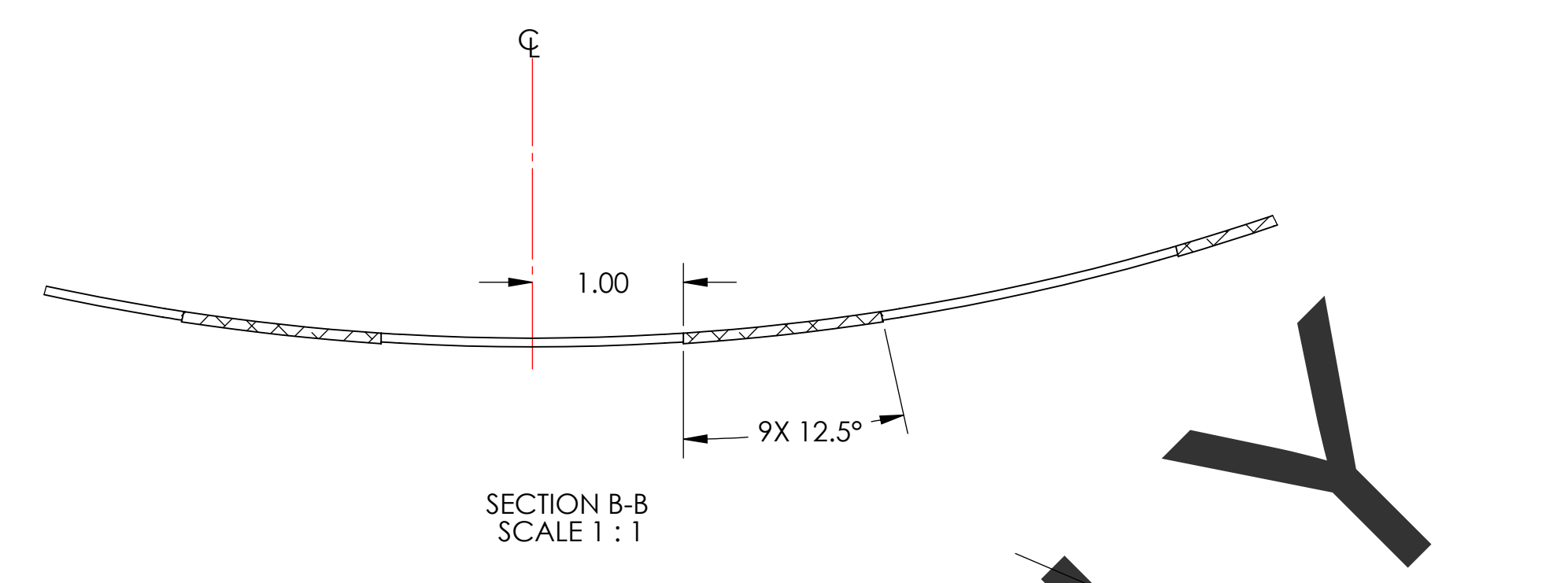
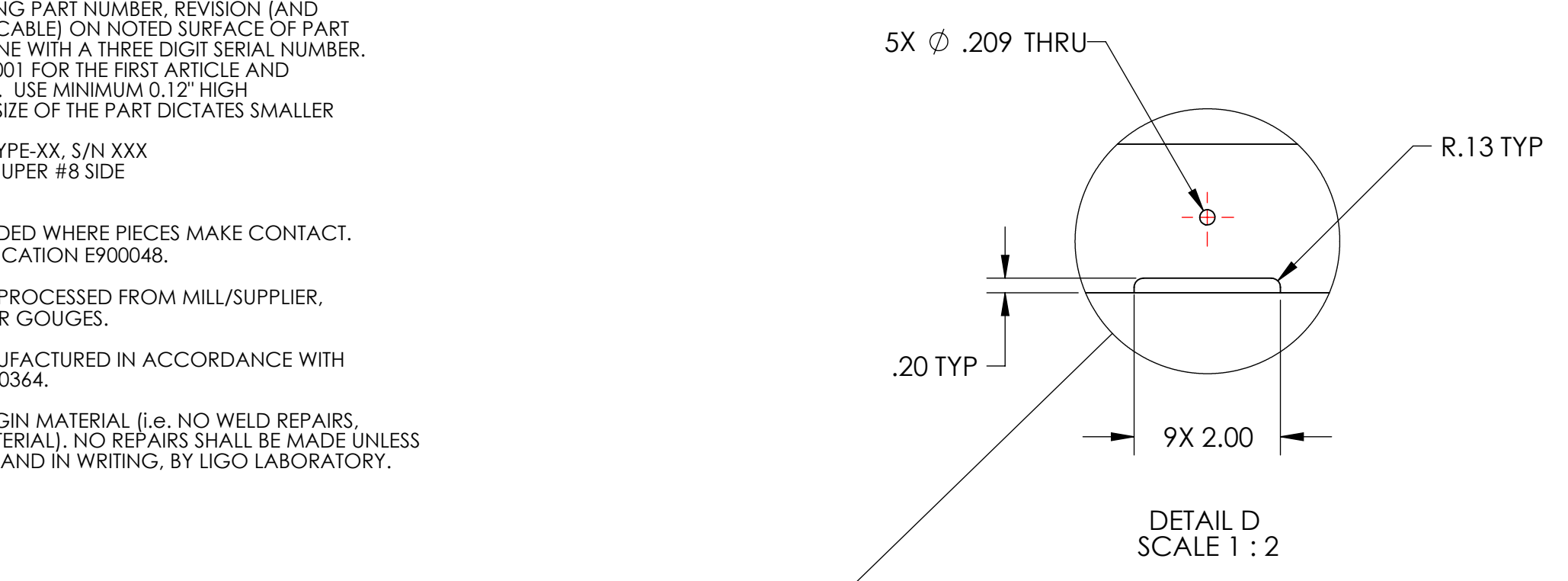
FOR QUOTE ONLY

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)				LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES .005-.015 ON ALL EDGES AND HOLES. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.				<b>SYSTEM</b> ADVANCED LIGO		<b>SUB-SYSTEM</b> AOS	
<b>MATERIAL</b> 18 GAUGE 304 SSTL				<b>FINISH</b> SUPER #8 (9)		<b>PART NAME</b> RIGHT FACE PLATE, ETM X	
<b>DIMENSIONS ARE IN</b> TOLERANCES: .XX ± .06 .XXX ± .010 ANGULAR ± 0.5°				<b>DESIGNER</b> TQ. NGUYEN		<b>DATE</b> 4 DEC 2010	
<b>NEXT ASSY</b> D1003183				<b>CHECKER</b> M. SMITH		<b>SIZE</b> D	
<b>APPROVAL</b> D. COYNE				<b>DWG. NO.</b> D1003189		<b>REV.</b> v2	
<b>SCALE:</b> 1:6				<b>PROJECTION:</b>		<b>SHEET 1 OF 1</b>	

D:\003189\aligo\_MonField\_Cryo\_Baffle\_Right\_Half\_Face\_Plate\_ETM\_X\_H1\_PART\_PDM\_REV\_X.030\_DRAWING\_PDM\_REV\_X.024

- NOTES CONTINUED:**
- ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS. UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE
  - ⑥ CONE AND LIP TO BE WELDED WHERE PIECES MAKE CONTACT. WELD MUST BE PER SPECIFICATION E900048.
  - ⑦ SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER. FREE FROM SCRATCHES OR GOUGES.
  - 8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
  - 9. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

REV.	DATE	DCN #	DRAWING TREE #
v1	28 JUL 2010	E1000360-v2	-
v2	17 OCT 2011	E1000360-v3	-
-	-	-	-



FOR QUOTE ONLY

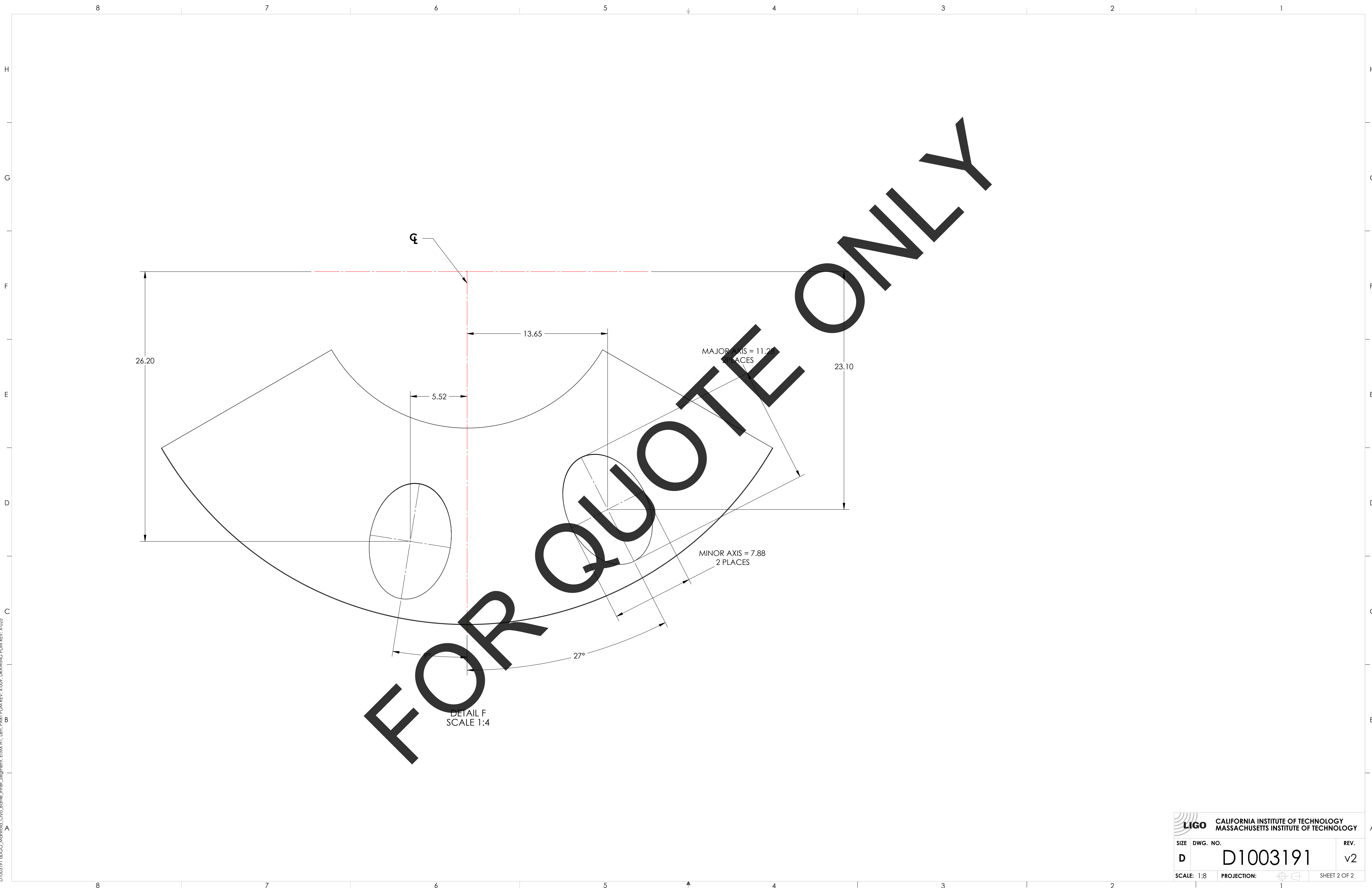
THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D0902656 FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.


NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
DIMENSIONS ARE IN INCHES	
TOLERANCES: .XX ± .06 .XXX ± .010	
ANGULAR ± 0.5°	
MATERIAL	FINISH
18 GAUGE 304 SSSL	⑦ SUPER #8

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
SYSTEM	SUB-SYSTEM
ADVANCED LIGO	AOS
NEXT ASSY	D1003188

PART NAME				MANIFOLD-CRYO BAFFLE INNER SEGMENT WELDMENT, ETMX H1, LEFT			
DESIGNER	TQ. NGUYEN	6 DEC 2010	SIZE	D	DWG. NO.	D1003191	REV.
DRAFTER	TQ. NGUYEN	7 DEC 2010					v2
CHECKER	M. SMITH						
APPROVAL	D. COYNE		SCALE:	1:8	PROJECTION:		SHEET 1 OF 2

D:\003191\dl\GCO\_MonField\_Cryo\_Baffle\_Inner\_Segment1\_ETMX\_H1\_Left\_Plate\_PDM\_REV-X-009\_Drawing\_PDM\_REV-X-025



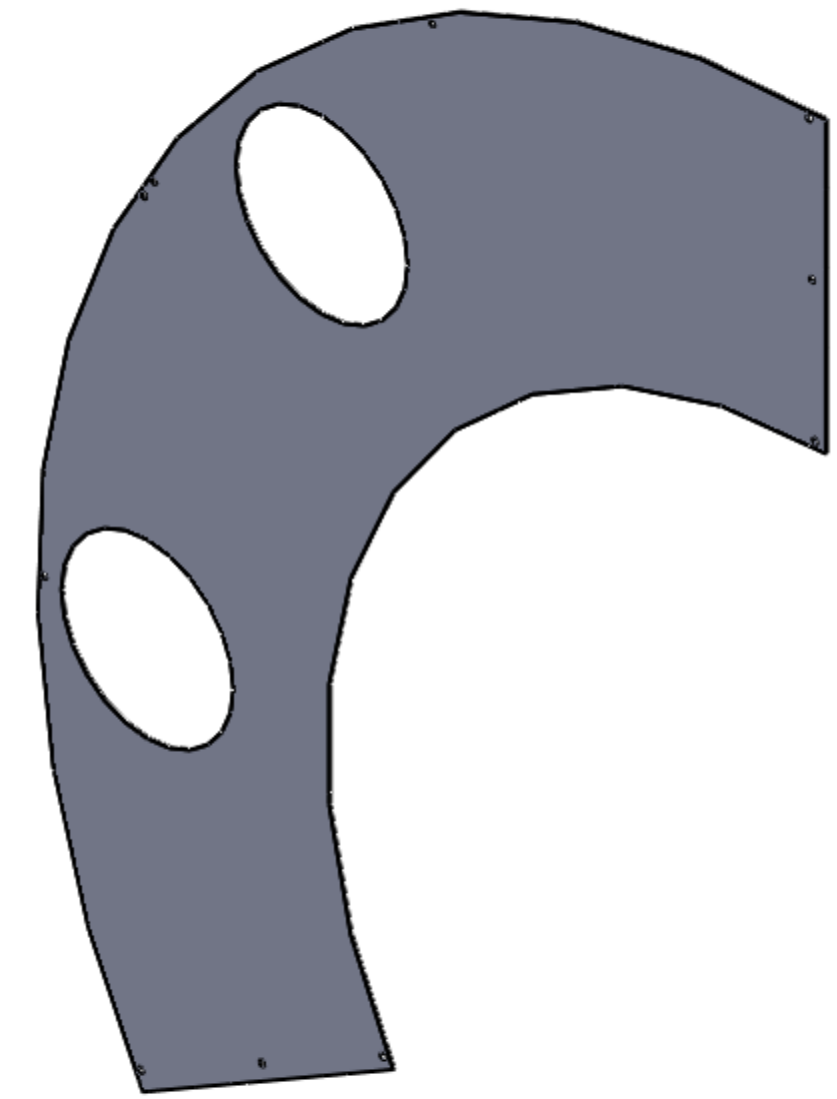
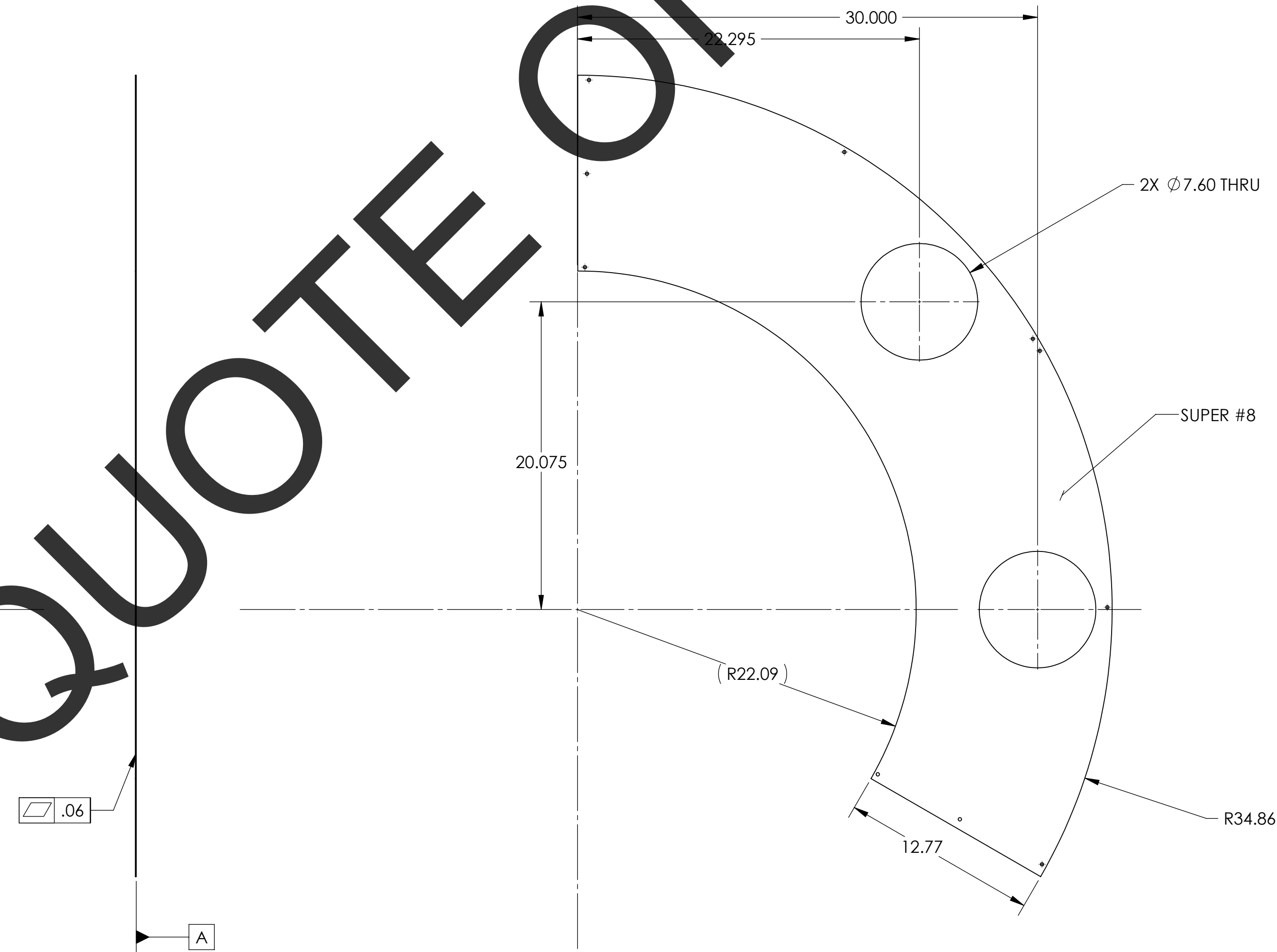
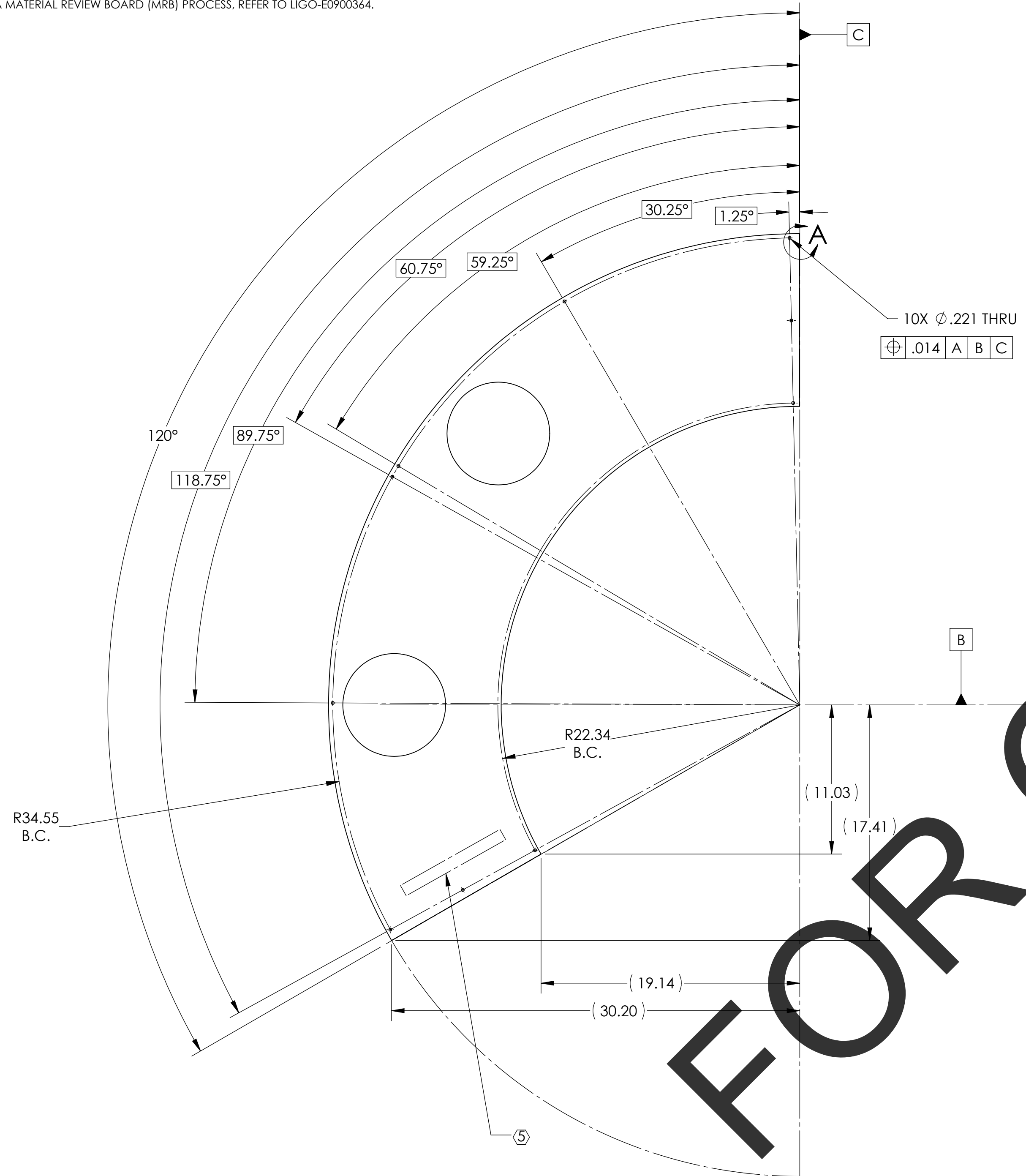
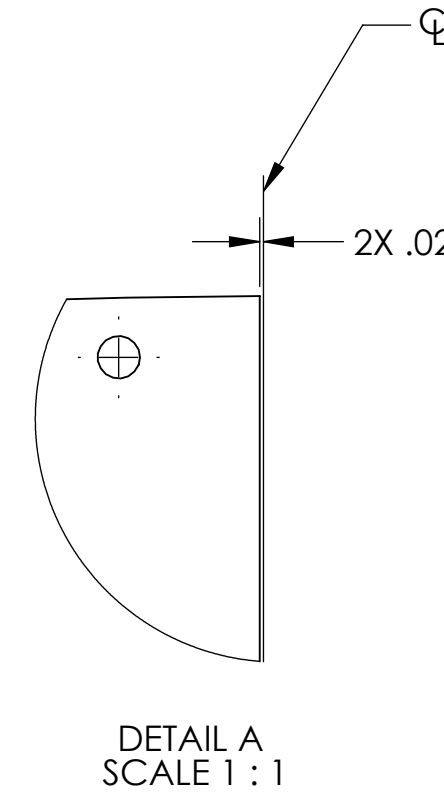
 <b>CALIFORNIA INSTITUTE OF TECHNOLOGY</b> <b>MASSACHUSETTS INSTITUTE OF TECHNOLOGY</b>		
SIZE	DWG. NO.	REV.
D	D1003191	v2
SCALE: 1:8	PROJECTION:	SHEET 2 OF 2

D:\003191\dl\G0\_MonField\_Cryo\_Baffle\_Inner\_Segment1\_ETMX-H1\_L1.dwg PDM REV. X:009 DRAWING PDM REV. X:025

- NOTES CONTINUED:**
- 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBERS, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBERS. SERIAL NUMBERS START AT 001 FOR FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM .12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPEXX, S/N XXX. DO NOT APPLY MARK ON SUPER #8 SIDE.
  - 6. APPROXIMATE WEIGHT = 11.074 LBS.
  - 7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
  - 8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (I.E. NOT WELD REPAIRS OR PLUGS) UNLESS APPROVED IN ADVANCE IN WRITING BY LIGO. REFER TO LIGO-E0900364.
  - 9. NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. IN GENERAL WELD REPAIRS AND PRESS FIT INSERT REPAIRS ARE NEVER ACCEPTABLE; THE MATERIAL SHOULD BE MADE WITH VIRGIN MATERIAL. SPECIAL CIRCUMSTANCES CAN BE REVIEWED IF / WHEN BROUGHT TO THE ATTENTION OF LIGO CONTRACTING OFFICER'S REPRESENTATIVE (COIR) THROUGH A MATERIAL REVIEW BOARD (MRB) PROCESS. REFER TO LIGO-E0900364.

10. PART TO BE OXIDIZED PER LIGO SPECIFICATION E1100842.

REV.	DATE	DCN #	DRAWING TREE #
v1	17 MAY 2011	E1000360	-
v2	30 OCT 2012	-	-
-	-	-	-



FOR QUOTE ONLY

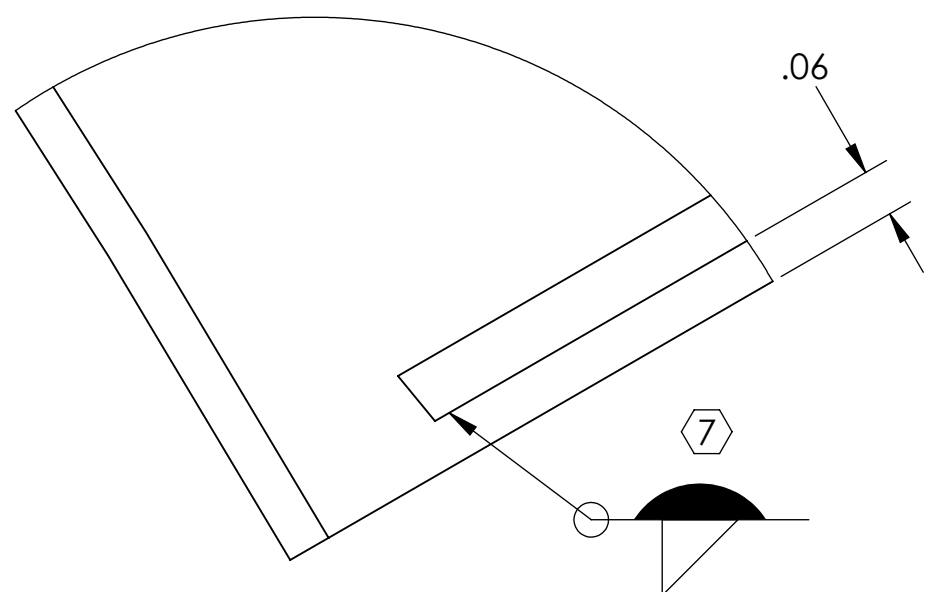
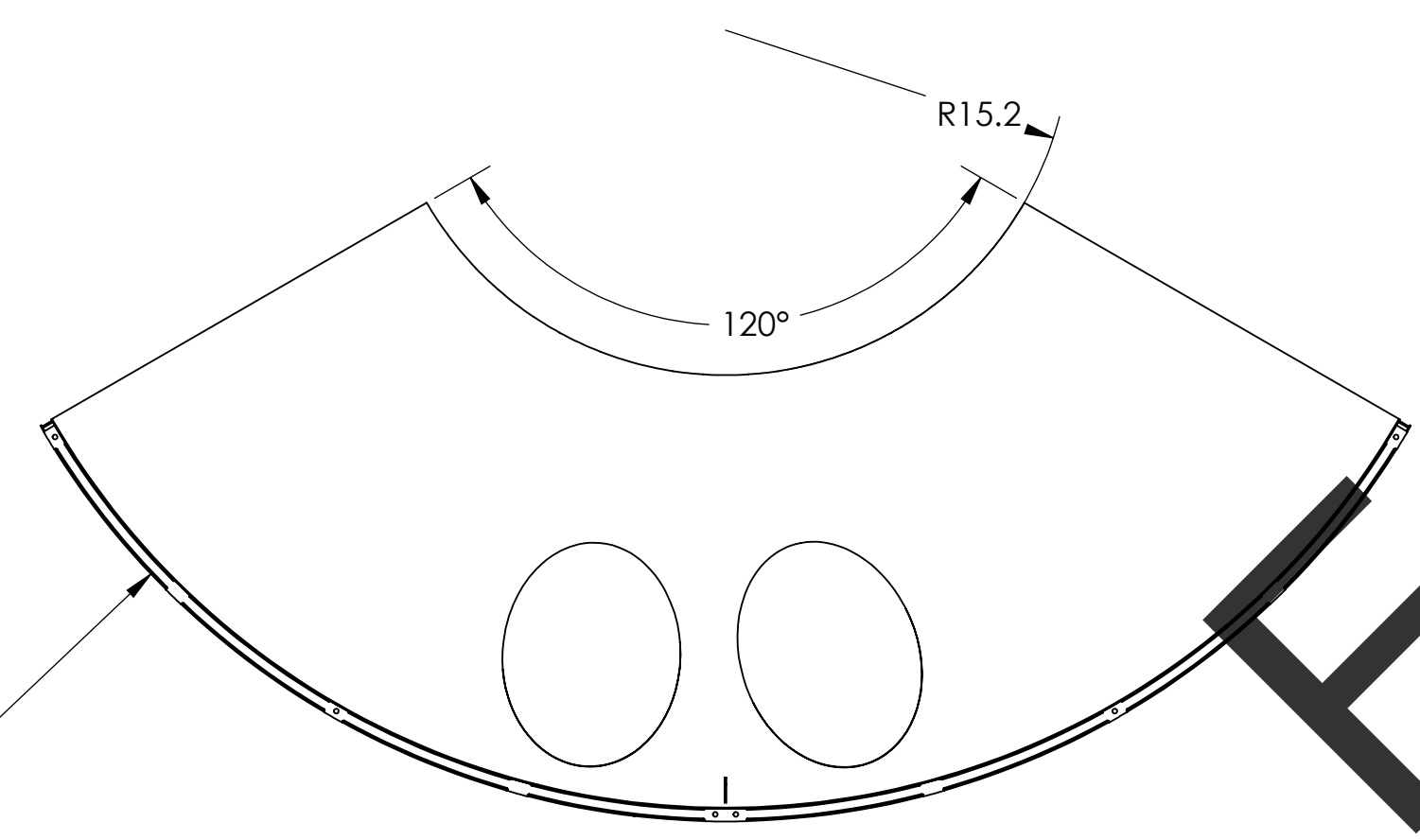
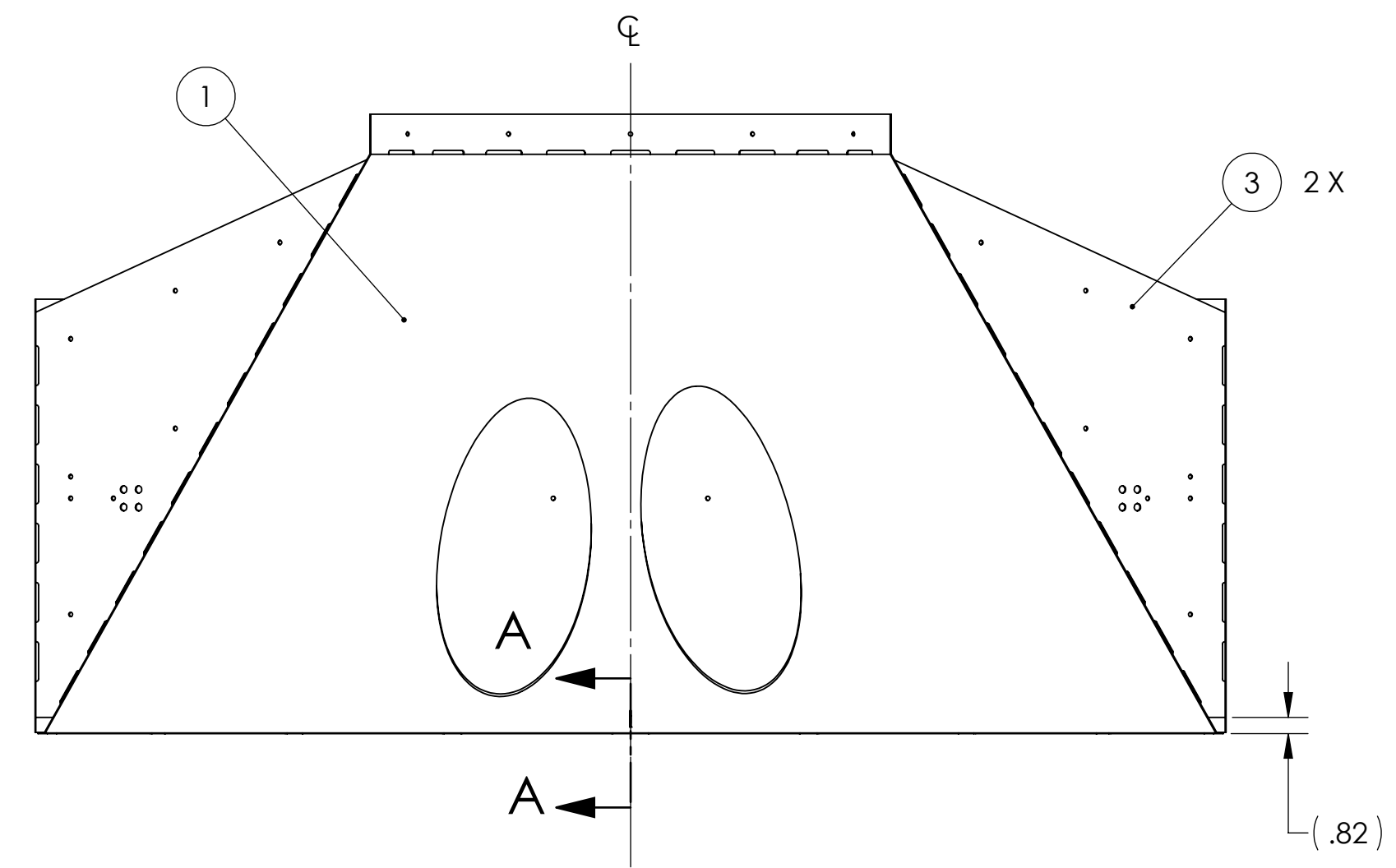
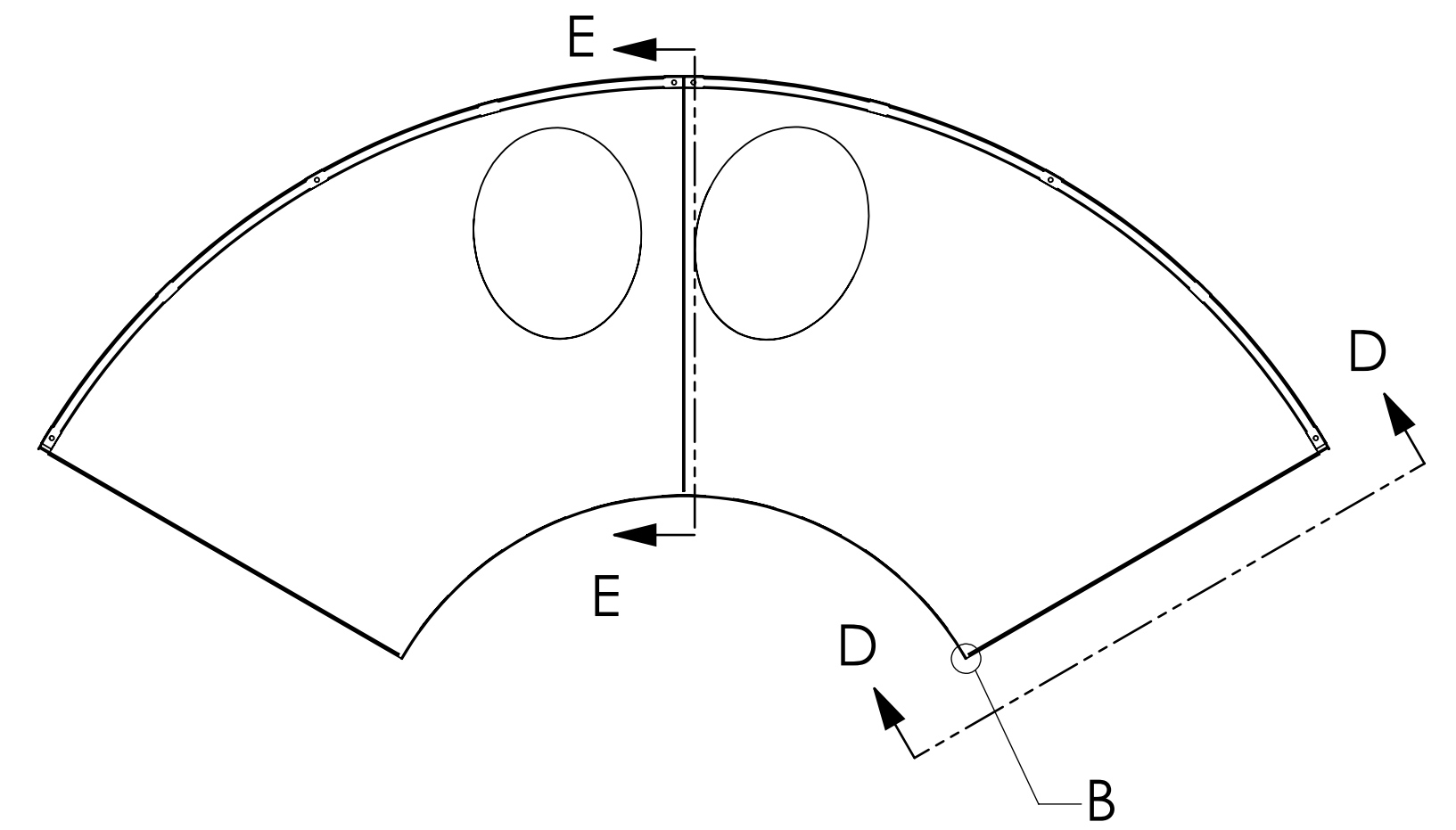
NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)				LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME			
DIMENSIONS ARE IN INCHES TOLERANCES: .XX ± .06 .XXX ± .010 ANGULAR ± 0.5°				1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, R.02 MIN. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		LEFT FACE PLATE, ETM X			
						MATERIAL 18 GAUGE 304 SSTL FINISH SUPER #8 10		SYSTEM ADVANCED LIGO SUB-SYSTEM AOS	
				NEXT ASSY D1003183		CHECKER M. SMITH		REV. v2	
						APPROVAL D. COYNE		SCALE: 1:6 PROJECTION: SHEET 1 OF 1	

NOTES CONTINUED:  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK OR MECHANICALLY STAMP (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS. UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX

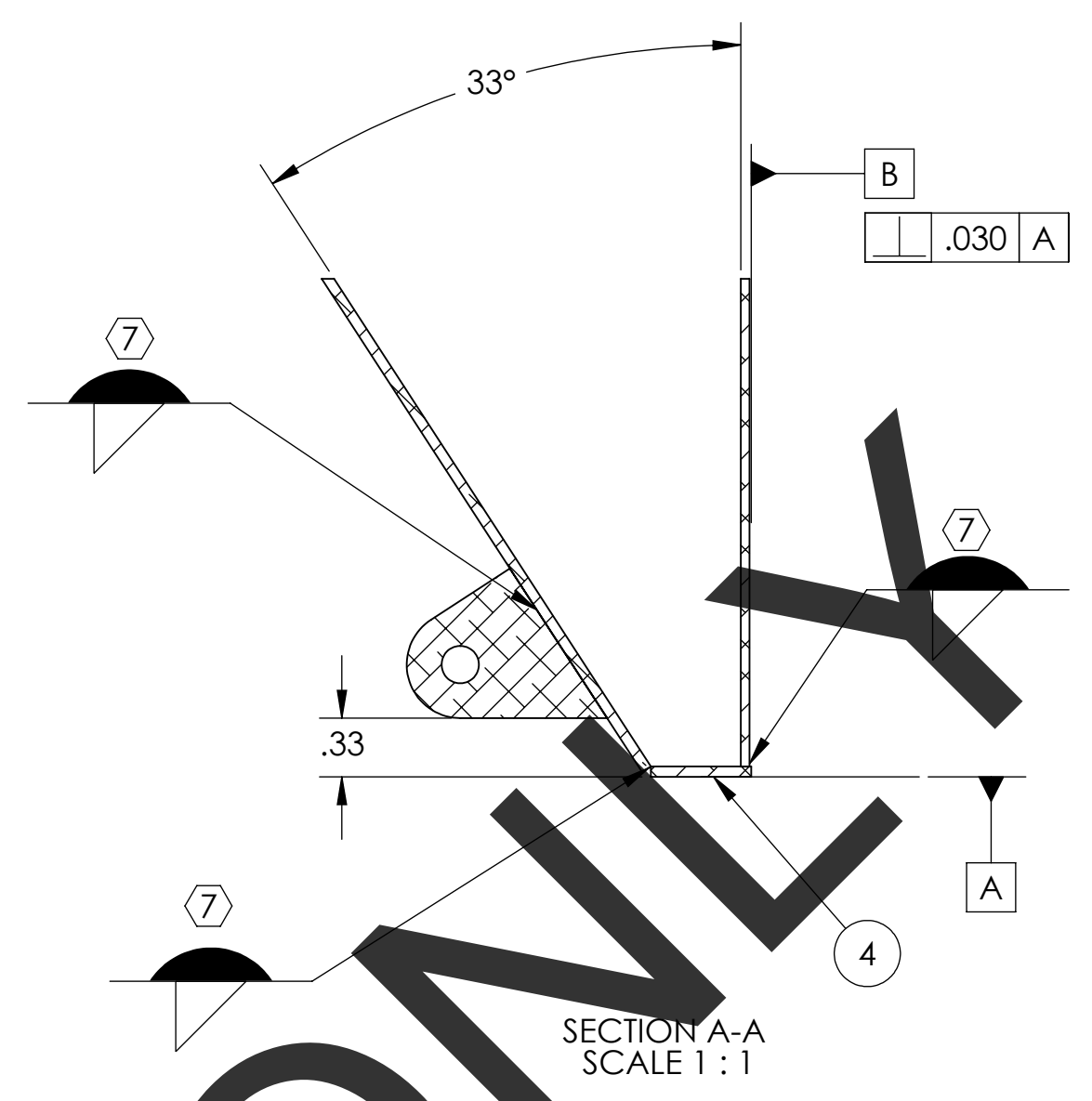
6. ASSEMBLY TO BE OXIDIZED AFTER WELDMENT IS COMPLETED PER SPECIFICATION E1100842.

7. FILLET WELDS WHERE ITEMS 1 & 3, 1 & 5, 2 & 3, 1 & 4 MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048

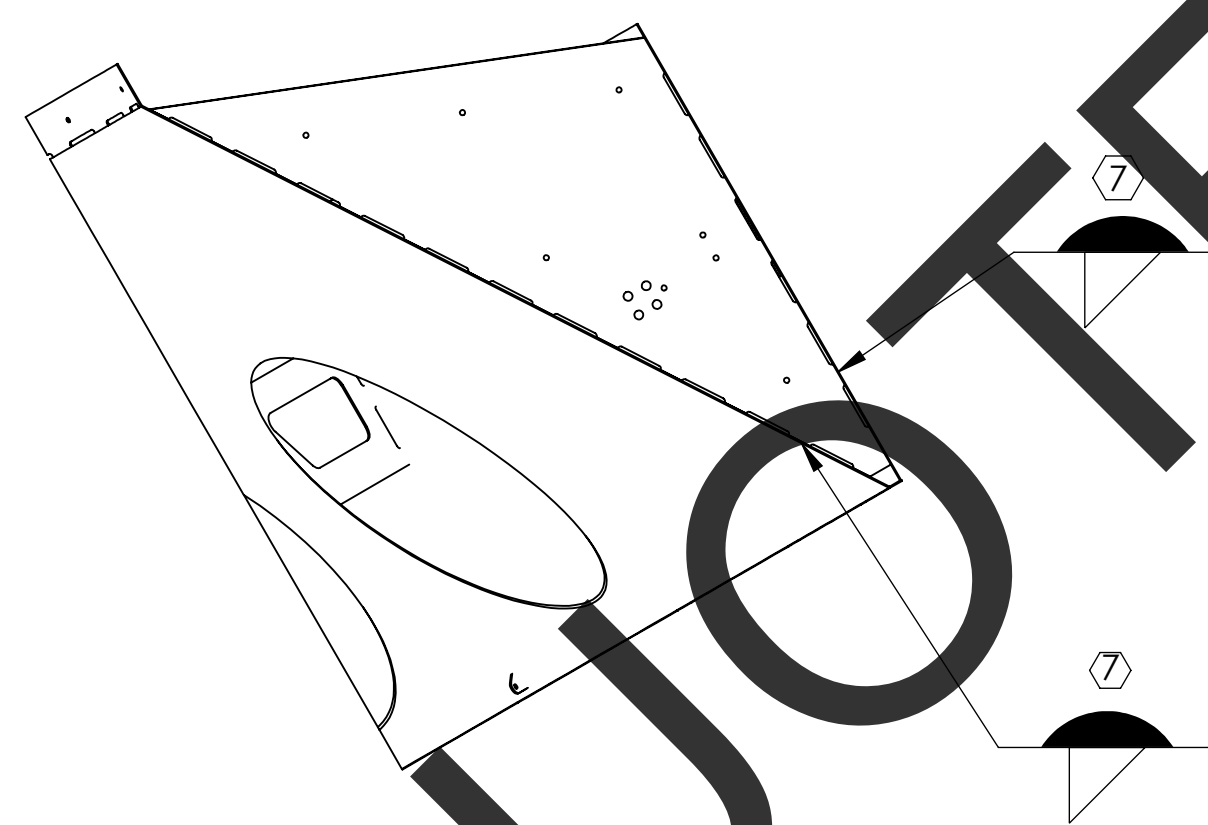
REV.	DATE	DCN #	DRAWING TREE #
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v2	17 OCT 2011	E1000360-v3	-
-	-	-	-



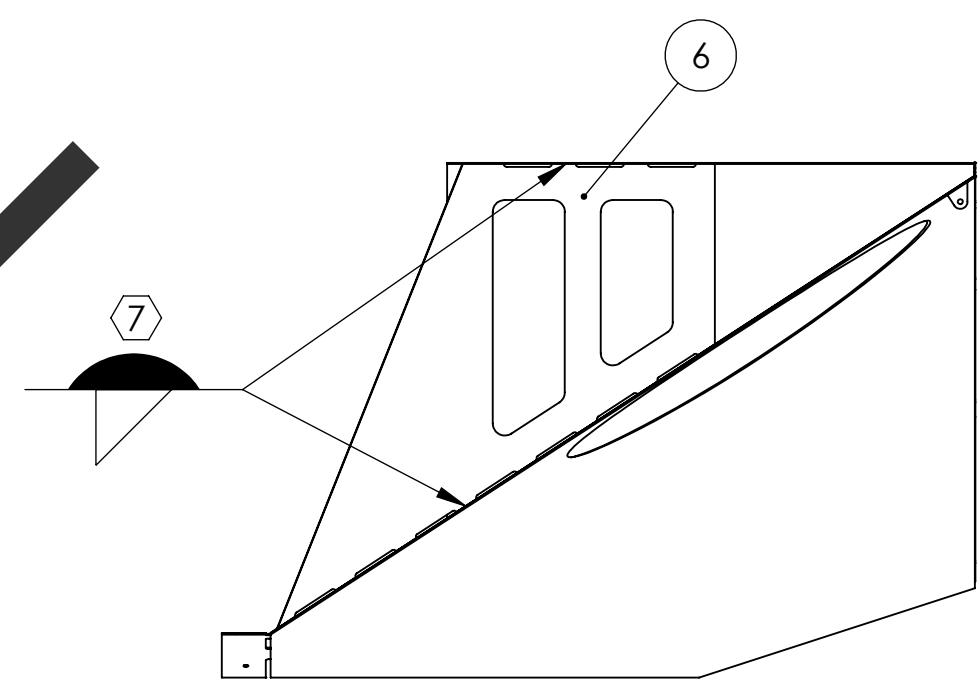
DETAIL B  
SCALE 4 : 1



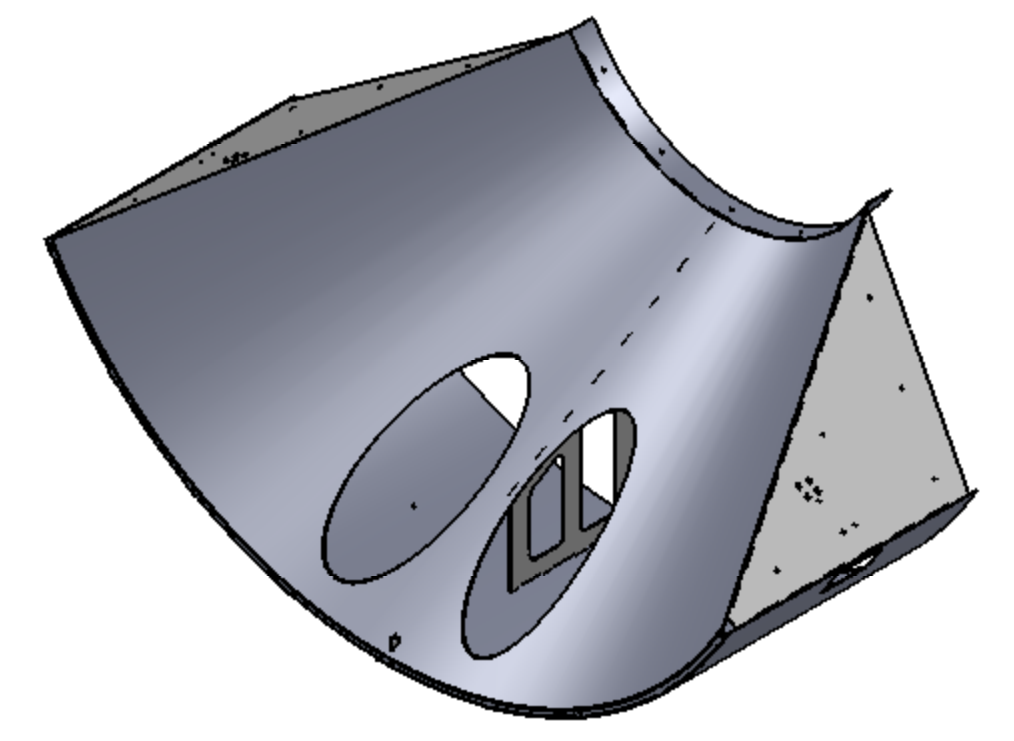
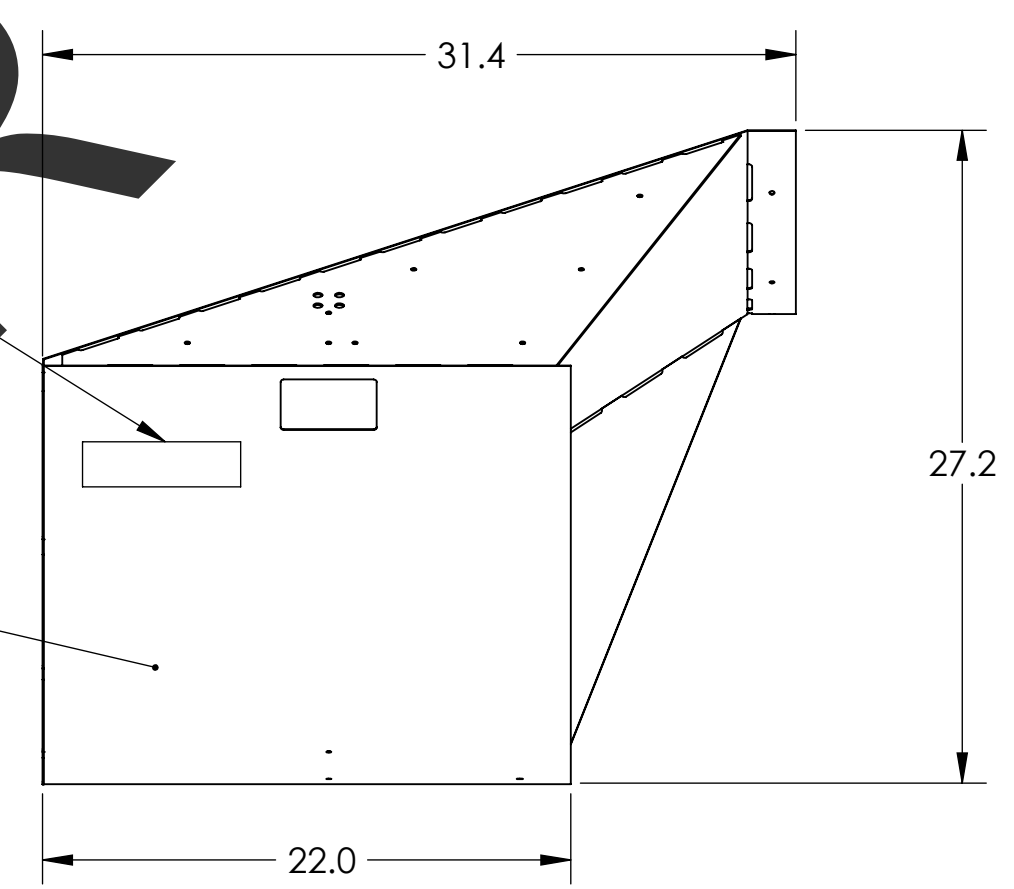
SECTION A-A  
SCALE 1 : 1



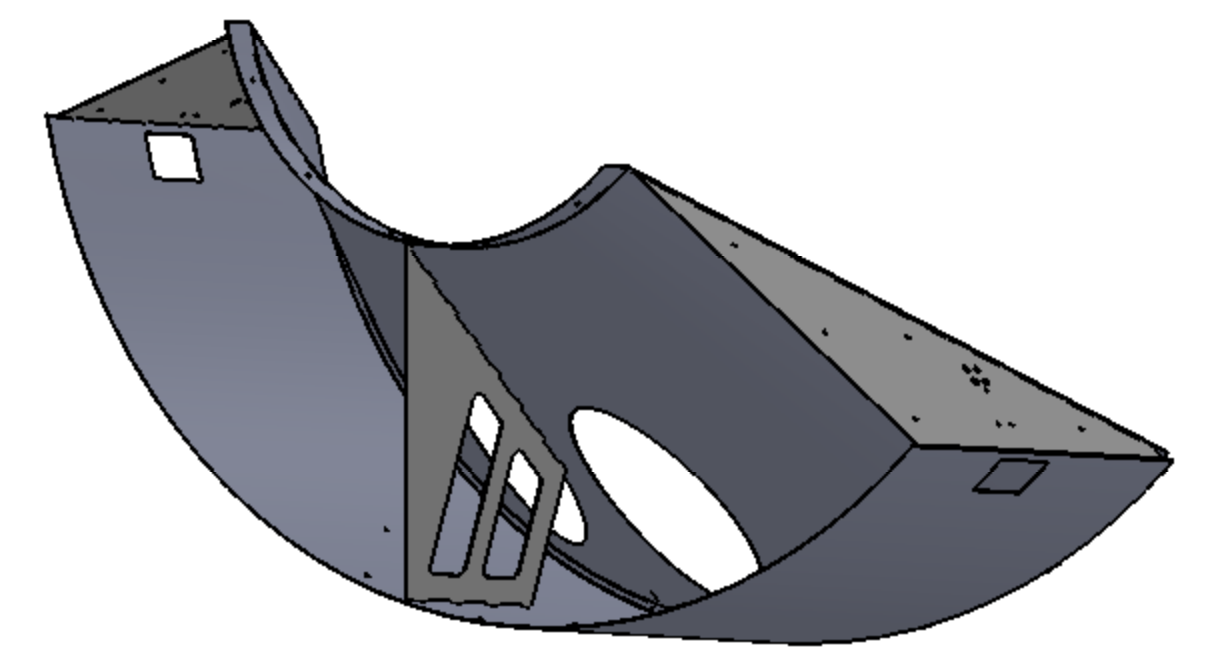
SECTION D-D



SECTION E-E



GENERAL VIEW  
FOR REFERENCE ONLY  
NO SCALE



FOR QUOTE ONLY

ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ	SPARE	TOTAL
6	D1002849	MANIFOLD CRYO BAFFLE WELDMENT BRACE	14 GAUGE 304 SSSL	1		1
5	D1000536	BAFFLE BRACE BRACKET	14 GAUGE 304 SSSL	1		1
4	D1001073	RADIAL ATTACHMENT NUT PLATE	14 GAUGE 304 SSSL	1		1
3	D0902621	MANIFOLD CRYO BAFFLE BRACKET	14 GAUGE 304 SSSL	2		2
2	D0902620	RADIAL SEGMENT, BOTTOM	18 GAUGE 304 SSSL	1		1
1	D1003230	MANIFOLD-CRYO BAFFLE INNER SEGMENT, ETMY H1, BOTTOM	18 GAUGE 304 SSSL	1		1

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)  
 1. INTERPRET DRAWING PER ASME Y14.5-1994.  
 2. REMOVE ALL SHARP EDGES .005-.015 ON ALL EDGES AND HOLES.  
 3. DO NOT SCALE FROM DRAWING.  
 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

DIMENSIONS ARE IN INCHES  
 TOLERANCES:  
 .X ± .1  
 .XX ± .06  
 .XXX ± .010  
 ANGULAR ± 1.0°

MATERIAL: N/A  
 FINISH: N/A

**LIGO** CALIFORNIA INSTITUTE OF TECHNOLOGY  
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO  
 SUB-SYSTEM: AOS  
 NEXT ASSY: D1003227

PART NAME: MANIFOLD -CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMY H1, BOTTOM

DESIGNER: TQ, NGUYEN  
 DRAFTER: TQ, NGUYEN  
 CHECKER: M. SMITH  
 APPROVAL: D. COYNE

DATE: 16 DEC 2010  
 DATE: 29 JUL 2011

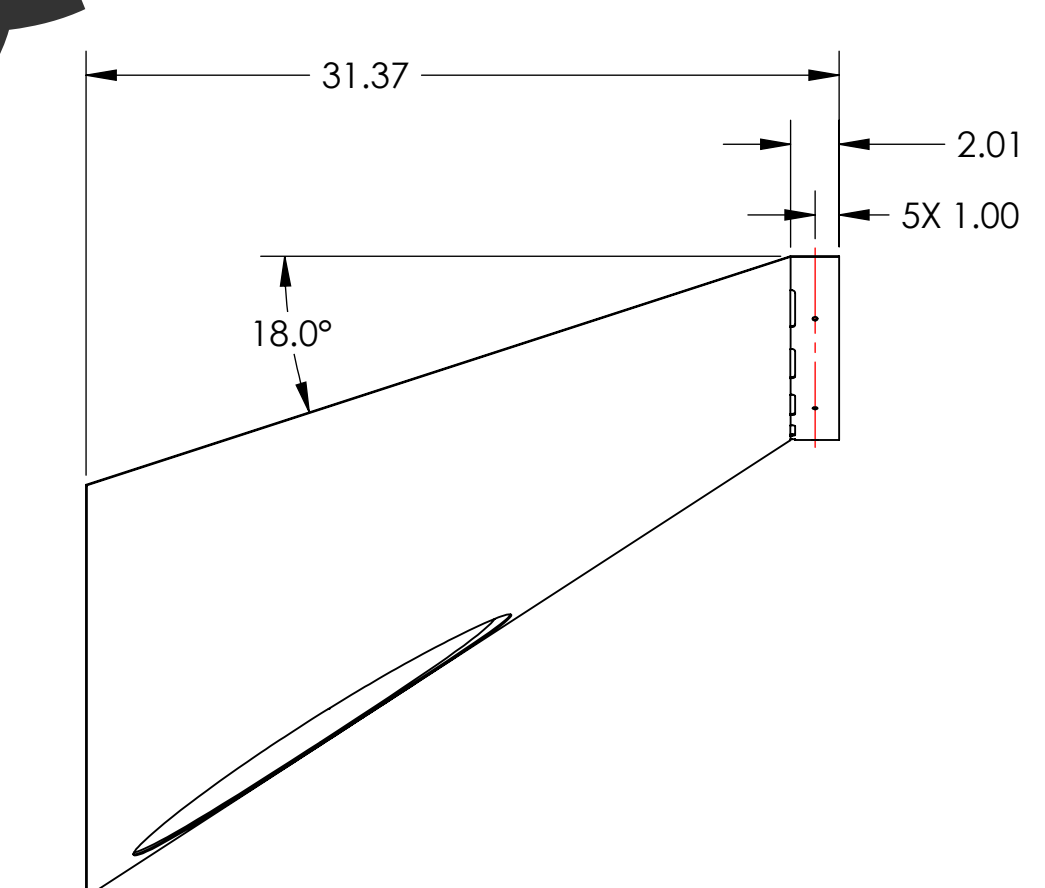
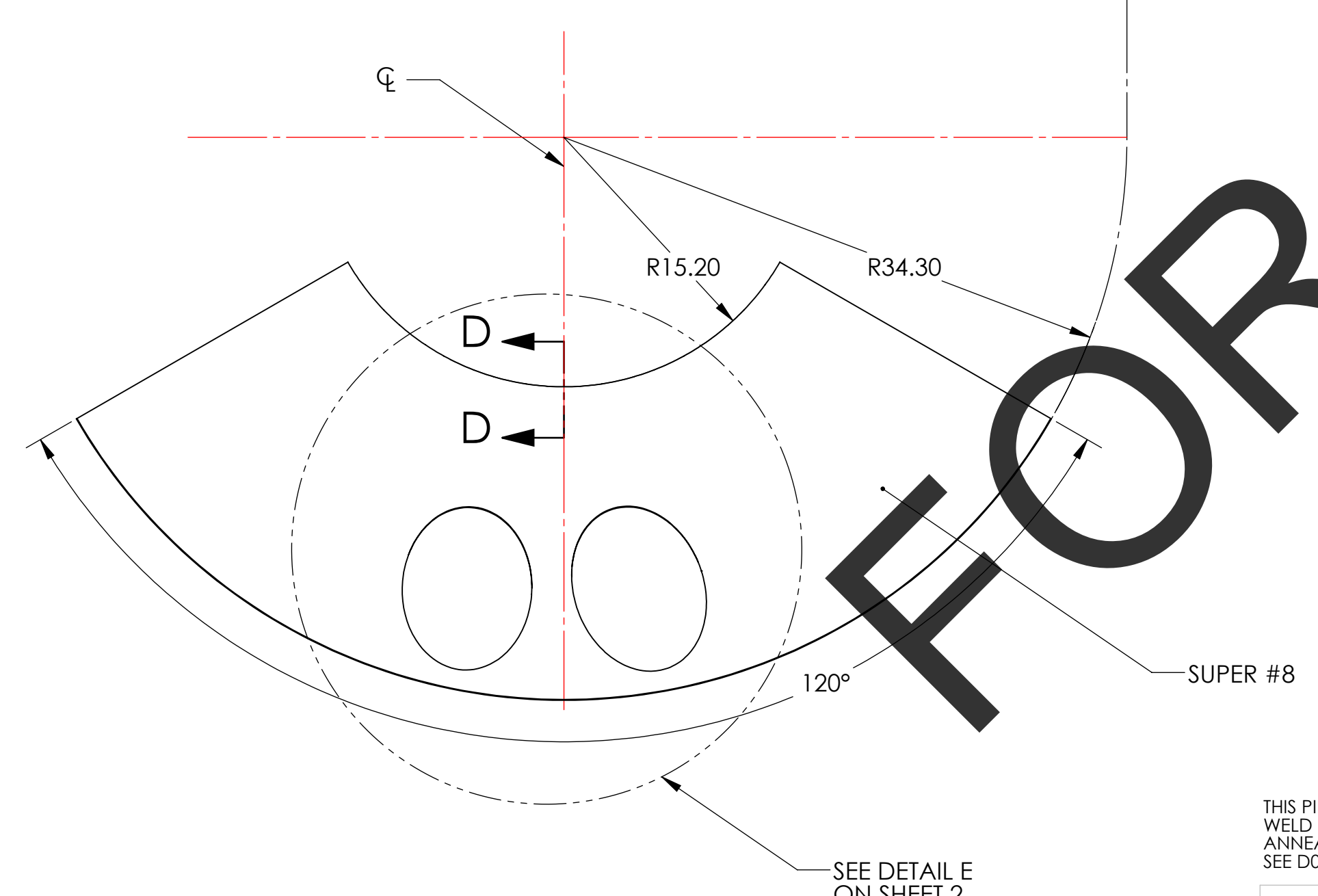
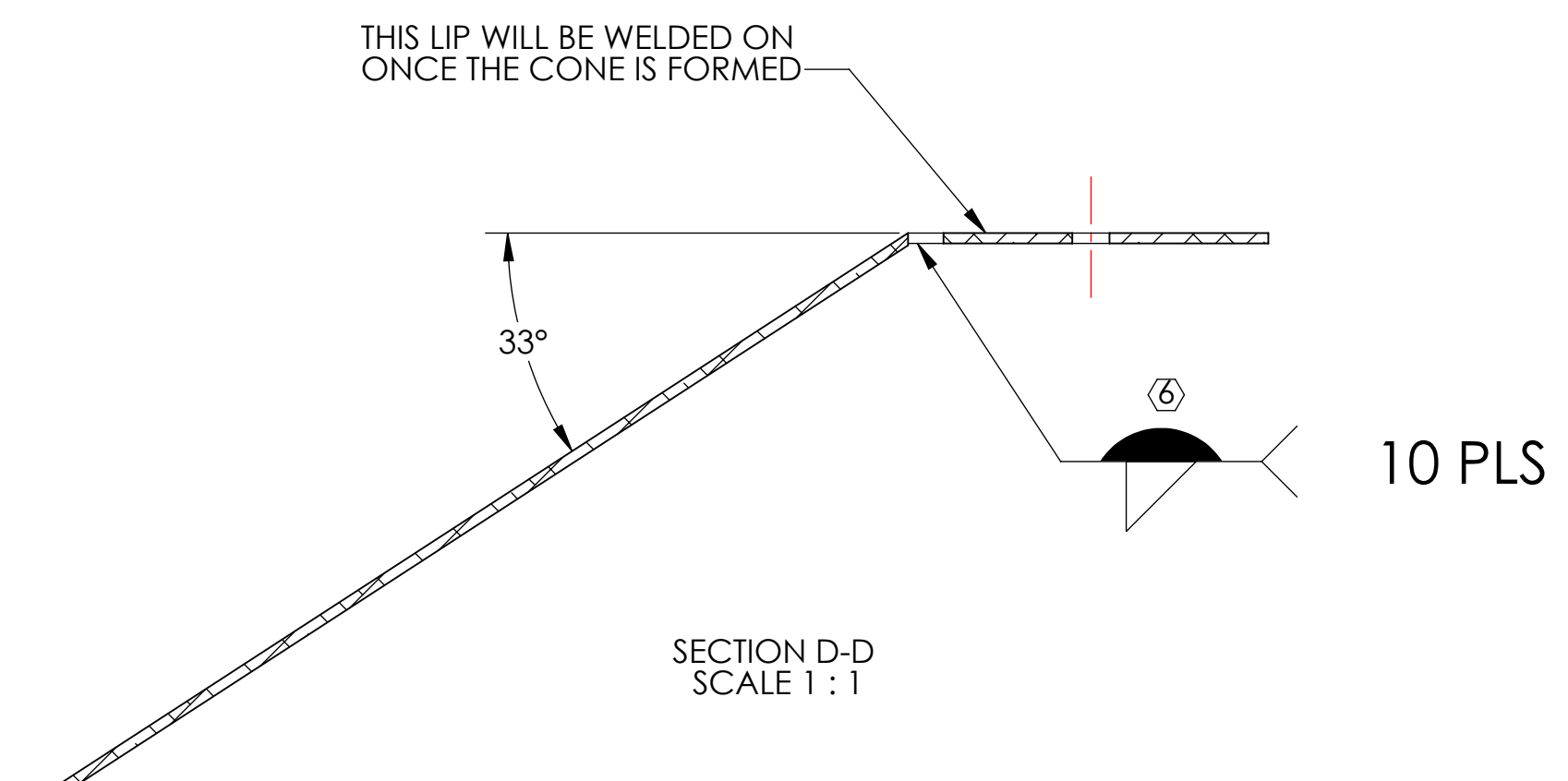
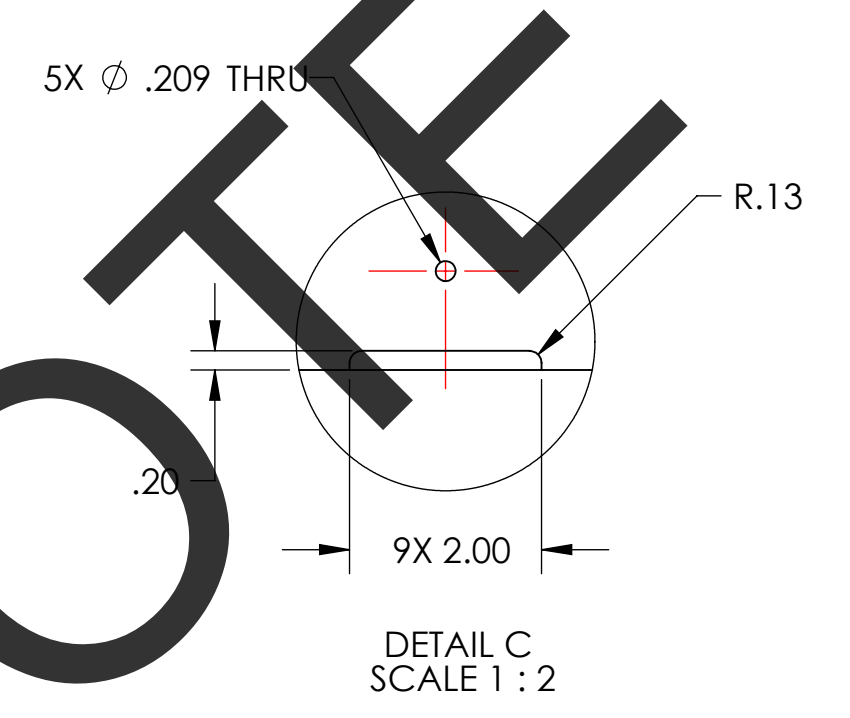
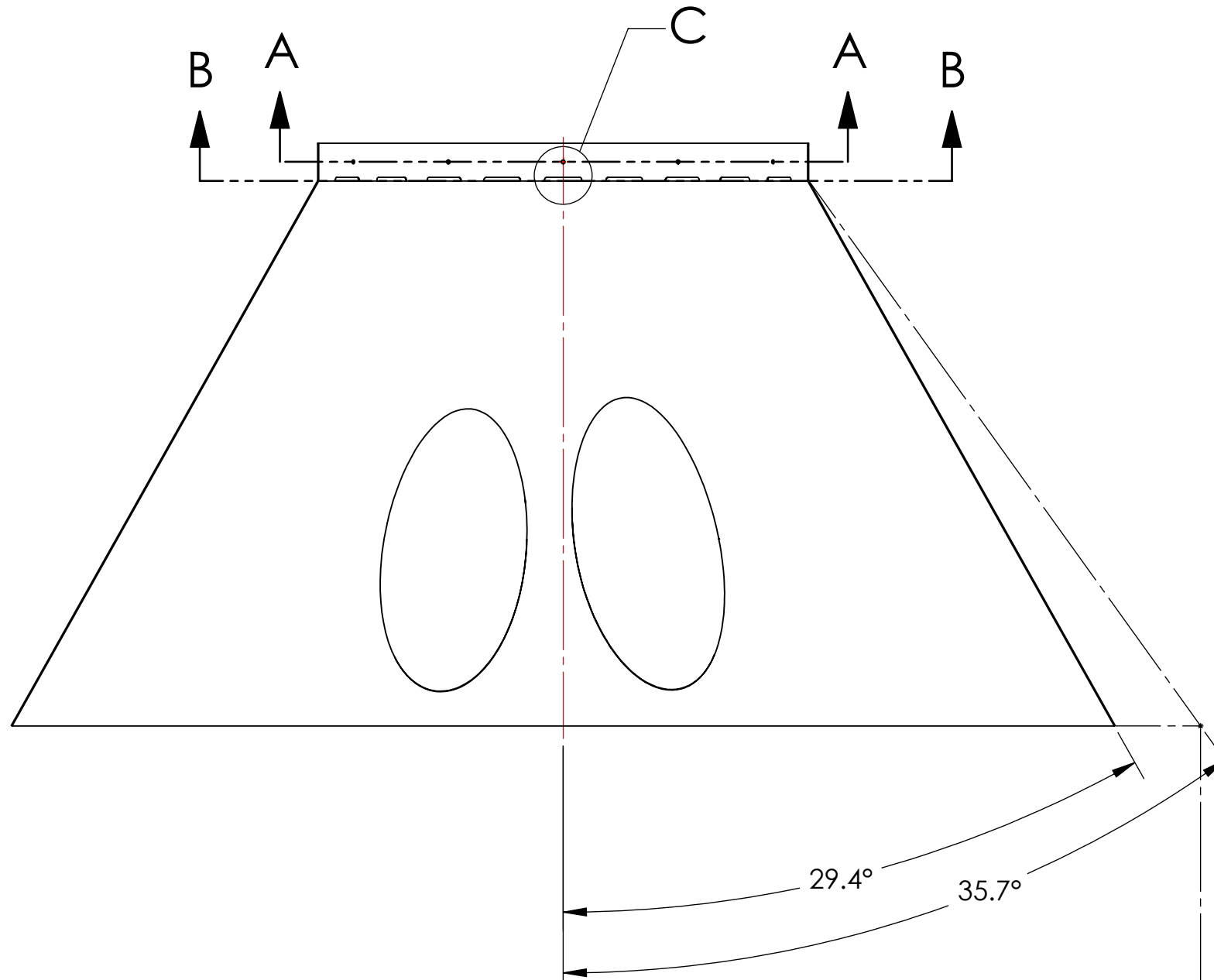
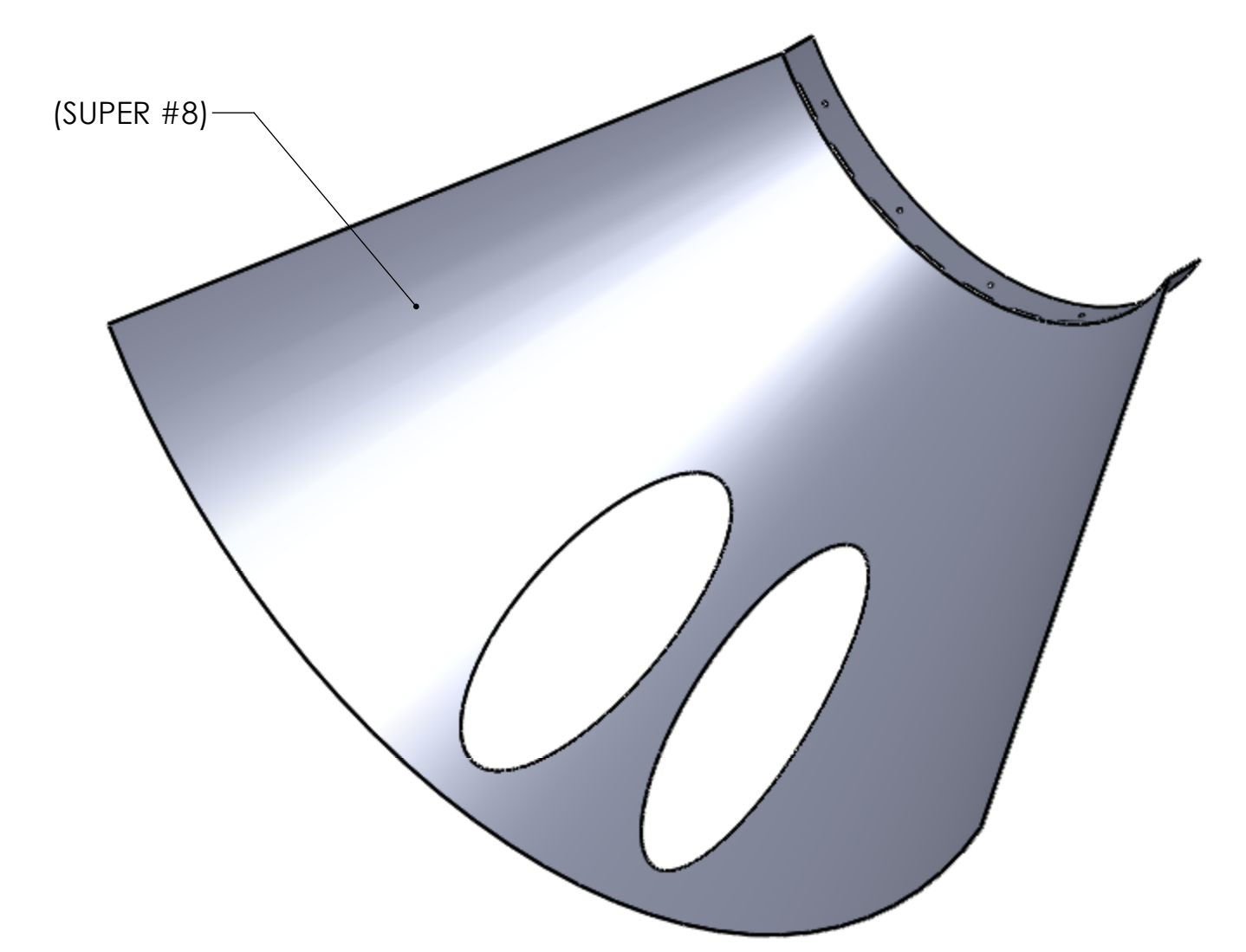
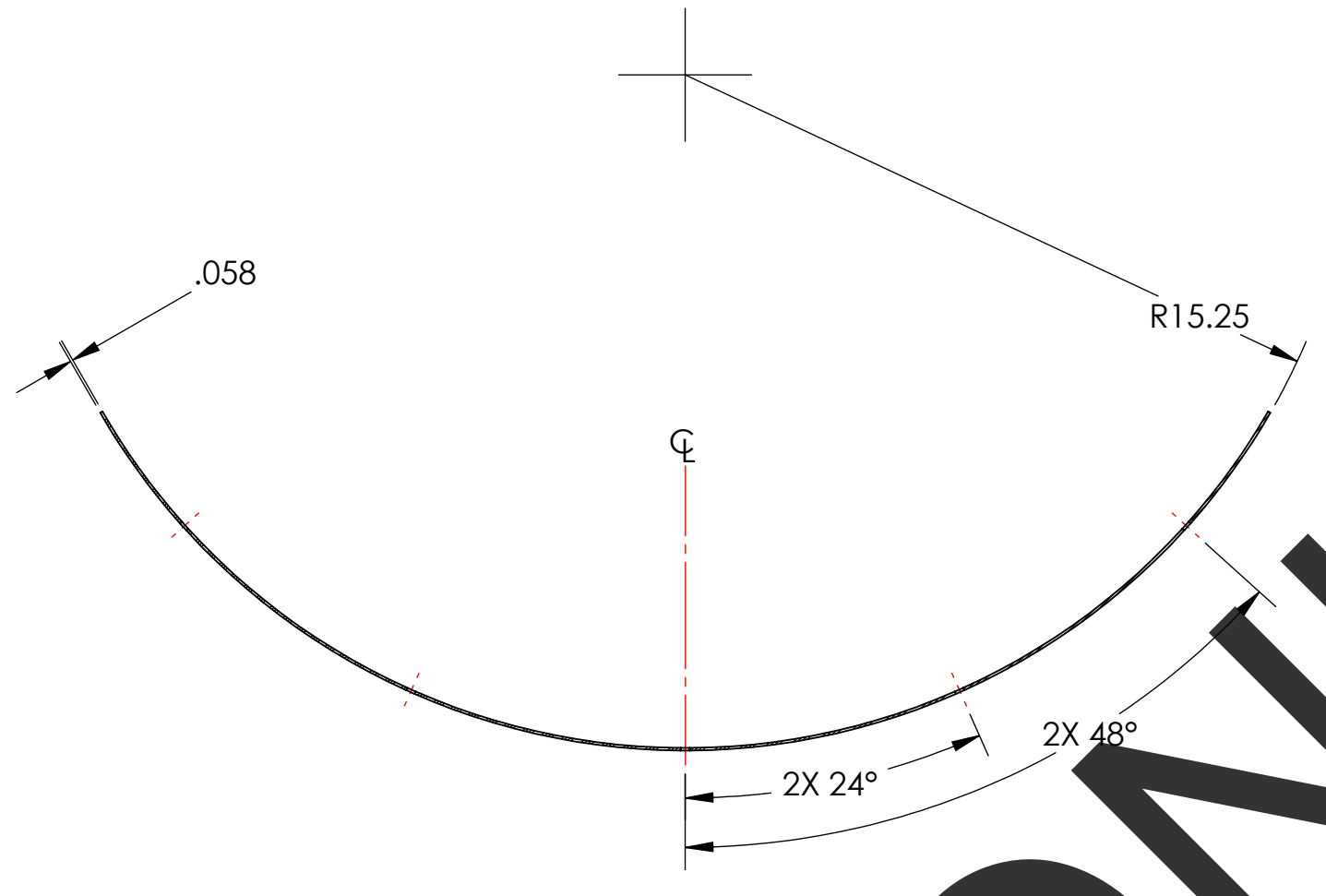
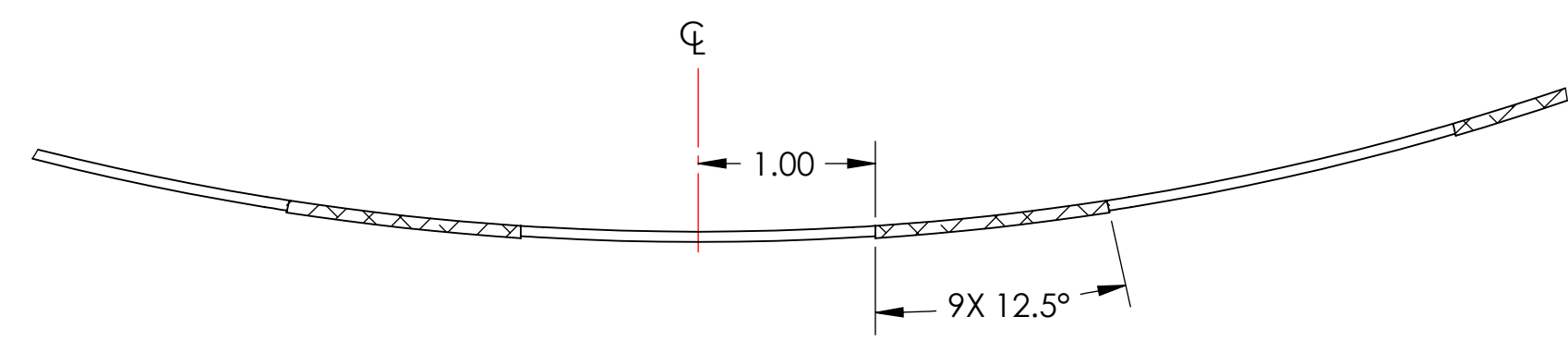
SIZE: D  
 DWG. NO.: D1003229  
 REV.: v2

SCALE: 1:8  
 PROJECTION: [Symbol]  
 SHEET 1 OF 1

D1003229\_dLIGO\_Manifold\_Cryo\_Baffle\_Segment\_Subassembly\_Weldment\_ETMY\_H1\_Bottom\_PARR\_PDM\_REV\_K006\_DRAWING\_PDM\_REV\_X001

- NOTES CONTINUED:**
- 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES), DRAWING PART NUMBER, REVISION (AND VARIANT OR TYPE IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE
  - 6. CONE AND LIP TO BE WELDED WHERE PIECES MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048.
  - 7. DELETED
  - 8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
  - 9. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.
  - 10. SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

REV.	DATE	DCN #	DRAWING TREE #
V1	07 SEP 2010	E1000360	E1000090
V2	21 OCT 2011	E1000360-V3	-
-	-	-	-



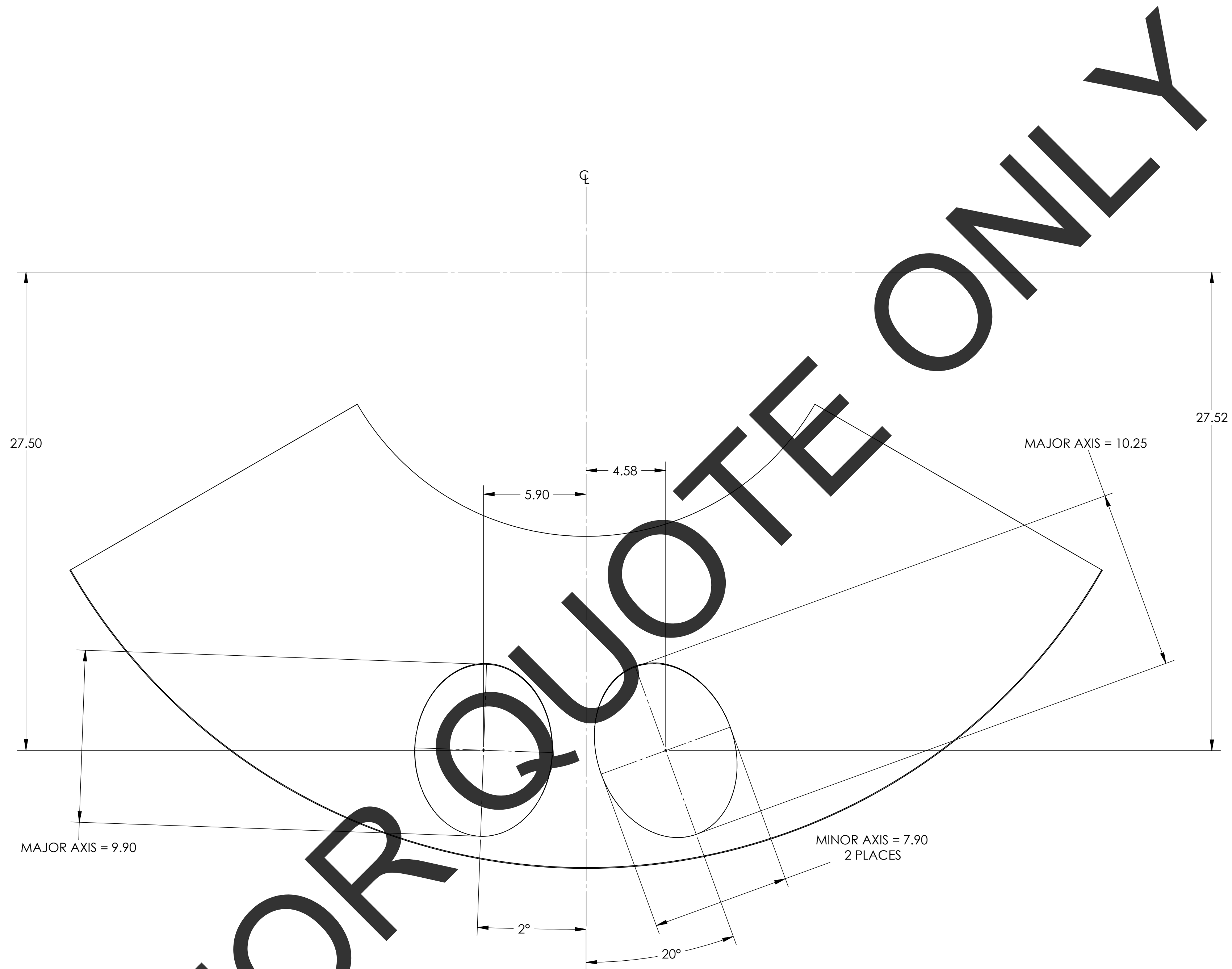
THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D0902654 FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.

DIMENSIONS ARE IN INCHES		TOLERANCES: .XX ± .03 .XXX ± .010		ANGULAR ± 0.5°	
NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)					
1. INTERPRET DRAWING PER ASME Y14.5-1994.					
2. REMOVE ALL SHARP EDGES, .005-.015 ON ALL EDGES AND HOLES.					
3. DO NOT SCALE FROM DRAWING.					
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.					
MATERIAL		FINISH		NEXT ASSY	
18 GAUGE 304 SSTL		10 SUPER #8		D1003229	

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME		MANIFOLD-CRYO BAFFLE INNER SEGMENT, ETMY H1, BOTTOM	
DESIGNER	TQ. NGUYEN	16 DEC 2010	SIZE	DWG. NO.	REV.
DRAFTER	TQ. NGUYEN	17 AUG 2010	D	D1003230	v2
CHECKER	M. SMITH				
APPROVAL	D. COYNE		SCALE: 1:8	PROJECTION:	SHEET 1 OF 2

FOR QUOTE ONLY

D:\003230.dwg\_Monfield\_Cryo\_Baffle\_Inner\_Segment1\_ETMY\_H1\_Bottom\_PART PDM REV: X017, DRAWING PDM REV: X007



DETAIL E  
SCALE 1 : 4

 <b>CALIFORNIA INSTITUTE OF TECHNOLOGY</b> <b>MASSACHUSETTS INSTITUTE OF TECHNOLOGY</b>		REV.
SIZE	DWG. NO.	REV.
D	D1003230	v2
SCALE: 1:8	PROJECTION:	SHEET 2 OF 2

D:\003230.dwg; Montfield\_Cryo\_Baffle\_Inner\_Segment1\_ETMX-H1\_L\_Baffle\_PART.PDM; REV: X017; DRAWING.PDM; REV: X007

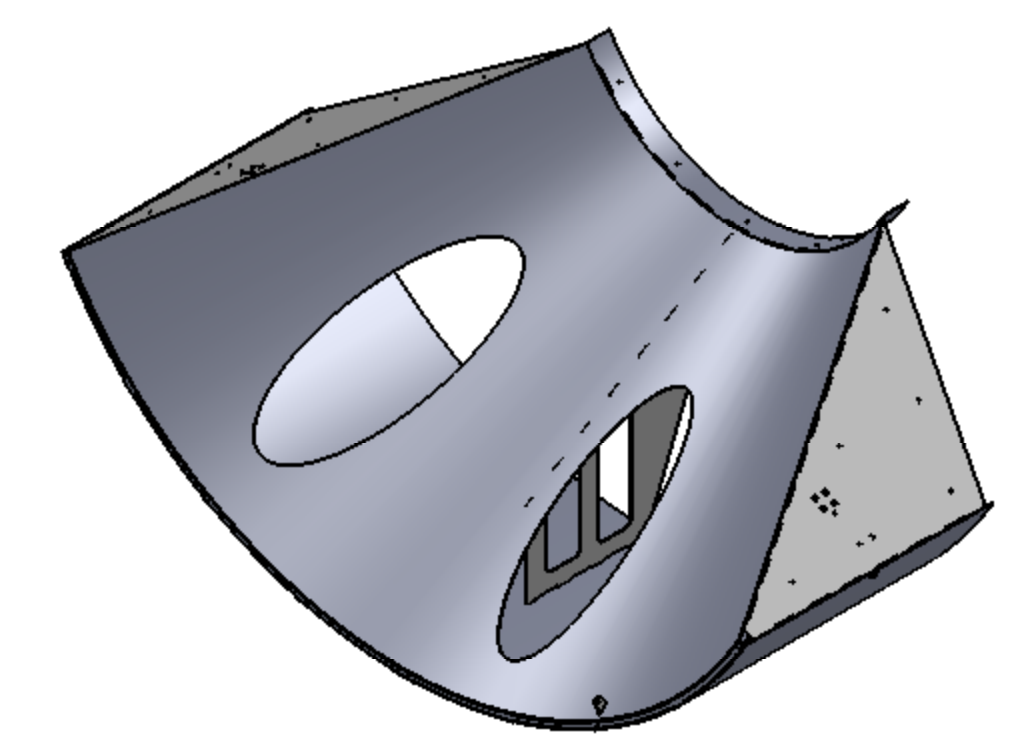
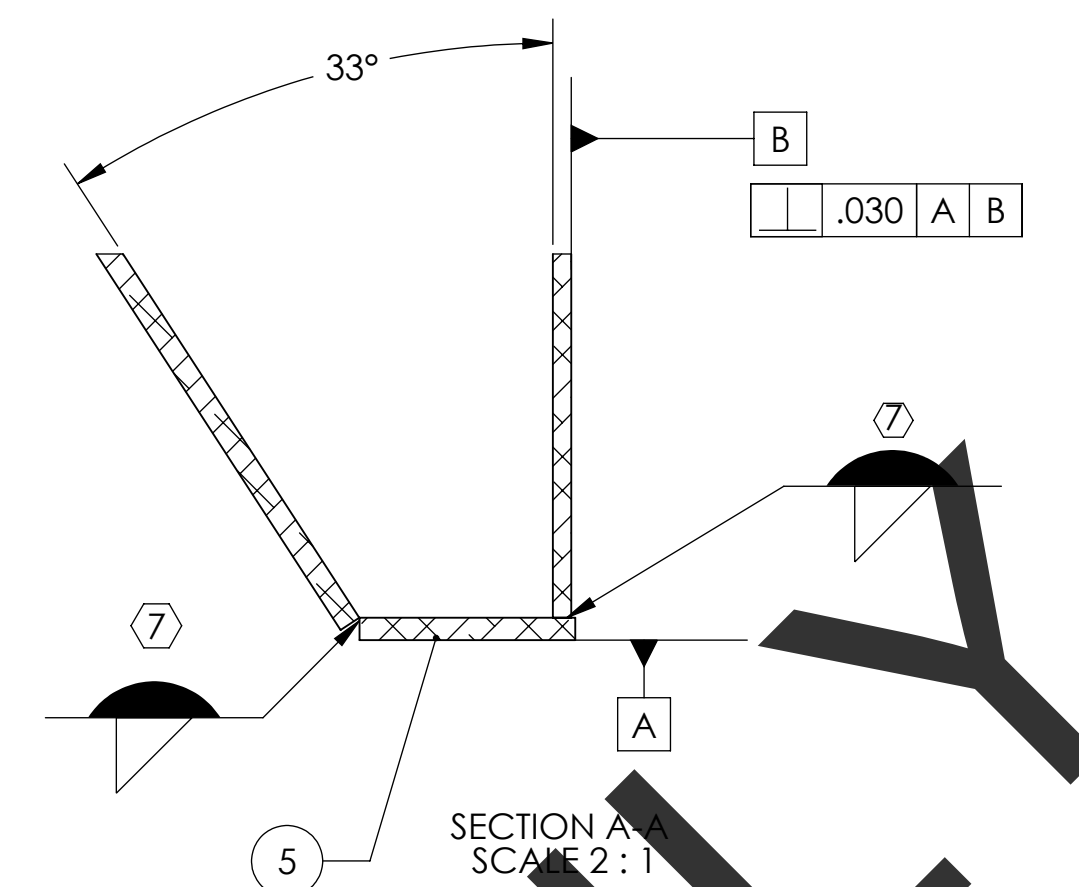
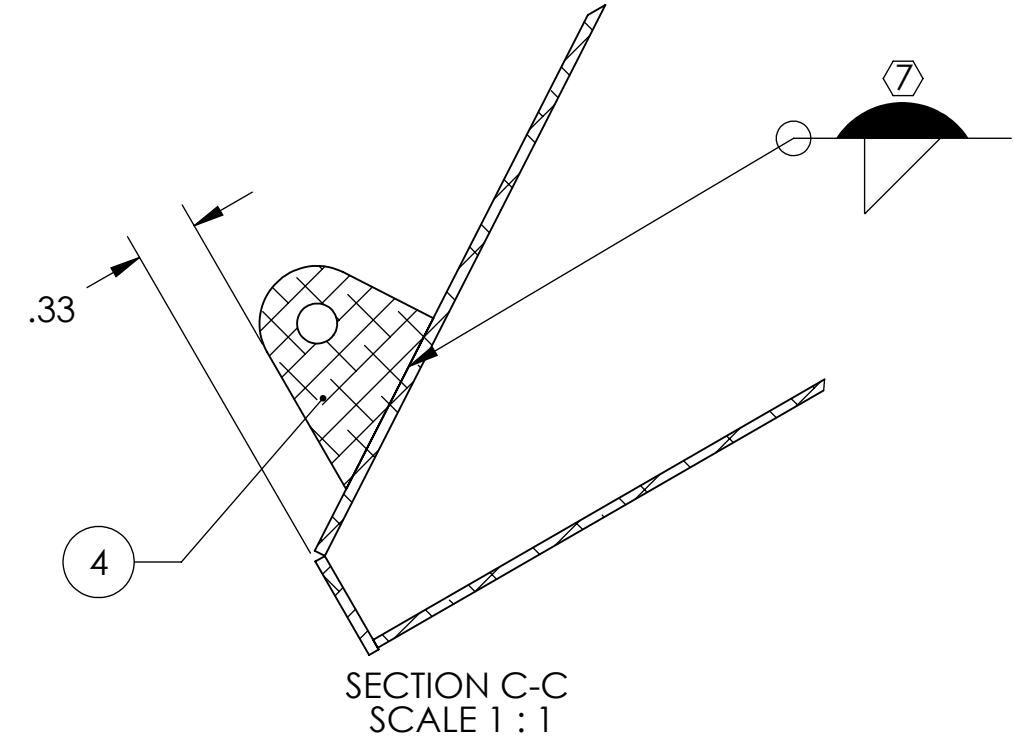
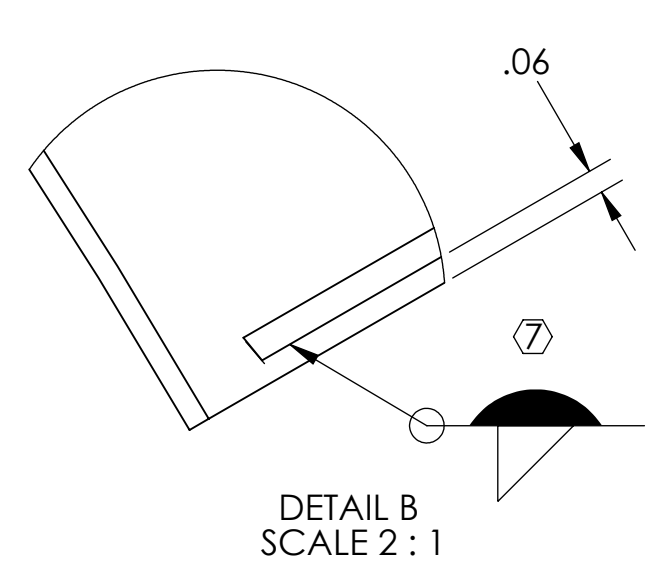
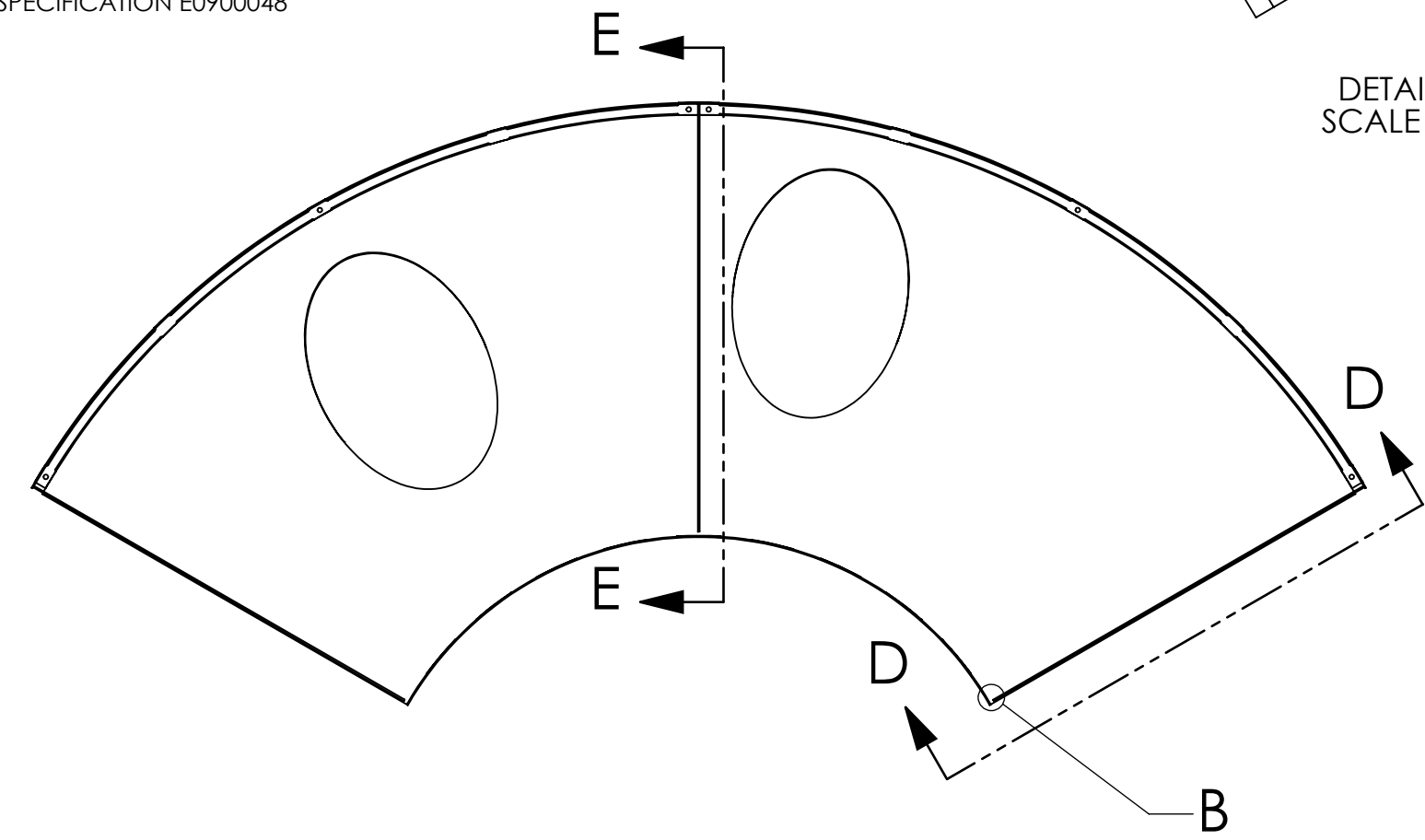


NOTES CONTINUED:  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR TYPE IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS.  
 EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX  
 DO NOT APPLY MARK ON SUPER #8 SIDE

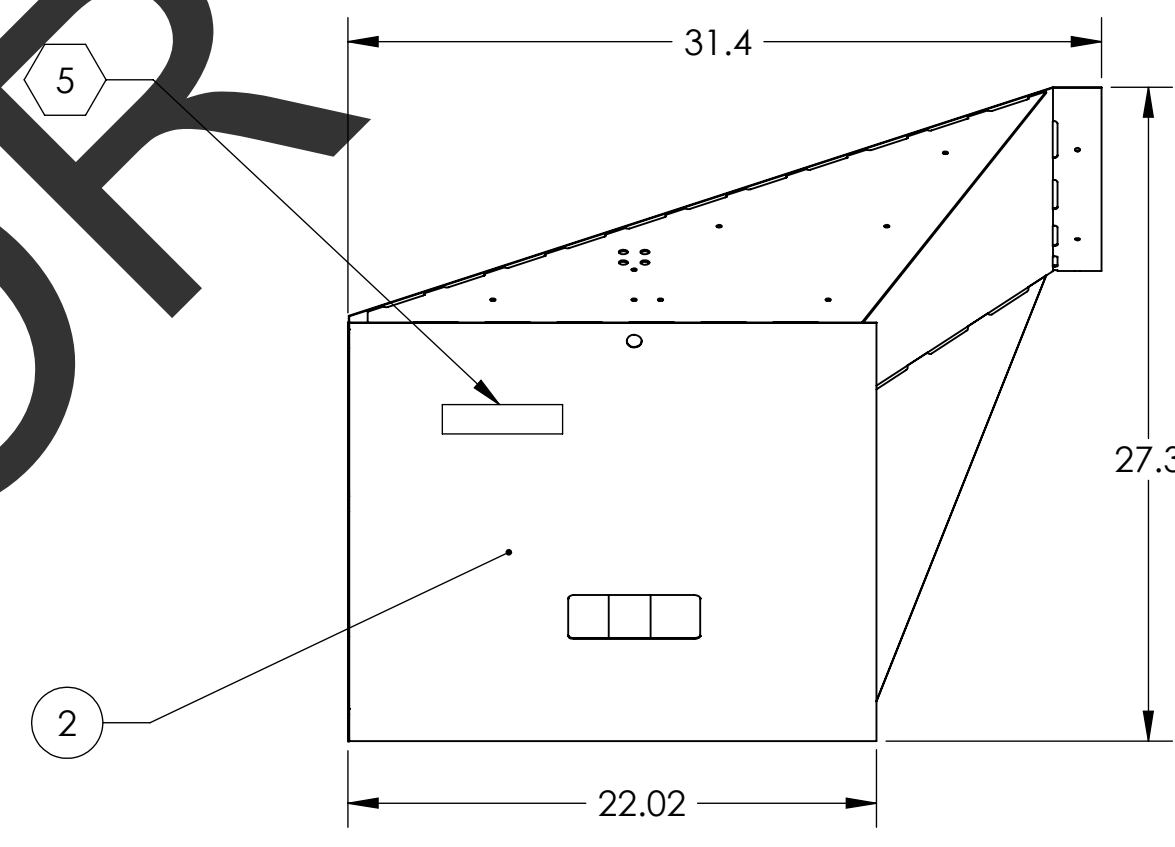
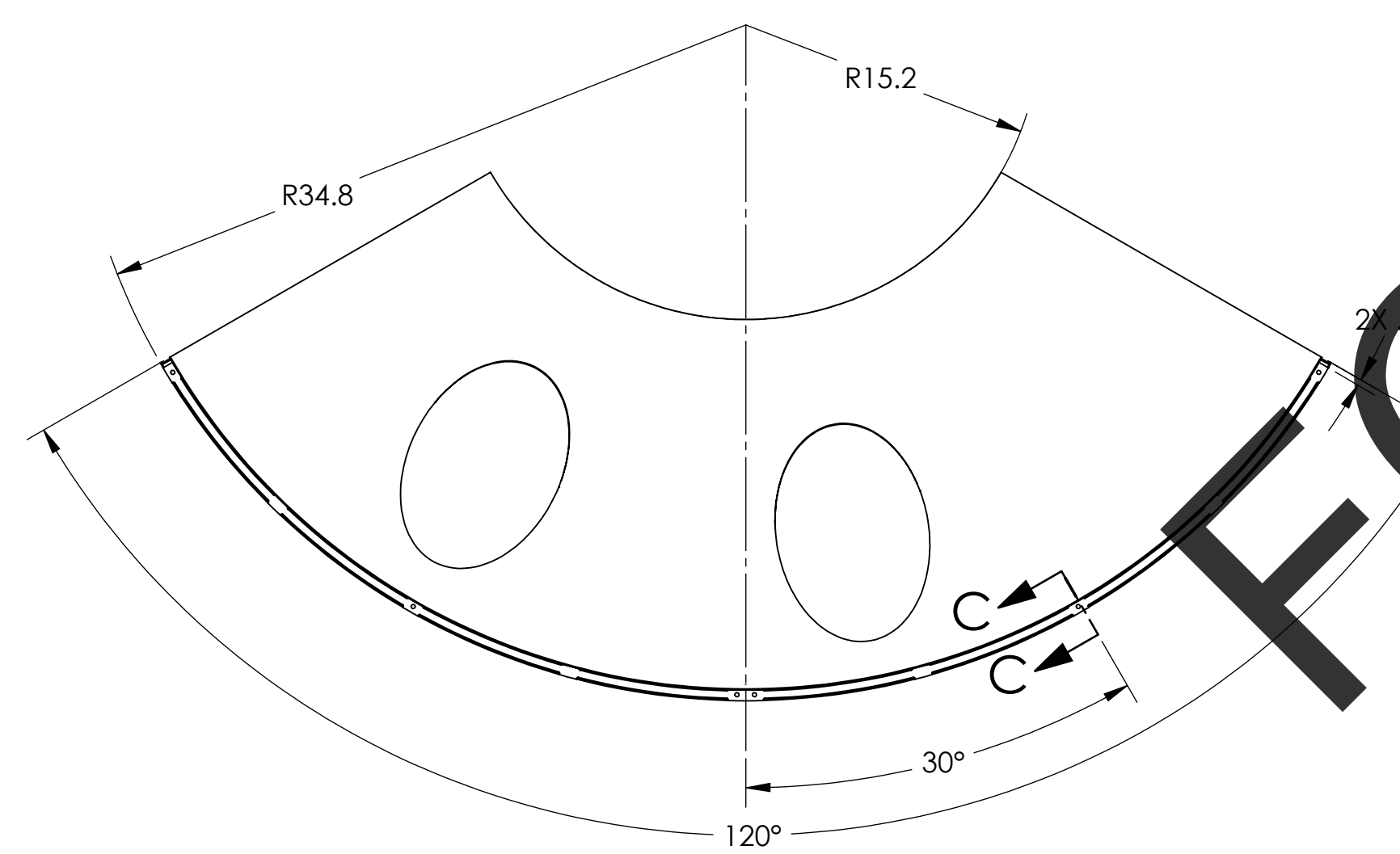
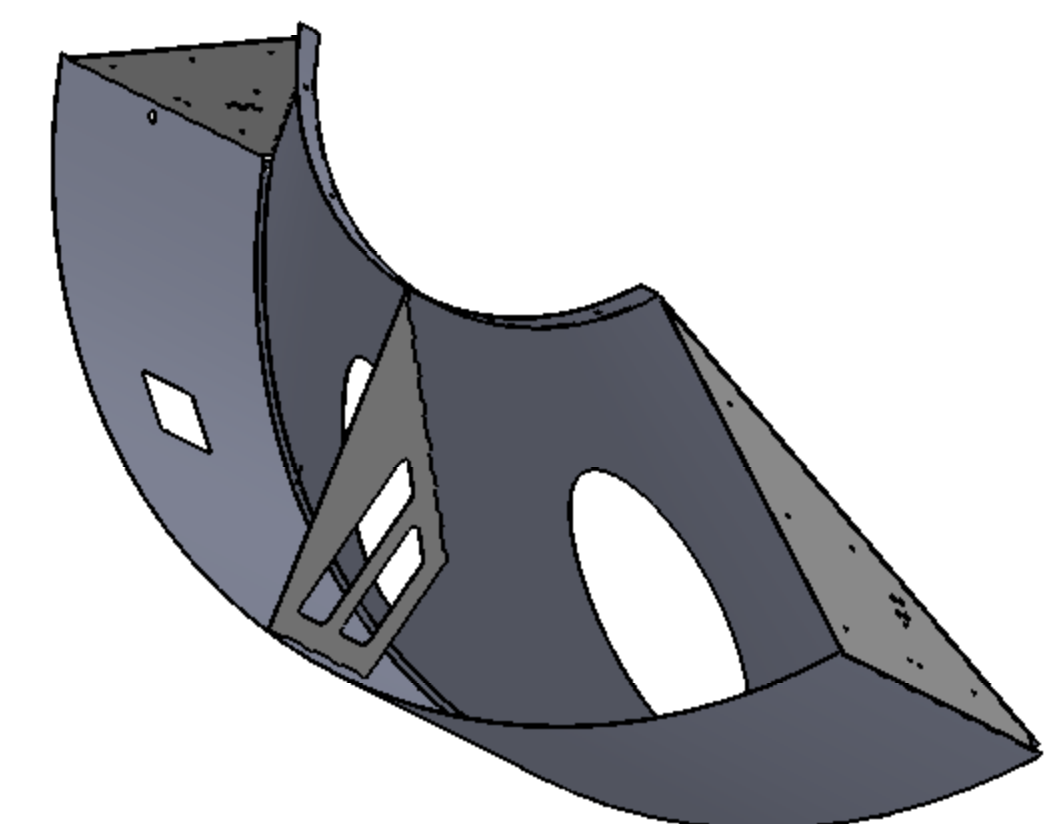
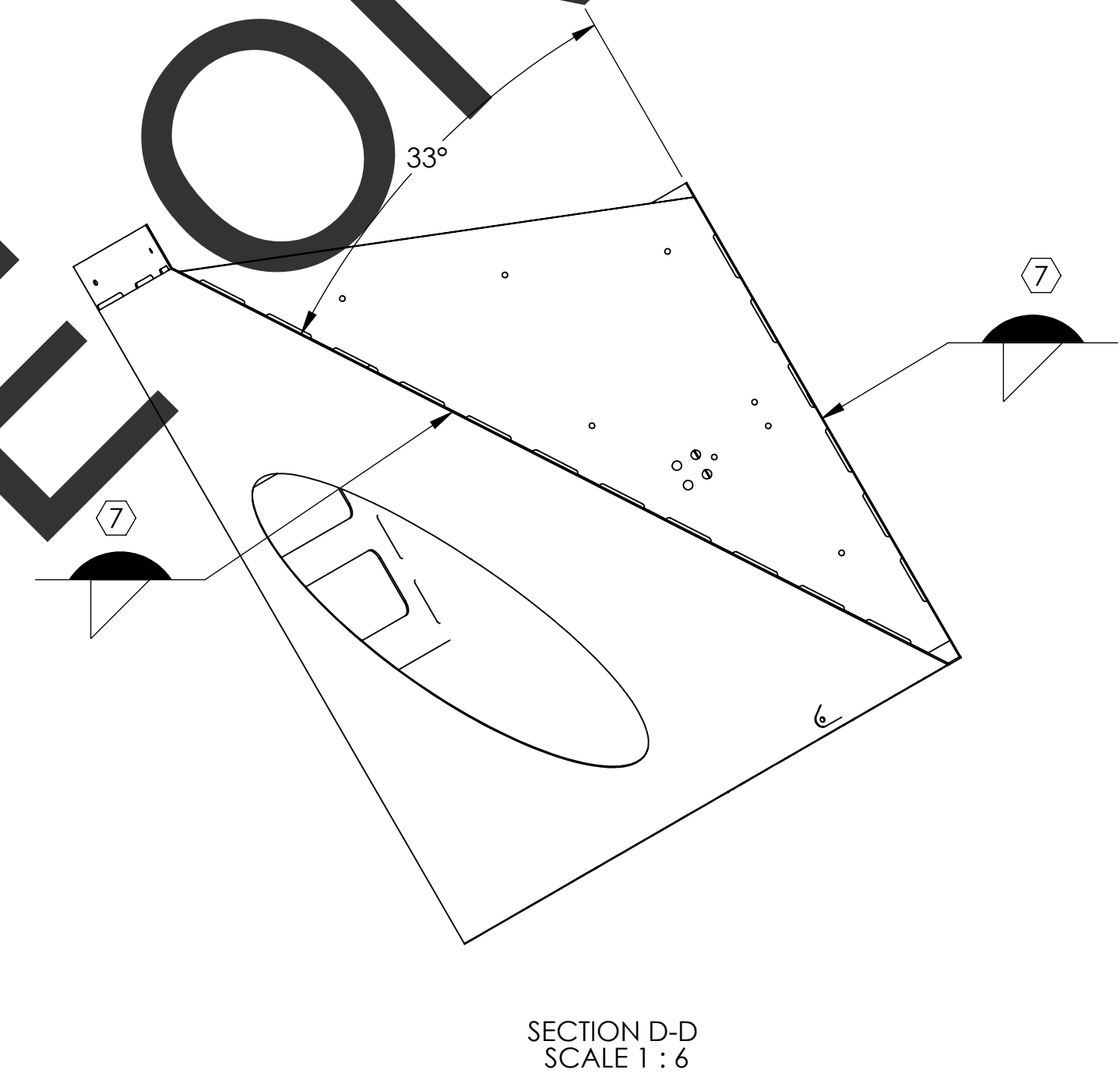
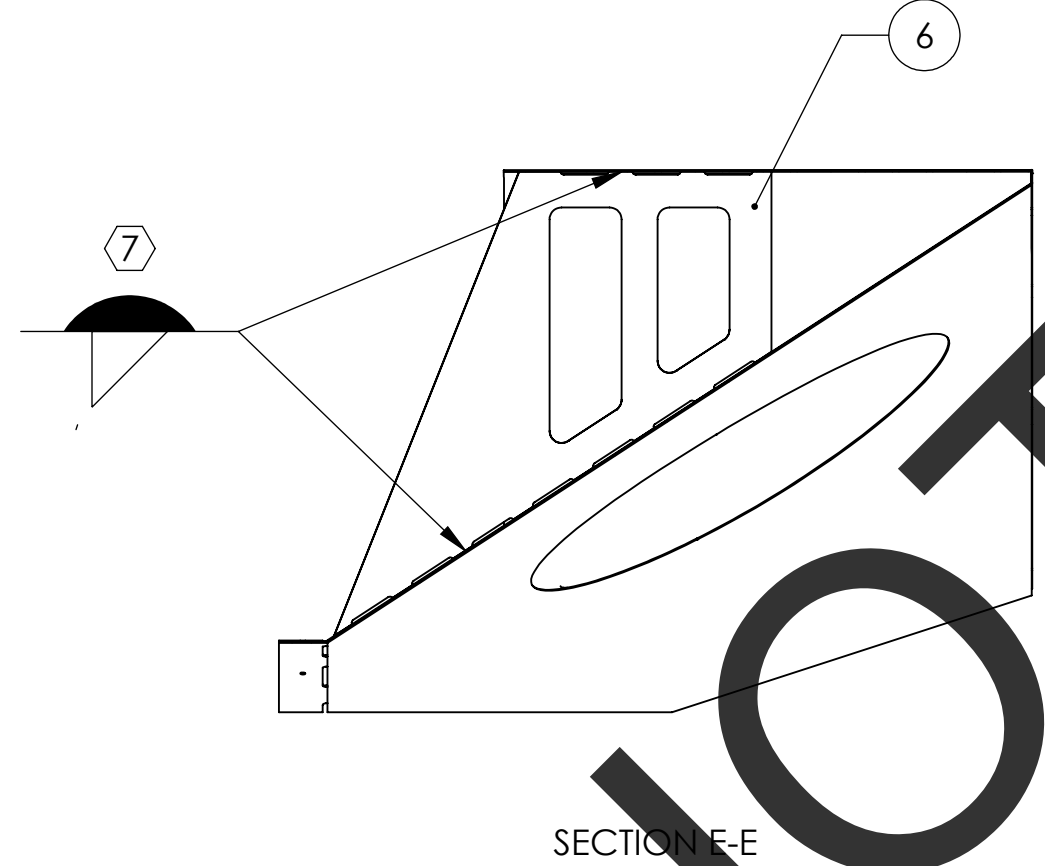
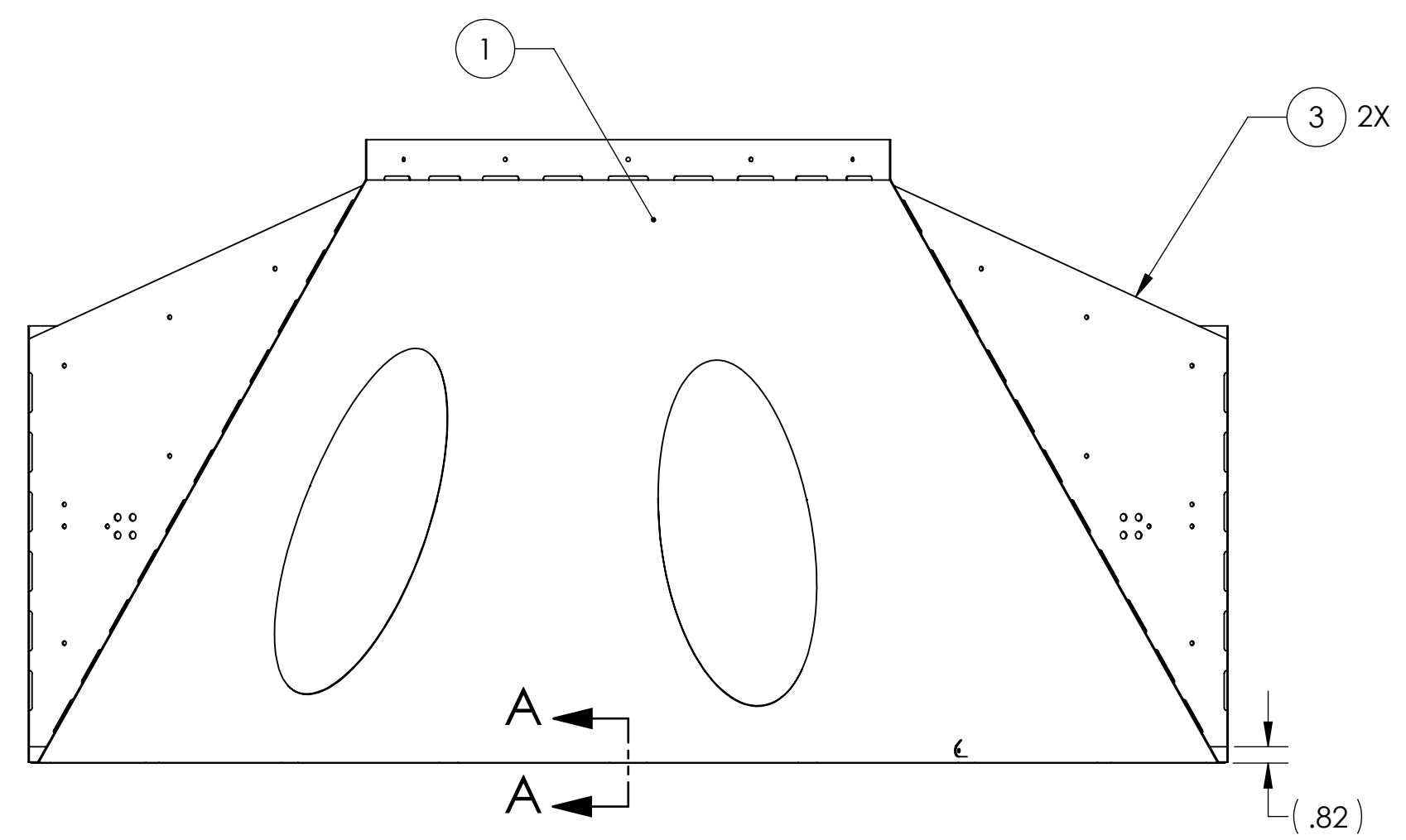
6. ASSEMBLY TO BE OXIDIZED AFTER WELDMENT IS COMPLETED PER SPECIFICATION E1000083

7. FILLET WELDS WHERE ITEMS MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048

REV.	DATE	DCN #	DRAWING TREE #
v1	29 JUL 2011	E1000360-v2	-
v2	17 OCT 2011	E1000360-v3	



GENERAL VIEW FOR REFERENCE ONLY NO SCALE



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	QTY.	SPARE	TOTAL
6	D1002849	MANIFOLD CRYO BAFFLE WELDMENT BRACE	14 GAUGE 304 SSTL	1		0
5	D1000559	RADIAL SEGMENT, RIGHT	18 GAUGE 304 SSTL	1		0
4	D1001073	RADIAL ATTACHMENT NUT PLATE	14 GAUGE 304 SSTL	1		0
3	D1000536	BAFFLE BRACE BRACKET	14 GAUGE 304 SSTL	1		0
2	D0902621	MANIFOLD CRYO BAFFLE BRACKET	14 GAUGE 304 SSTL	2		0
1	D1003232	MANIFOLD-CRYO BAFFLE INNER SEGMENT WELDMENT, ETMY H1, RIGHT	18 GAUGE 304 SSTL	1		0

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)  
 1. INTERPRET DRAWING PER ASME Y14.5-1994.  
 2. REMOVE ALL SHARP EDGES, R.02 MIN.  
 3. DO NOT SCALE FROM DRAWING.  
 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

DIMENSIONS ARE IN INCHES  
 TOLERANCES:  
 .X ± .1  
 .XX ± .06  
 .XXX ± .010  
 ANGULAR ± 1.0°

MATERIAL: N/A  
 FINISH: N/A

**LIGO** CALIFORNIA INSTITUTE OF TECHNOLOGY  
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO  
 SUB-SYSTEM: AOS  
 NEXT ASSY: D1003227

PARTS LIST  
 PART NAME: MANIFOLD CRYO BAFFLE SEGMENT SUBASSEMBLY WELDMENT, ETMY H1, RIGHT

DESIGNER: TQ. NGUYEN 16 DEC 2010  
 DRAFTER: TQ. NGUYEN 29 SEP 2011  
 CHECKER: M. SMITH  
 APPROVAL: D. COYNE

SIZE: D  
 DWG. NO.: D1003231  
 REV.: v2

SCALE: 1:8  
 PROJECTION:

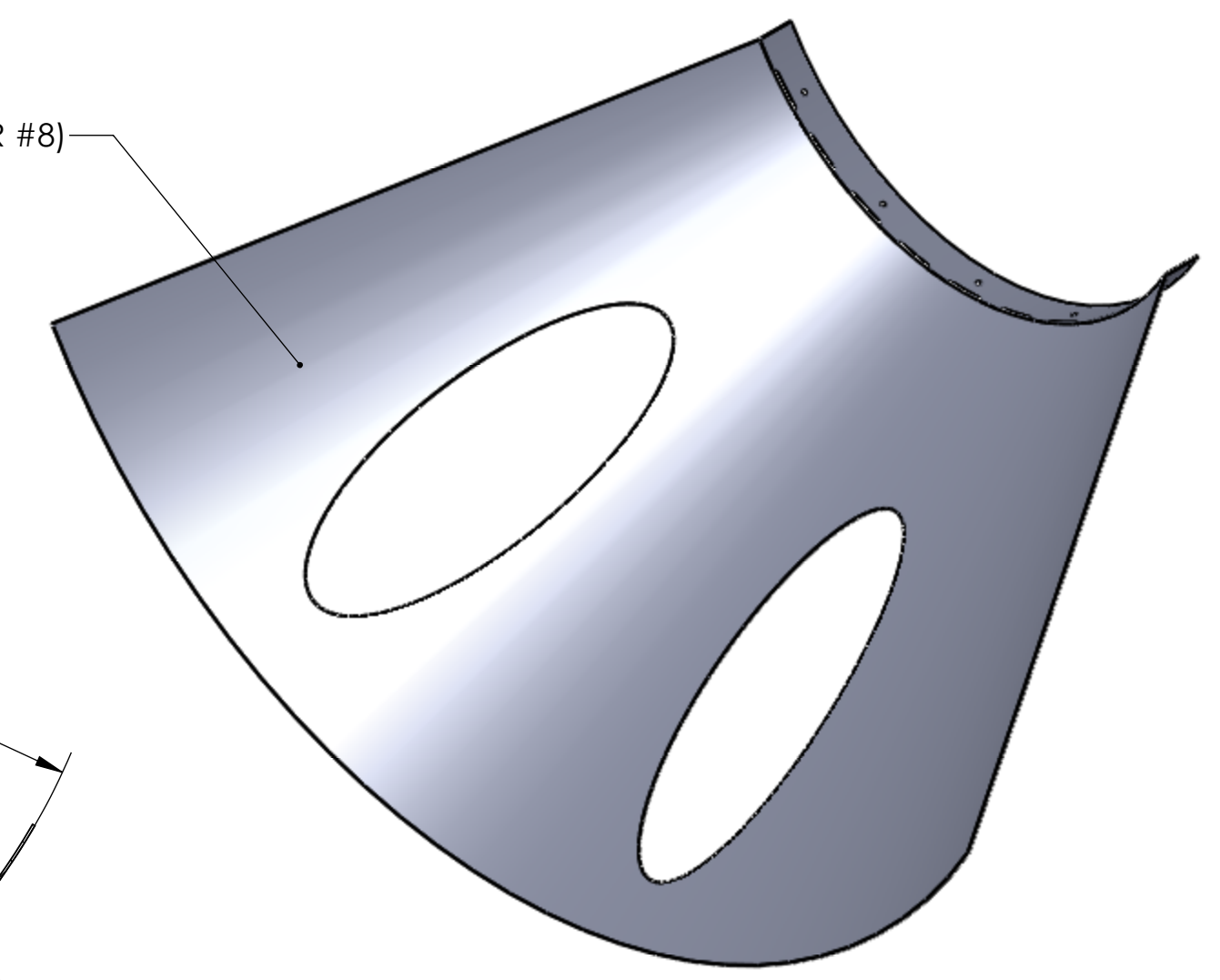
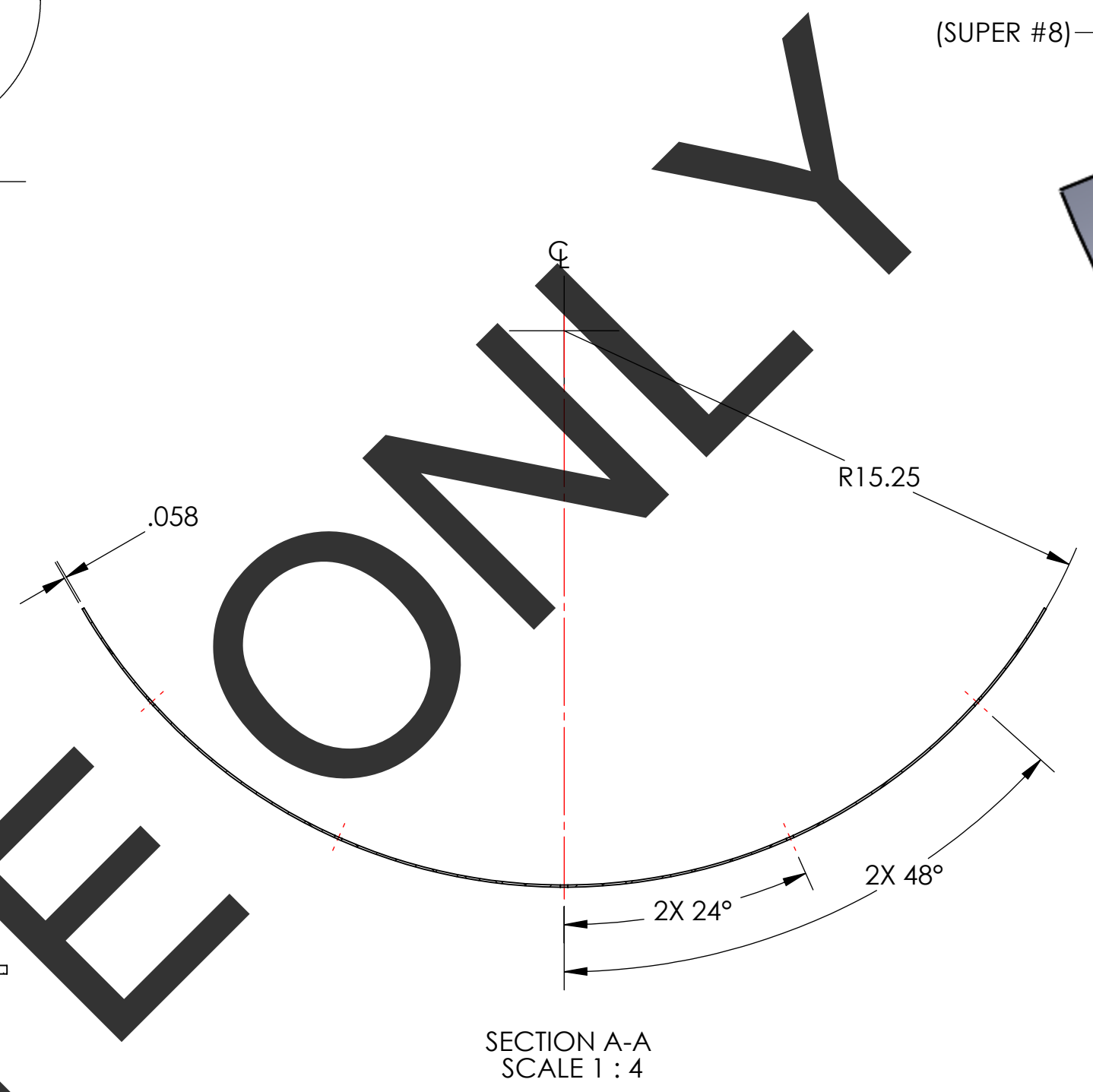
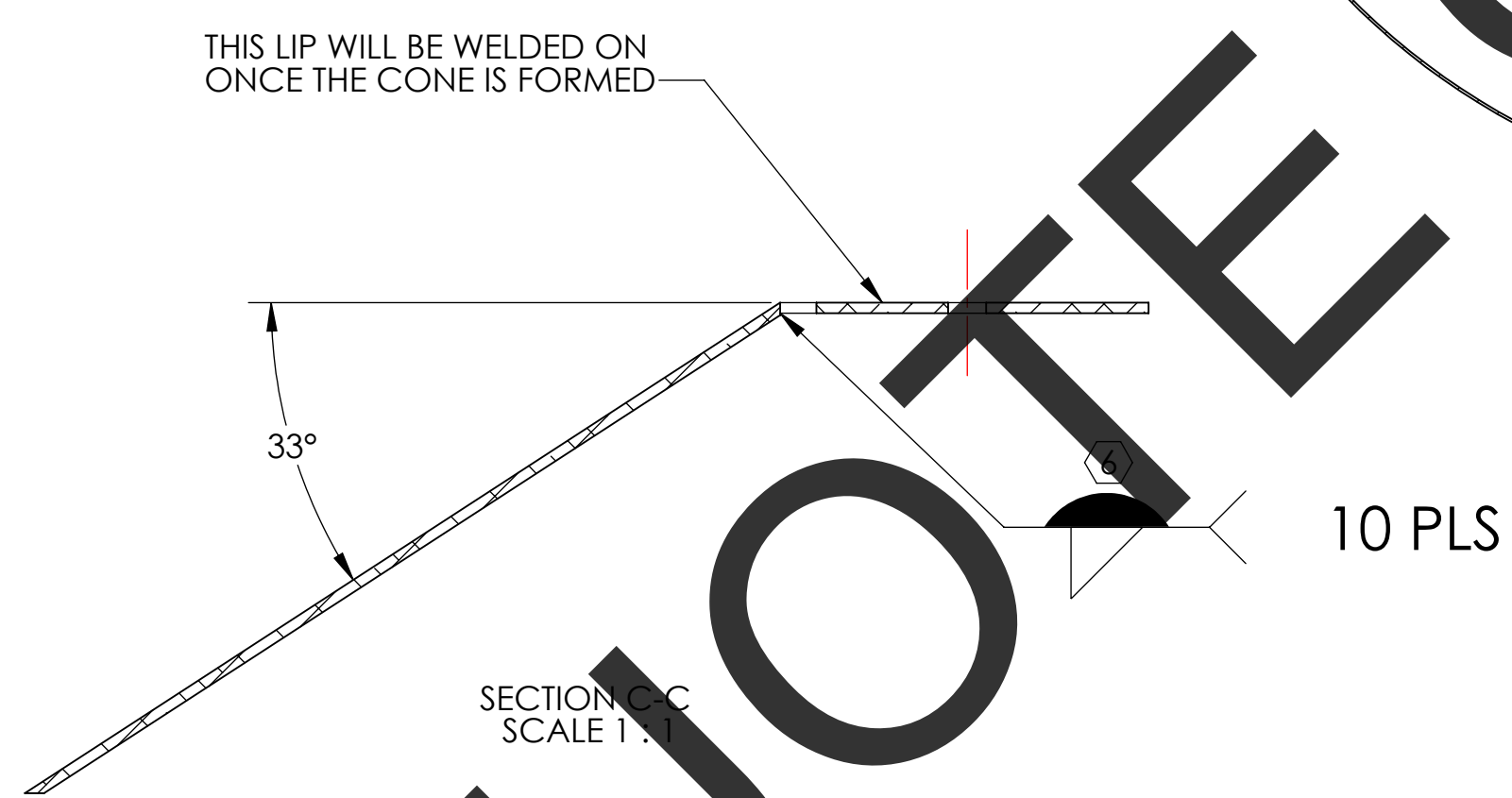
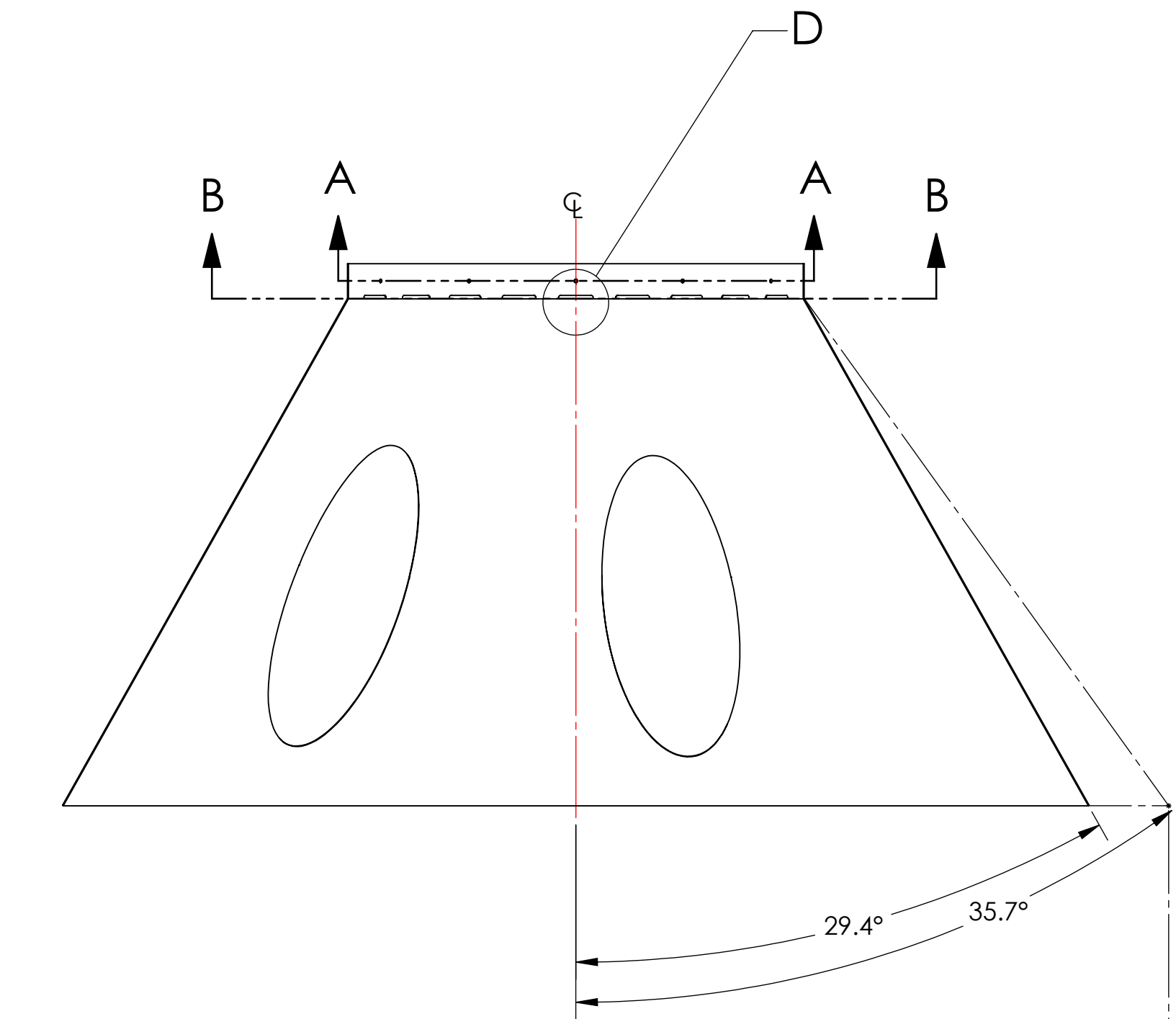
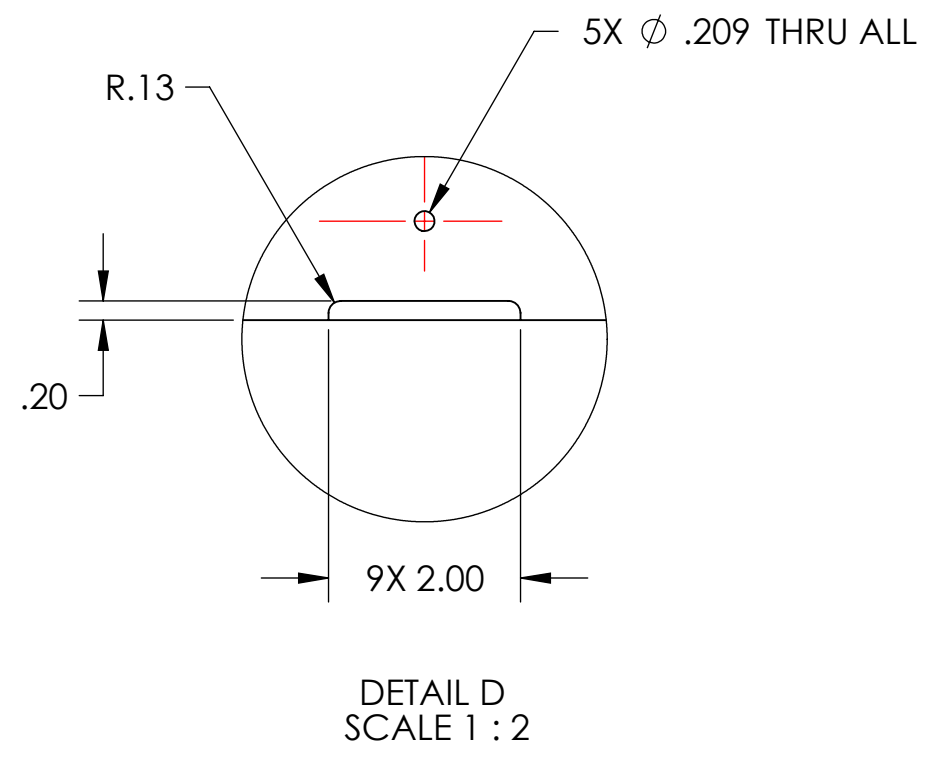
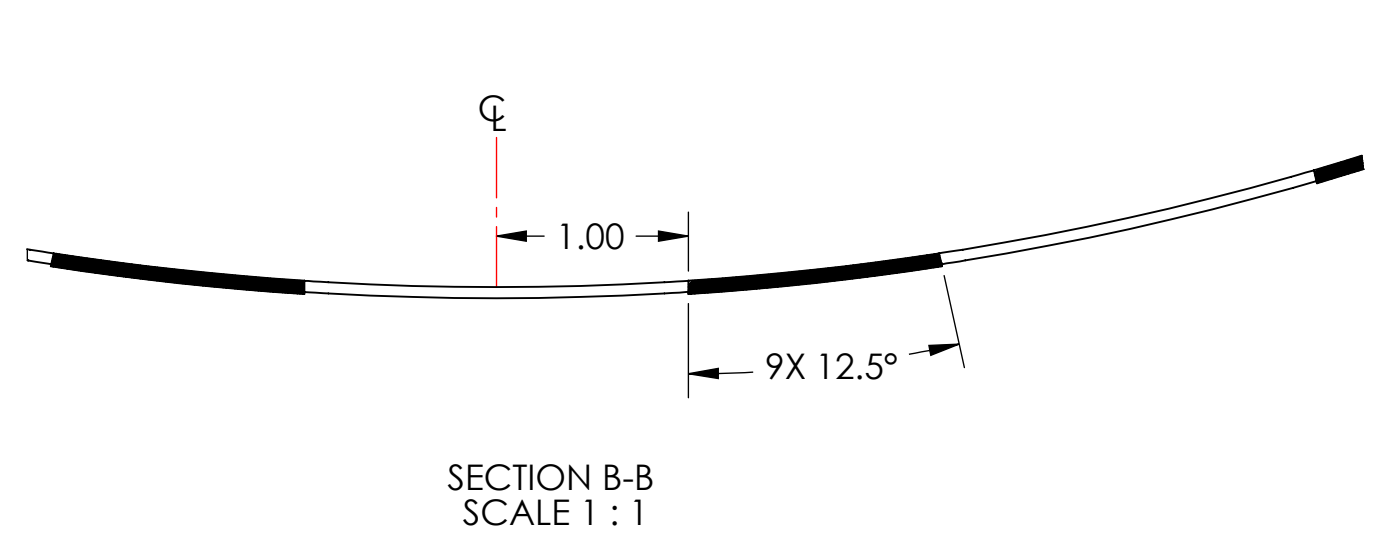
SHEET 1 OF 1

FOR QUOTE ONLY

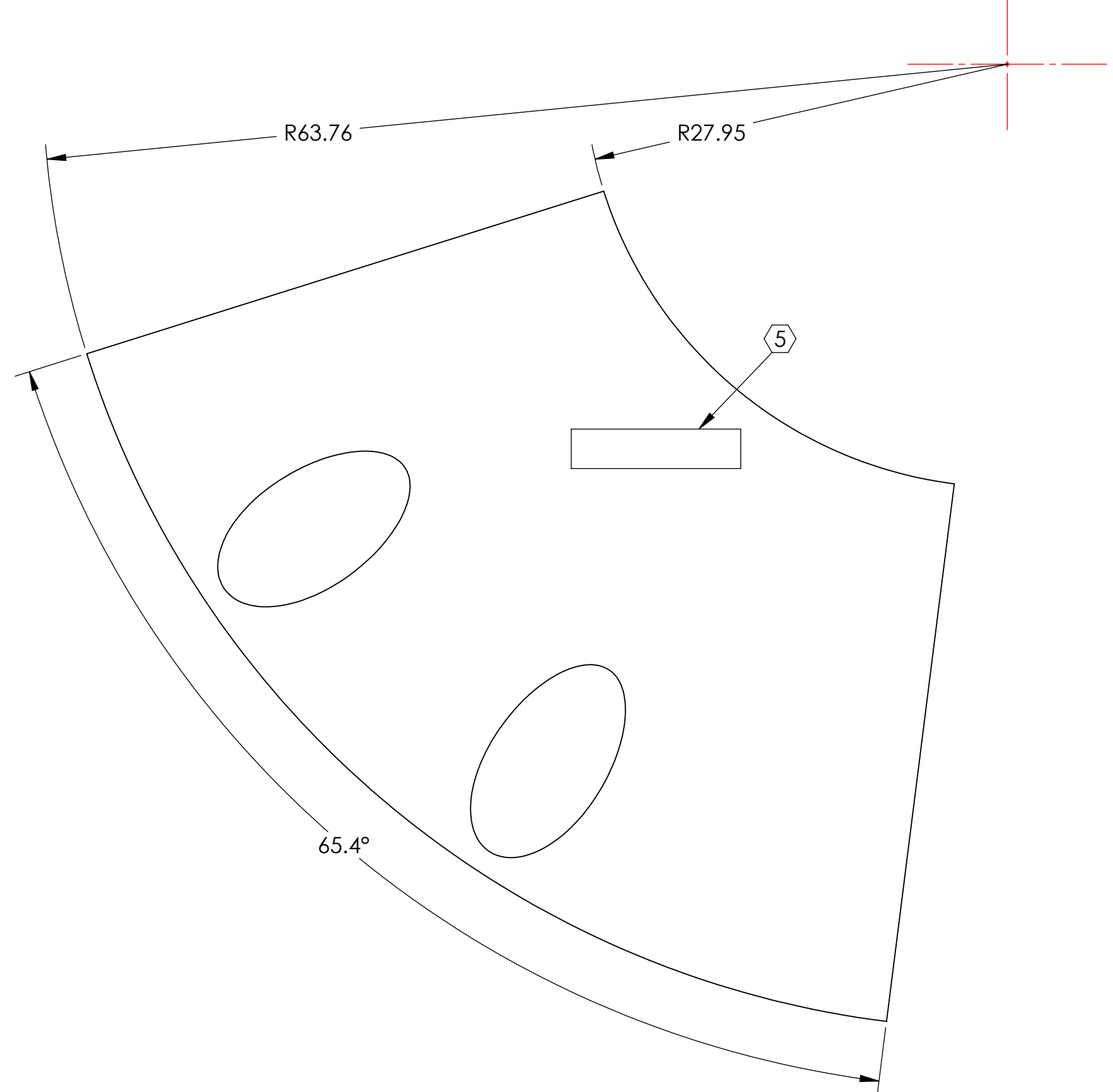
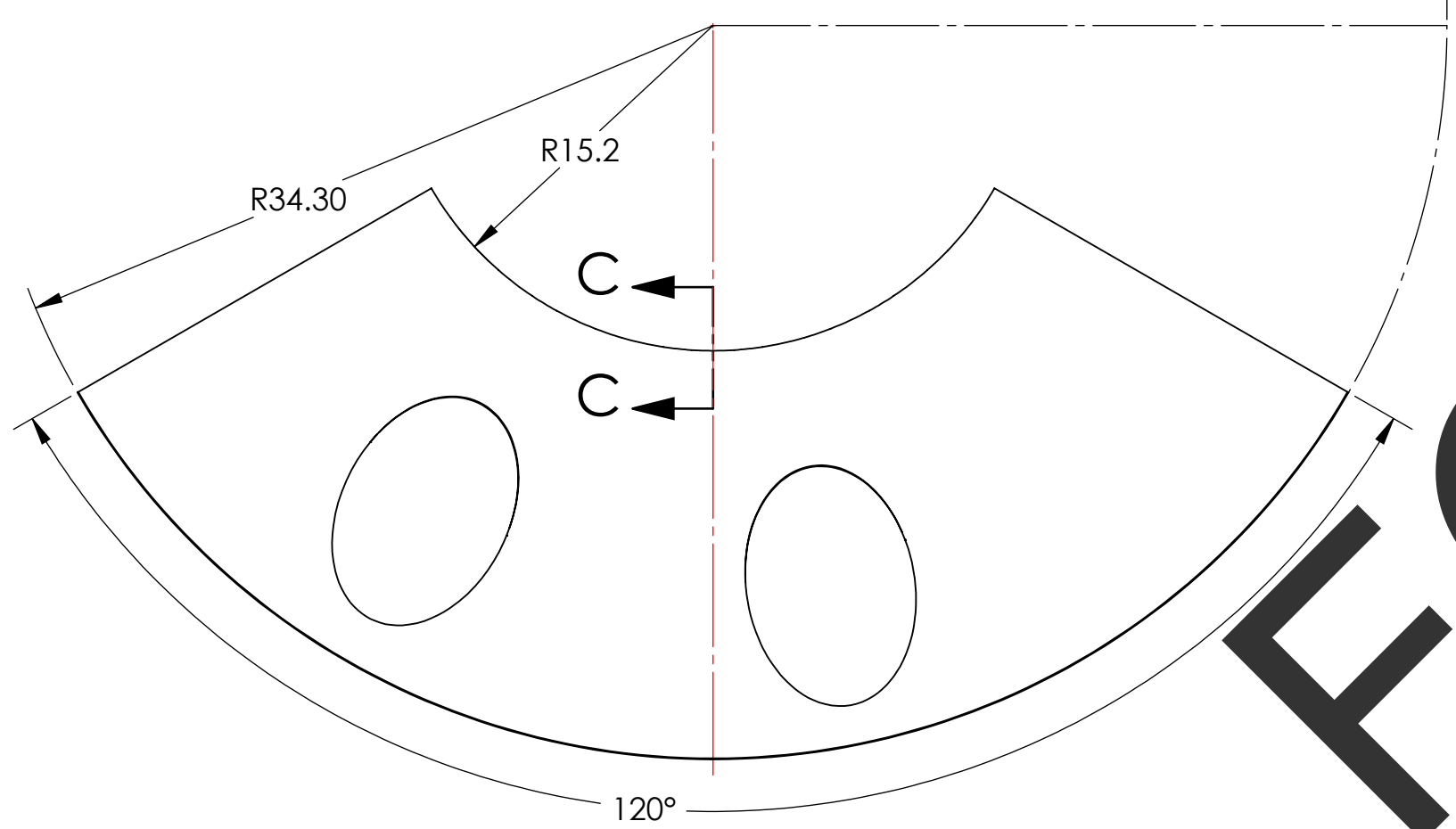
D1003231\_LIGO\_Manifold\_Cryo\_Baffle\_Segment\_Subassembly\_Weldment\_ETMY\_H1\_Right\_PRT\_PDM\_REV\_X-005\_DRAWING\_PDM\_REV\_X-002

REV.	DATE	DCN #	DRAWING TREE #
V1	1 SEP 2010	E1000360	E1000091
V2	17 OCT 2011	E1000360-V3	-
-	-	-	-

- NOTES CONTINUED:**
- ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS. UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE
  - ⑥ CONE AND LIP TO BE WELDED WHERE PIECES MAKE CONTACT. WELD MUST BE PER SPECIFICATION E900048.
  - ⑦ SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.
  - 8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
  - 9. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.



GENERAL VIEW FOR REFERENCE NO SCALE



FOR QUOTE ONLY

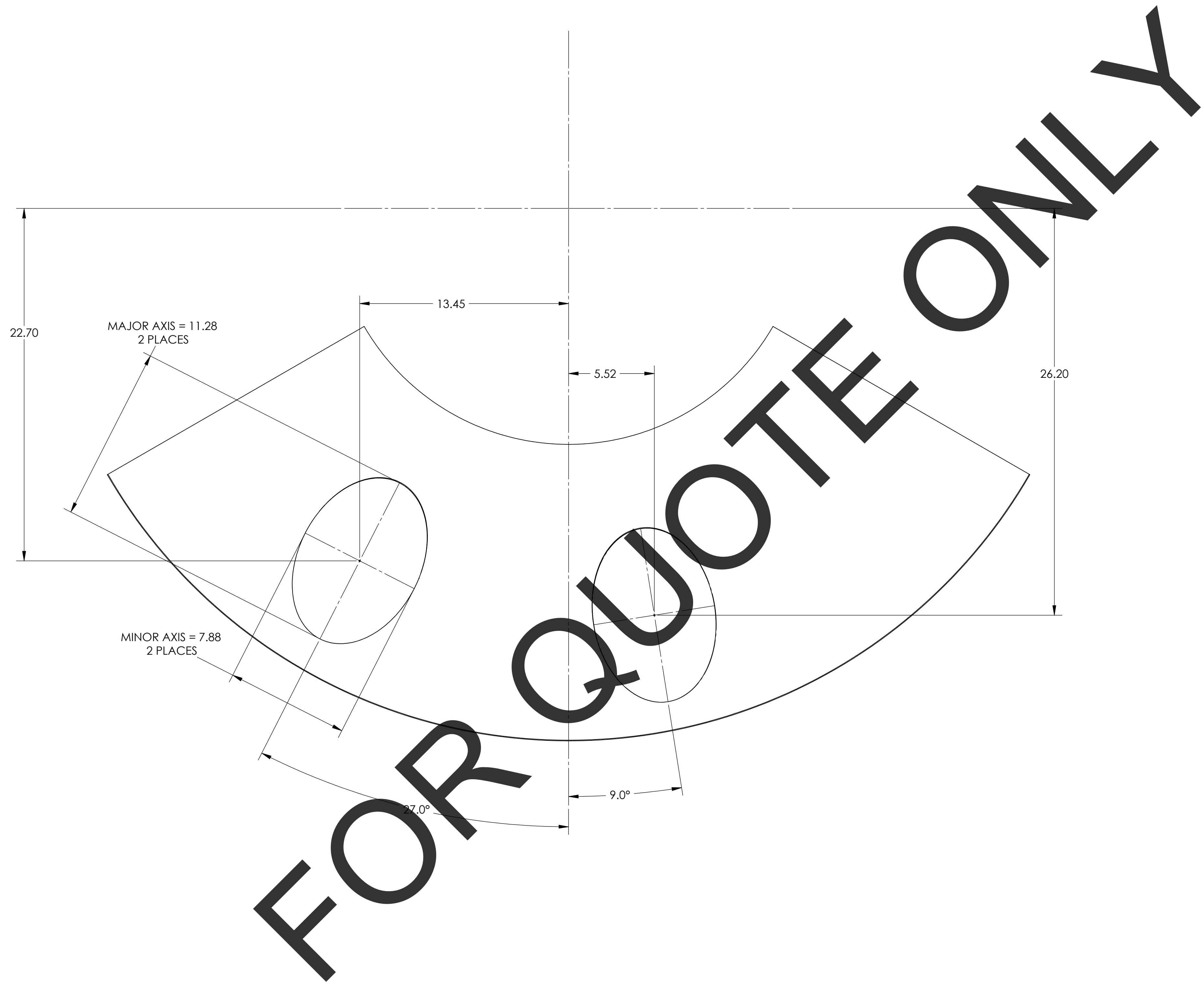
THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D0902654 FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
DIMENSIONS ARE IN INCHES	
TOLERANCES: .XX ± .06 .XXX ± .010	
ANGULAR ± 0.5°	
MATERIAL	FINISH
18 GAUGE 304 SSSL	⑦ SUPER #8

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
SYSTEM	SUB-SYSTEM
ADVANCED LIGO	AOS
NEXT ASSY	D1003231

PART NAME				MANIFOLD-CRYO BAFFLE INNER SEGMENT WELDMENT, ETMY H1, RIGHT			
DESIGNER	TQ. NGUYEN	16 DEC 2010	SIZE	DWG. NO.	REV.		
DRAFTER	TQ. NGUYEN	17 AUG 2010	D	D1003232	v2		
CHECKER	M. SMITH		SCALE: 1:8	PROJECTION:	SHEET 1 OF 2		
APPROVAL	D. COYNE						

D1003232.dwg\_Monitored\_Cryo\_Baffle\_Inner\_Segment\_ETMY\_H1\_RIGHT\_PART.PDM\_REV.X-004\_DRAWING.PDM\_REV.X-003



		CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
SIZE	DWG. NO.	REV.	
D	D1003232	v2	
SCALE: 1:8	PROJECTION:	SHEET 2 OF 2	

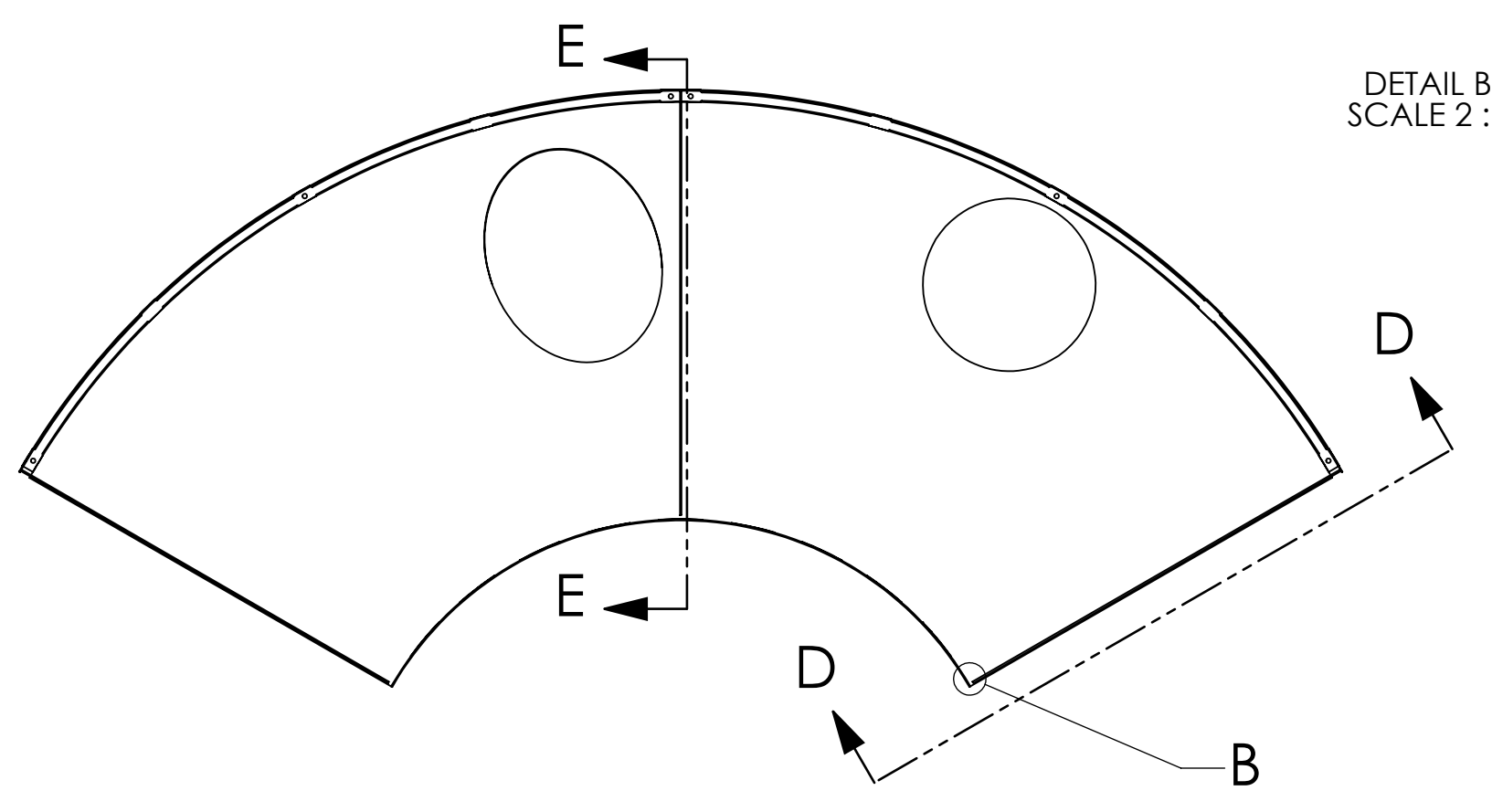
D:\003232.dwg\_Montréal\_Civ2\_Baffle\_Imes\_Segment1EM1.H1\_RIGHT\_PART.PDM REV: X-304L DRAWING PDM REV: X-003

**NOTES CONTINUED:**  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS.  
 EXAMPLE: D1003233-VY, TYPE-XX, S/N XXX  
 DO NOT APPLY MARK ON SUPER #8 SIDE

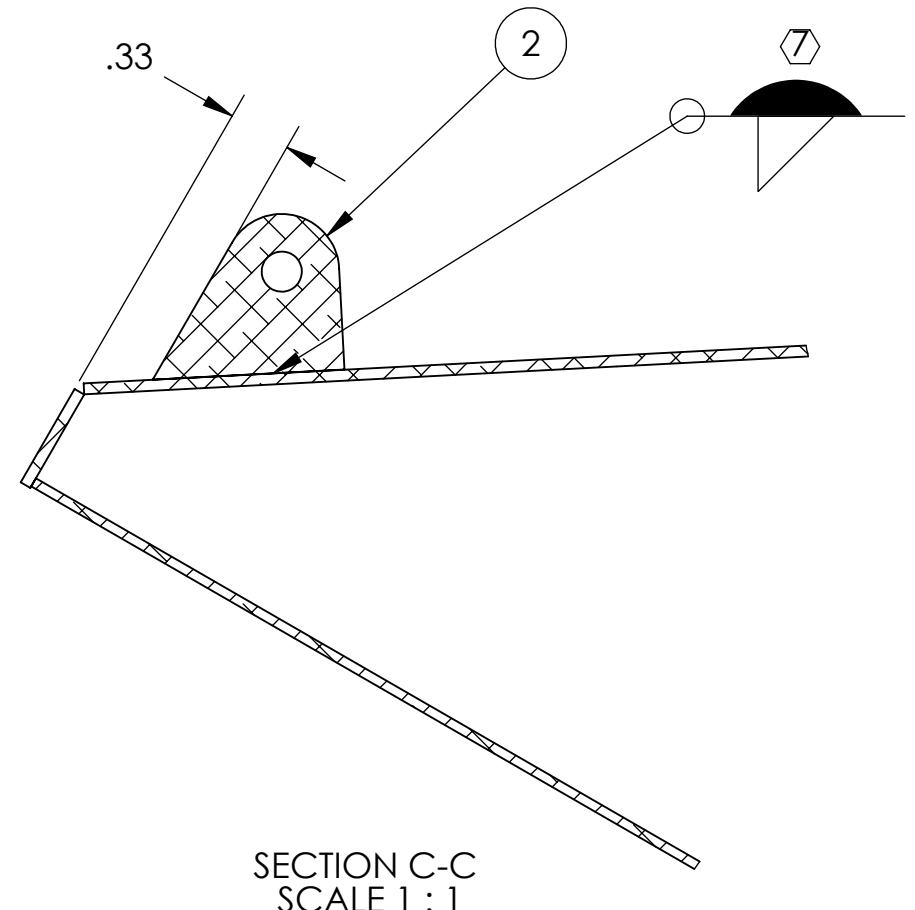
6. ASSEMBLY TO BE OXIDIZED AFTER WELDMENT IS COMPLETED PER SPECIFICATION E1100842.

7. FILLET WELDS WHERE ITEMS MAKE CONTACT. WELDING MUST BE PER SPECIFICATION E0900048.

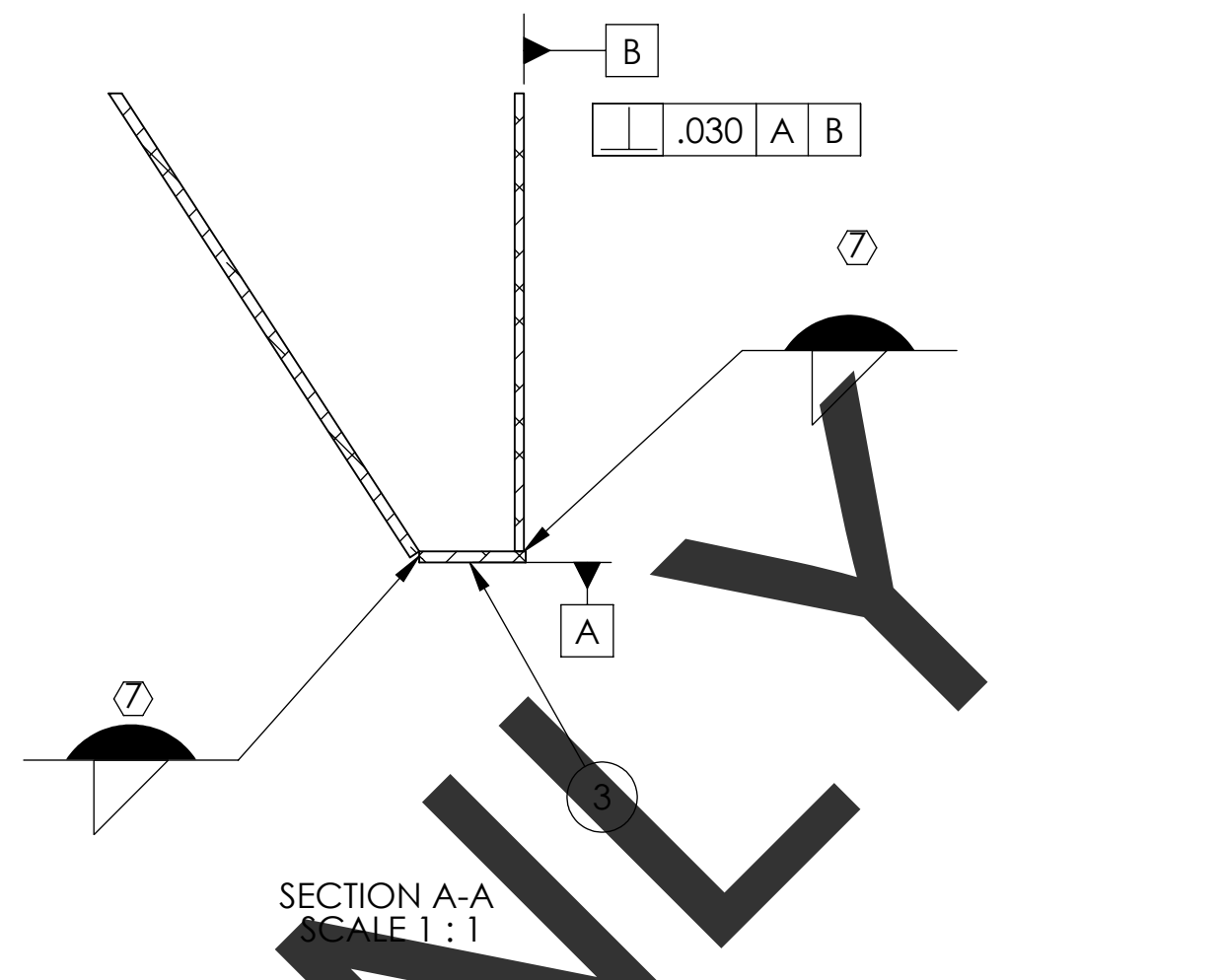
REV.	DATE	DCN #	DRAWING TREE #
v1	29 JUL 2011	E1000360-v2	-
v2	17 OCT 2011	E1000360-v3	-
-	-	-	-



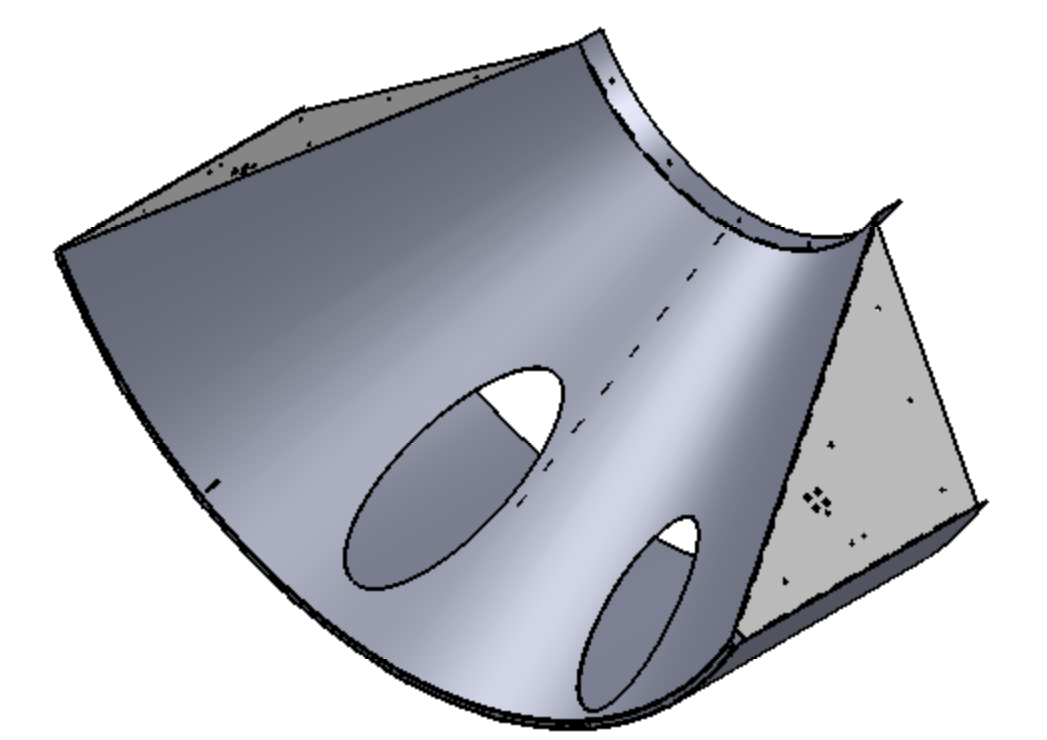
DETAIL B  
SCALE 2 : 1



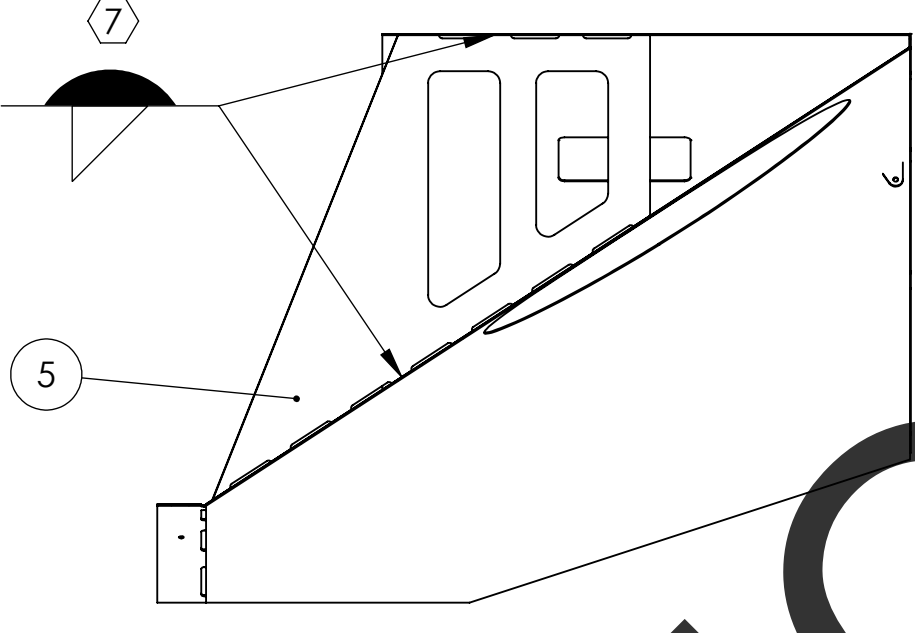
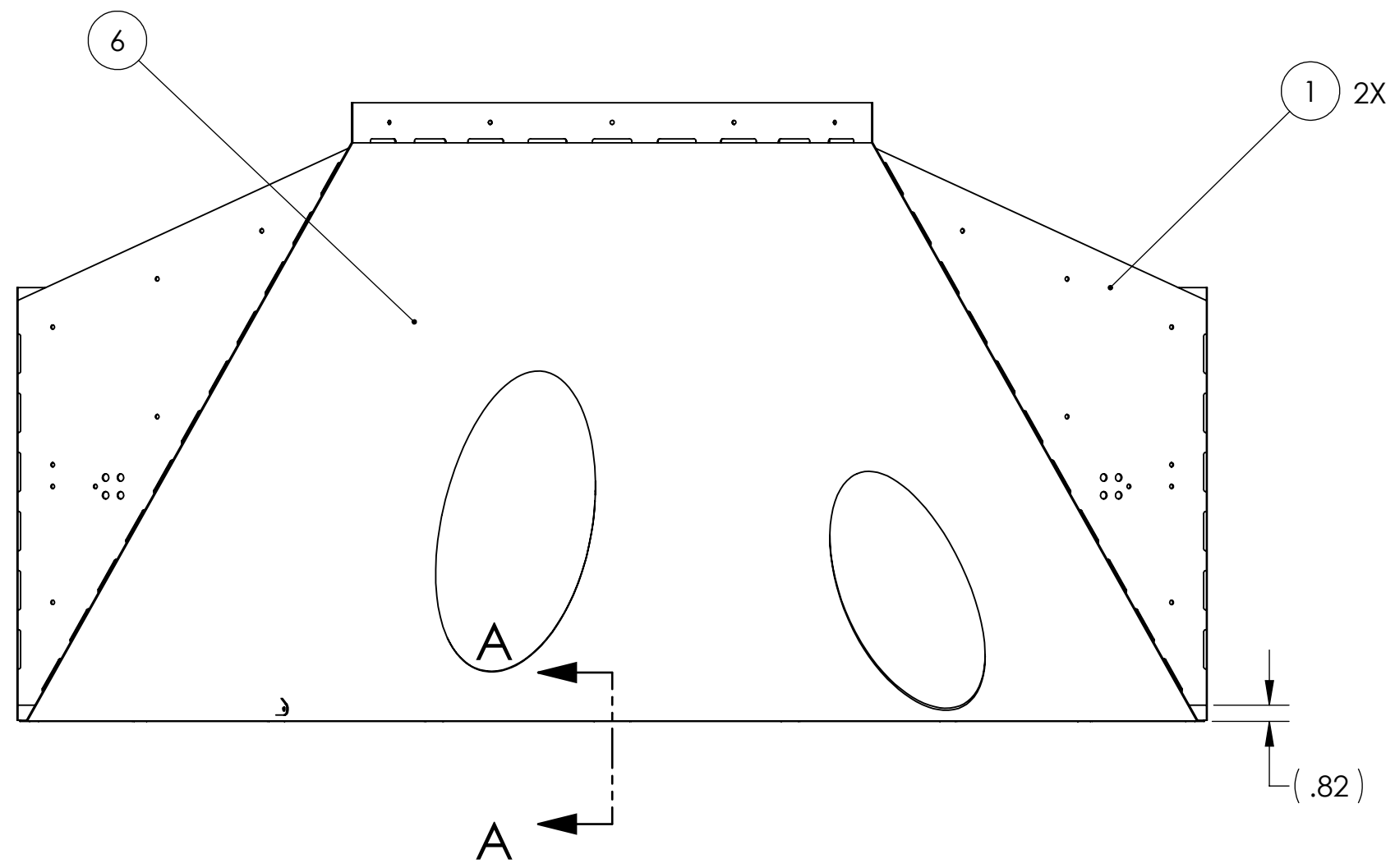
SECTION C-C  
SCALE 1 : 1



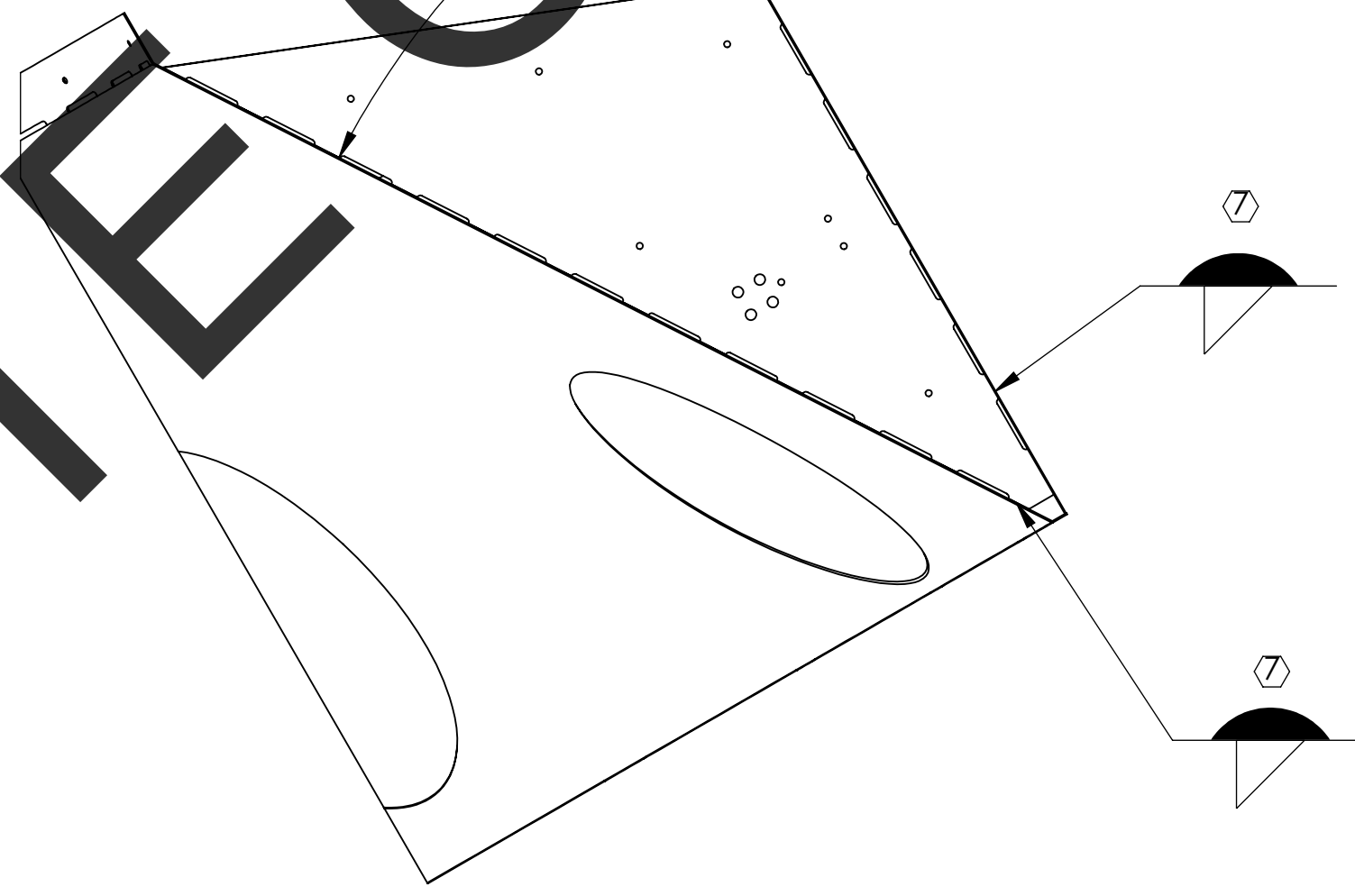
SECTION A-A  
SCALE 1 : 1



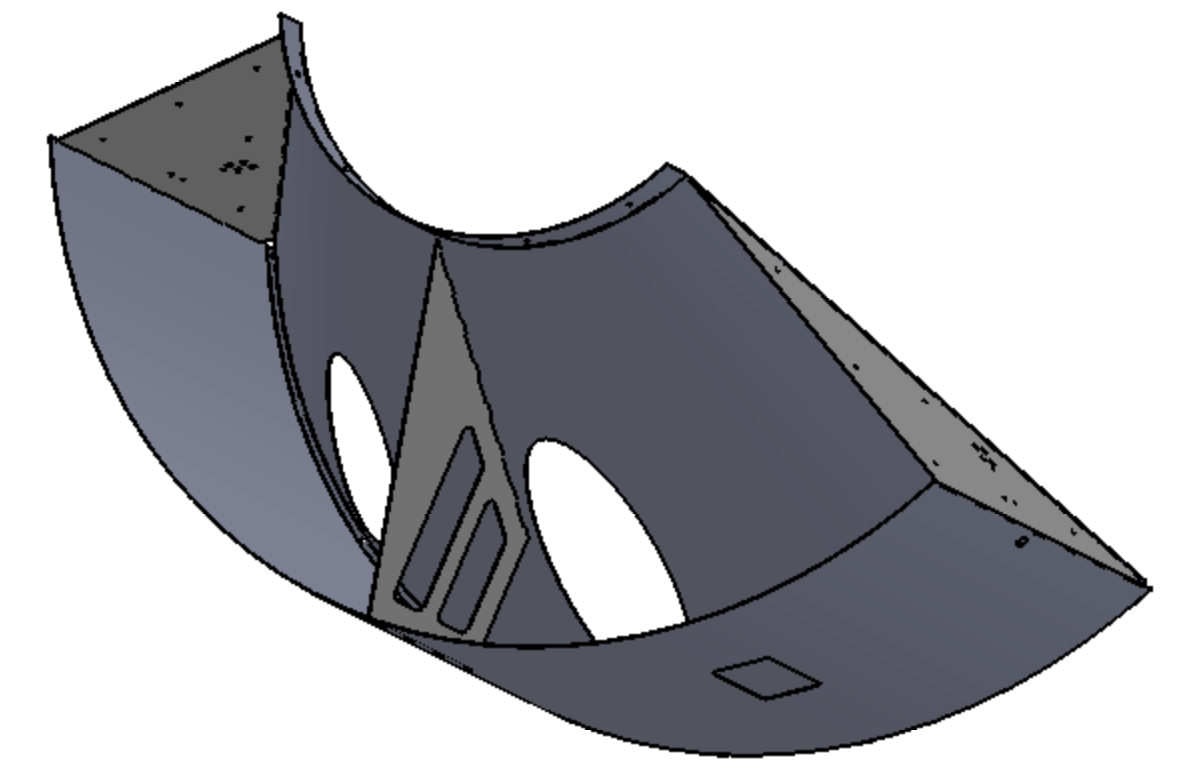
GENERAL VIEW  
FOR REFERENCE ONLY  
NO SCALE



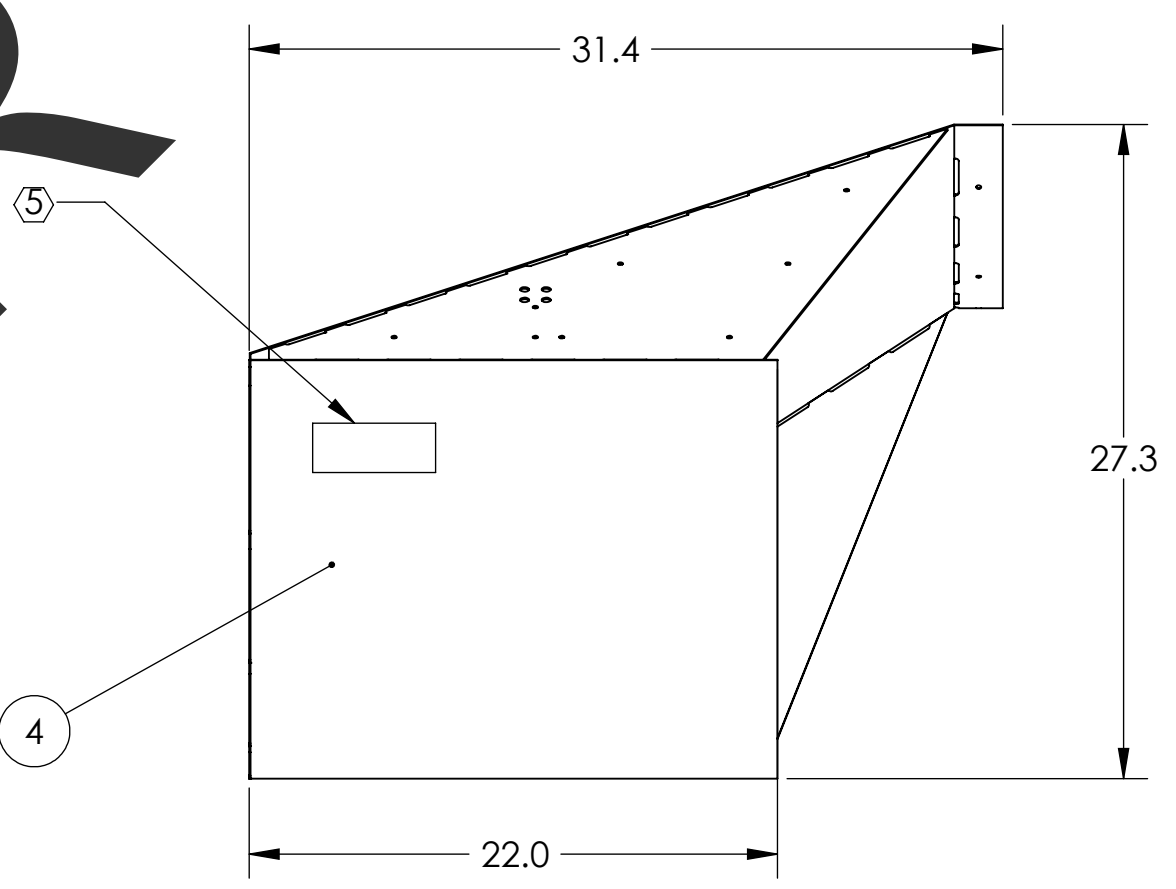
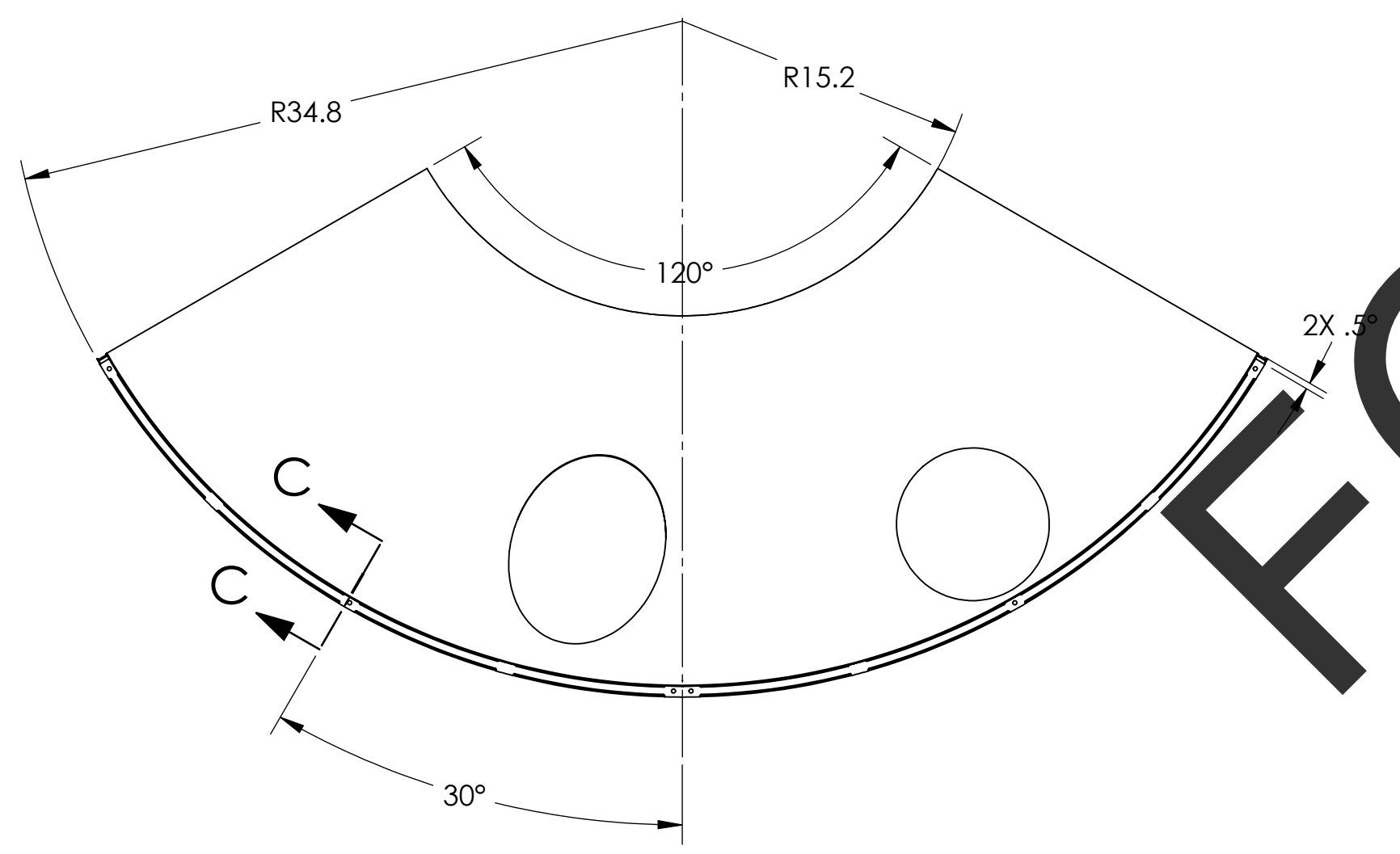
SECTION E-E



SECTION D-D  
SCALE 1 : 6



GENERAL VIEW  
FOR REFERENCE ONLY  
NO SCALE



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ	SPARE	TOTAL
6	D1003234	MANIFOLD-CRYO BAFFLE INNER SEGMENT WELDMENT, ETMY H1, LEFT	18 GAUGE 304 SSTL	1		1
5	D1002849	MANIFOLD CRYO BAFFLE WELDMENT BRACE	14 GAUGE 304 SSTL	1		1
4	D1000558	RADIAL SEGMENT, LEFT	18 GAUGE 304 SSTL	1		1
3	D1001073	RADIAL ATTACHMENT NUT PLATE	14 GAUGE 304 SSTL	1		1
2	D1000536	BAFFLE BRACE BRACKET	14 GAUGE 304 SSTL	1		1
1	D0902621	MANIFOLD CRYO BAFFLE BRACKET	14 GAUGE 304 SSTL	2		2

**NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)**  
 1. INTERPRET DRAWING PER ASME Y14.5-1994.  
 2. REMOVE ALL SHARP EDGES .005-.015 ON ALL EDGES AND HOLES.  
 3. DO NOT SCALE FROM DRAWING.  
 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

DIMENSIONS ARE IN INCHES

TOLERANCES:  
 .X ± .1  
 .XX ± .06  
 .XXX ± .010

ANGULAR ± 1.0°

MATERIAL: N/A  
 FINISH: N/A

**LIGO** CALIFORNIA INSTITUTE OF TECHNOLOGY  
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO  
 SUB-SYSTEM: AOS  
 NEXT ASSY: D1003227

**PART NAME** MANIFOLD-CRYO BAFFLE SEGMENT  
 SUBASSEMBLY WELDMENT, ETMY H1, LEFT

DESIGNER: TQ. NGUYEN 16 DEC 2010  
 DRAFTER: TQ. NGUYEN 07 SEP 2010  
 CHECKER: M. SMITH  
 APPROVAL: D. COYNE

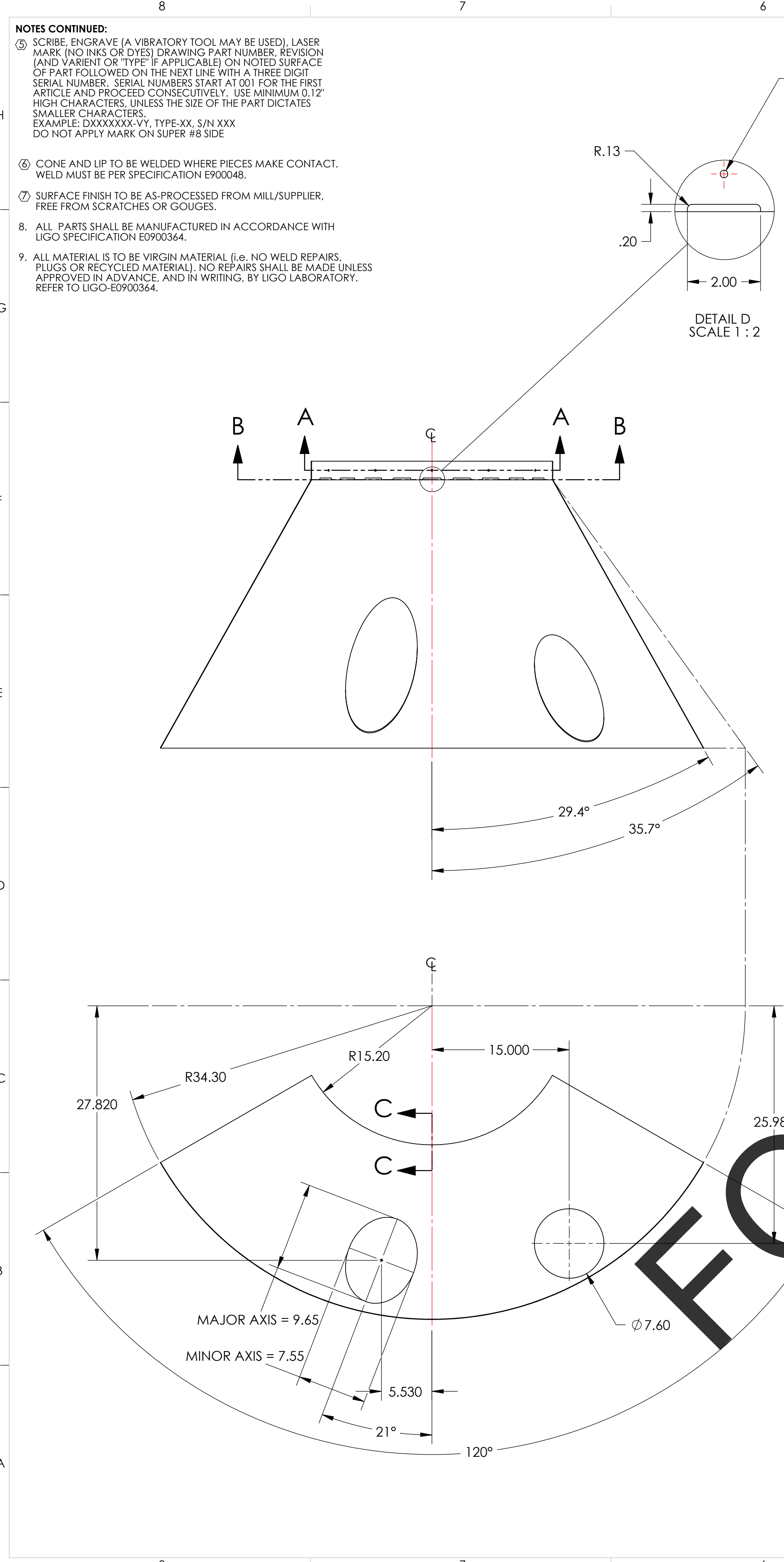
SIZE: D  
 DWG. NO.: D1003233  
 REV.: v2

SCALE: 1:8  
 PROJECTION:

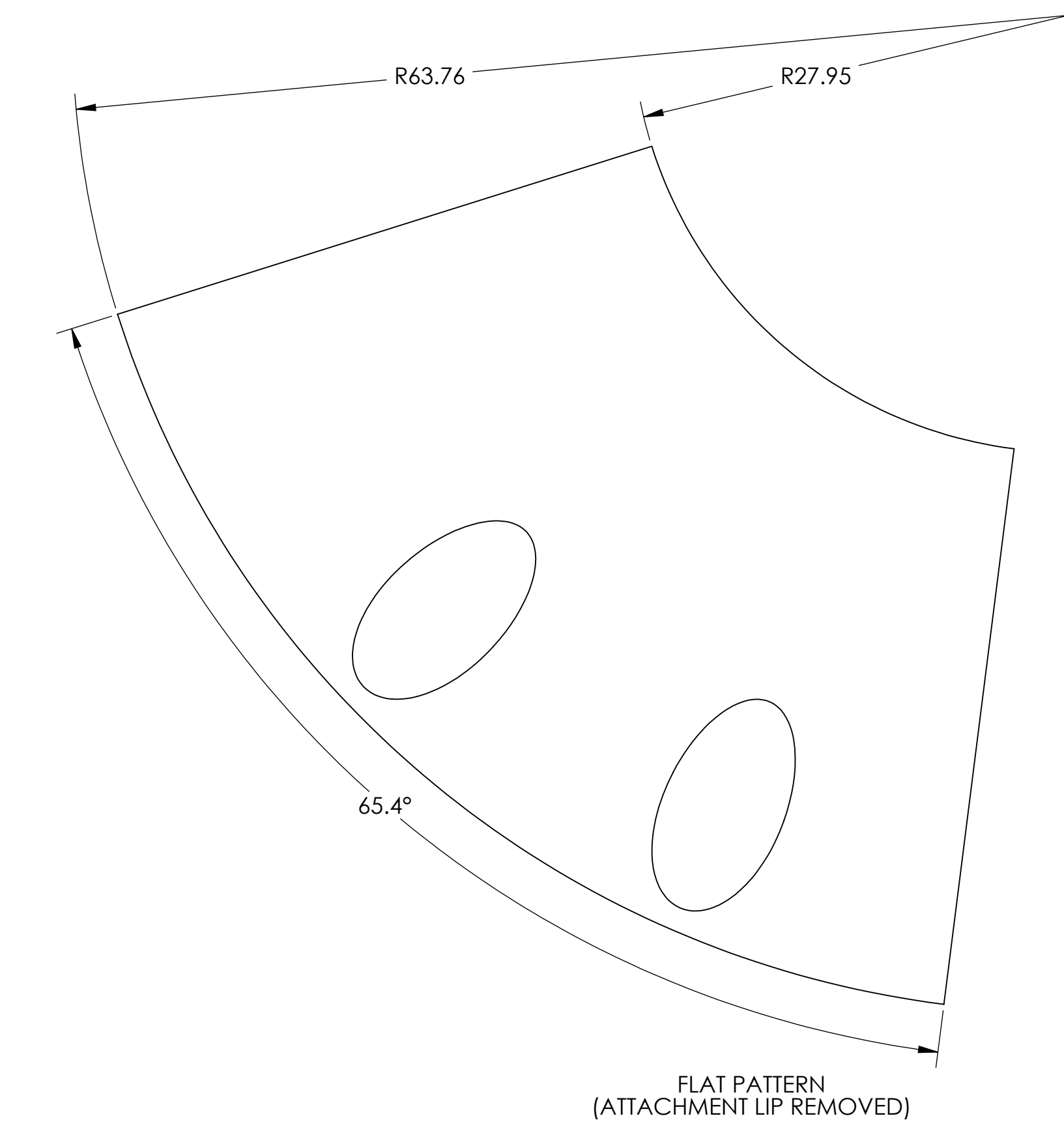
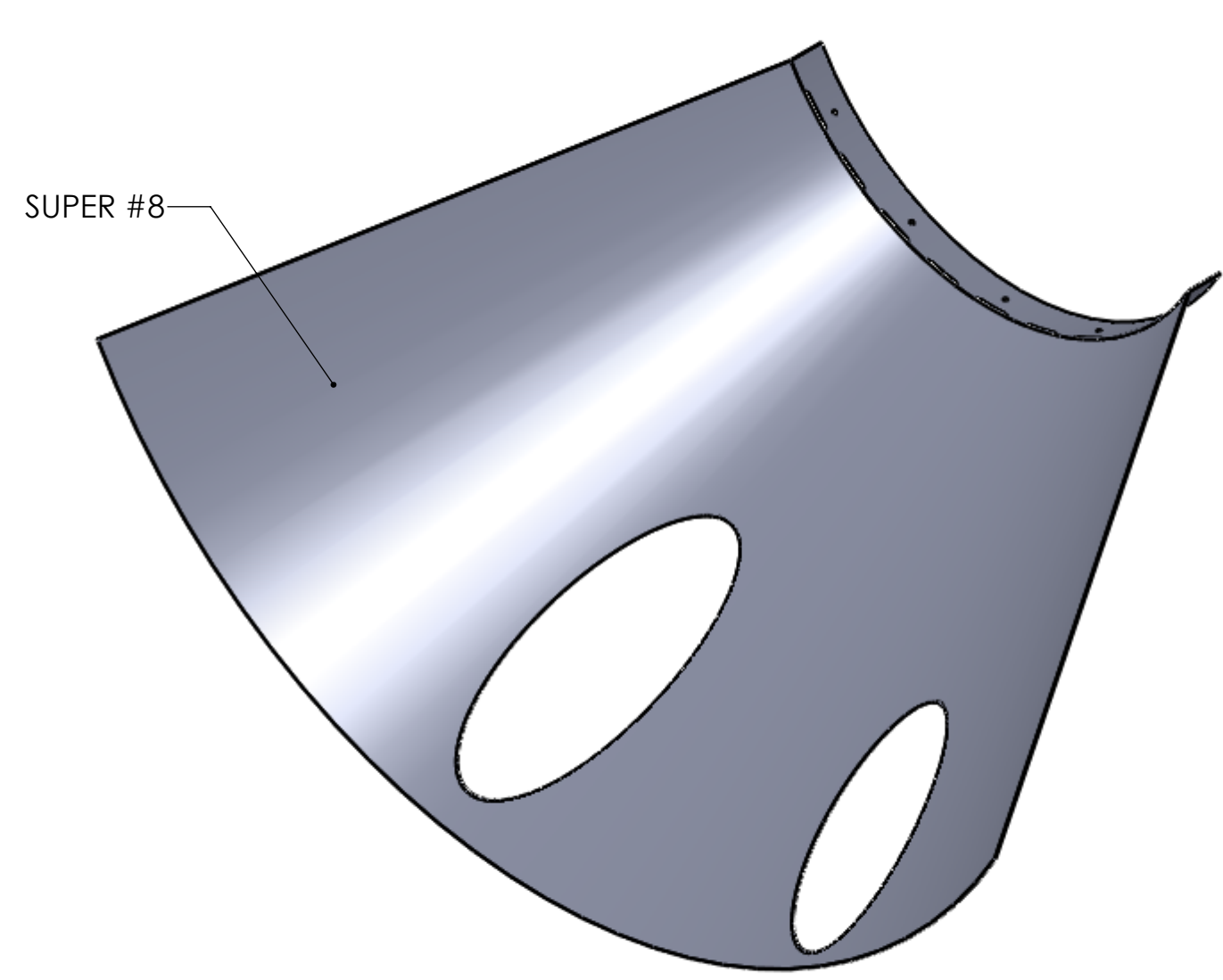
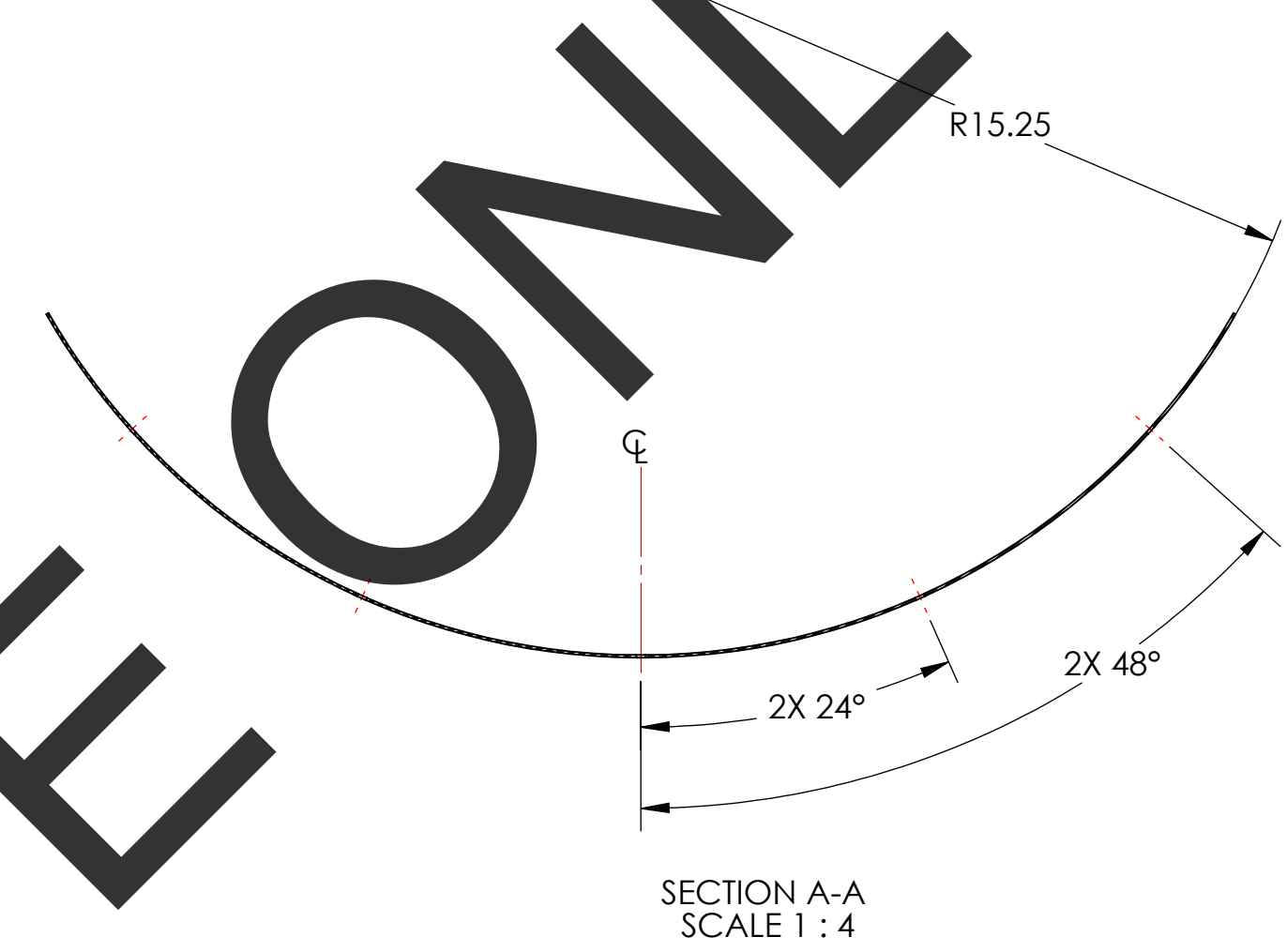
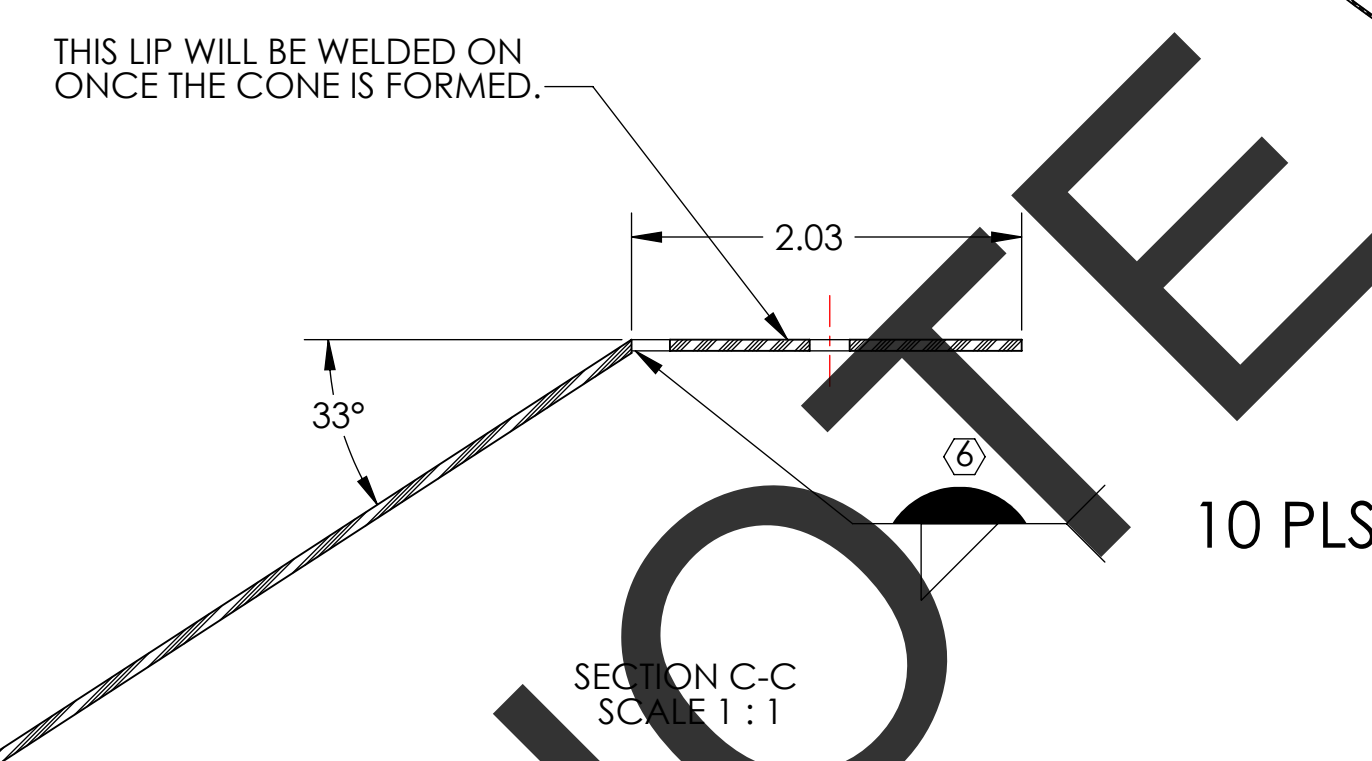
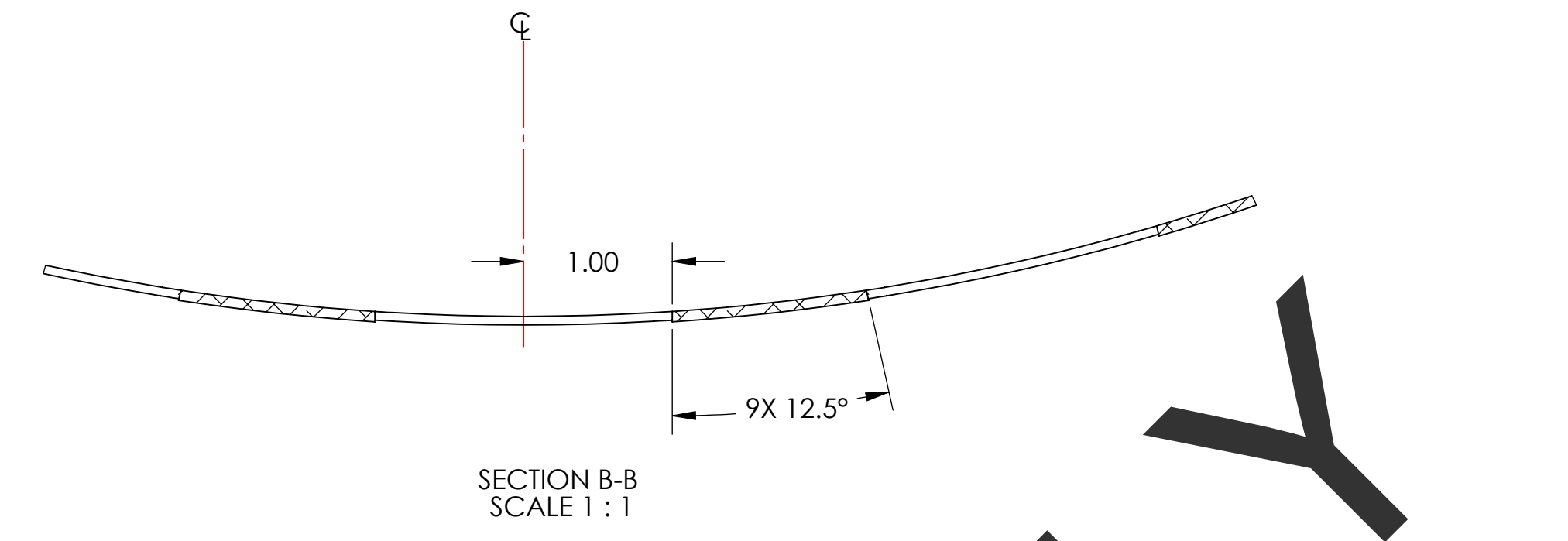
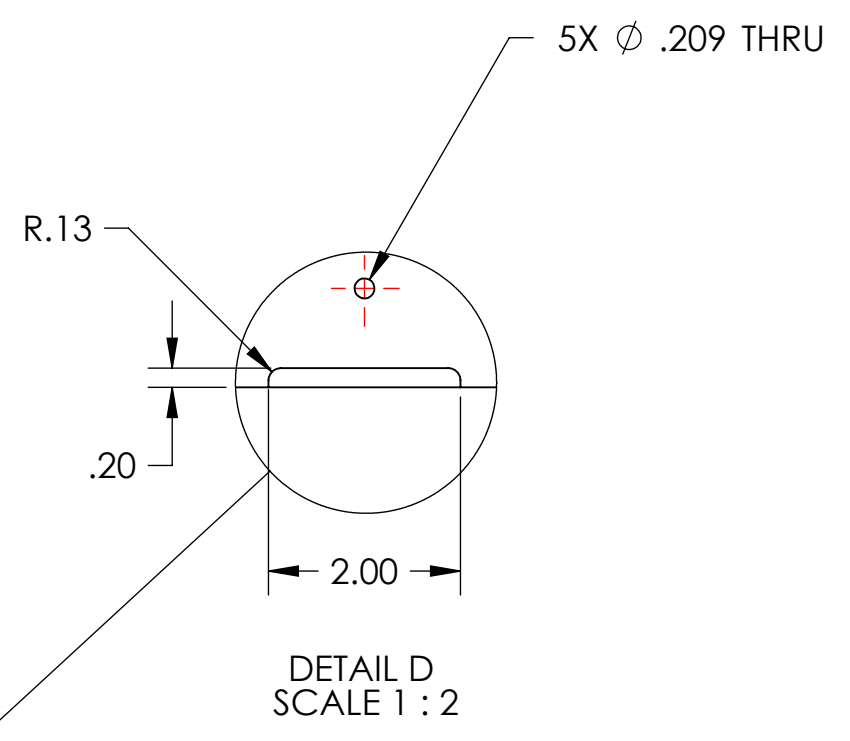
SHEET 1 OF 1

FOR QUOTE ONLY

D1003233\_duLIGO\_Manifold\_Cryo\_Baffle\_Segment\_Subassembly\_Weldment\_ETMY\_H1\_Left\_Pair\_PDM\_REV\_K-006\_DRAWING\_PDM\_REV\_X-002



- NOTES CONTINUED:**
- ⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR 'TYPE' IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE
  - ⑥ CONE AND LIP TO BE WELDED WHERE PIECES MAKE CONTACT. WELD MUST BE PER SPECIFICATION E900048.
  - ⑦ SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.
  - 8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
  - 9. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL), NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.



THIS PIECE IS PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D0902656 FOR REQUIRED DIMENSIONS FOR STRUCTURE AFTER WELDMENT.

DIMENSIONS ARE IN INCHES		TOLERANCES: .XX ± .06 .XXX ± .010		ANGULAR ± 0.5°	
NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)					
1. INTERPRET DRAWING PER ASME Y14.5-1994.					
2. REMOVE ALL SHARP EDGES, R.02 MIN.					
3. DO NOT SCALE FROM DRAWING.					
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.					
MATERIAL	18 GAUGE 304 SSSL		FINISH	⑦ SUPER #8	

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
SYSTEM	ADVANCED LIGO
SUB-SYSTEM	AOS
NEXT ASSY	D1003233

PART NAME		MANIFOLD-CRYO BAFFLE INNER SEGMENT WELDMENT, ETMY H1, LEFT			
DESIGNER	TQ. NGUYEN	16 DEC 2010	SIZE	DWG. NO.	
DRAFTER	TQ. NGUYEN	17 AUG 2010	D	D1003234	
CHECKER	M. SMITH			REV.	v3
APPROVAL	D. COYNE		SCALE: 1:8	PROJECTION:	SHEET 1 OF 1

FOR QUOTE ONLY

REV.	DATE	DCN #	DRAWING TREE #
v1	27 JUL 2011	E1000360-v2	-
v2	30 OCT 2012	E1000360-v3	-
		-	-

**NOTES CONTINUED:**

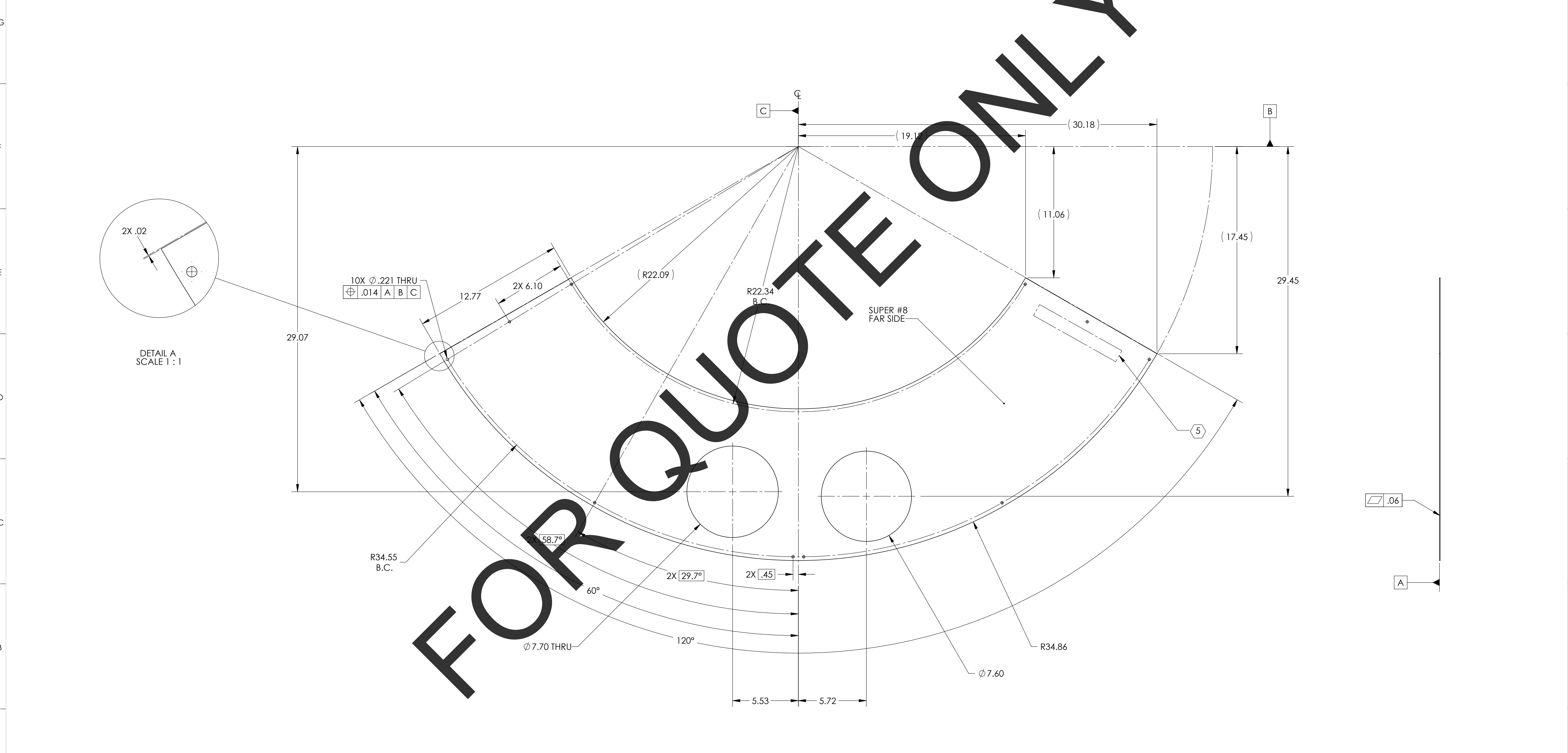
5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR TYPE IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS.  
EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX  
DO NOT APPLY MARK ON SUPER #8 SIDE

6. APPROXIMATE WEIGHT = 10.974 LBS

7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

9. PART TO BE OXIDIZED PER LIGO SPECIFICATION E1100842.

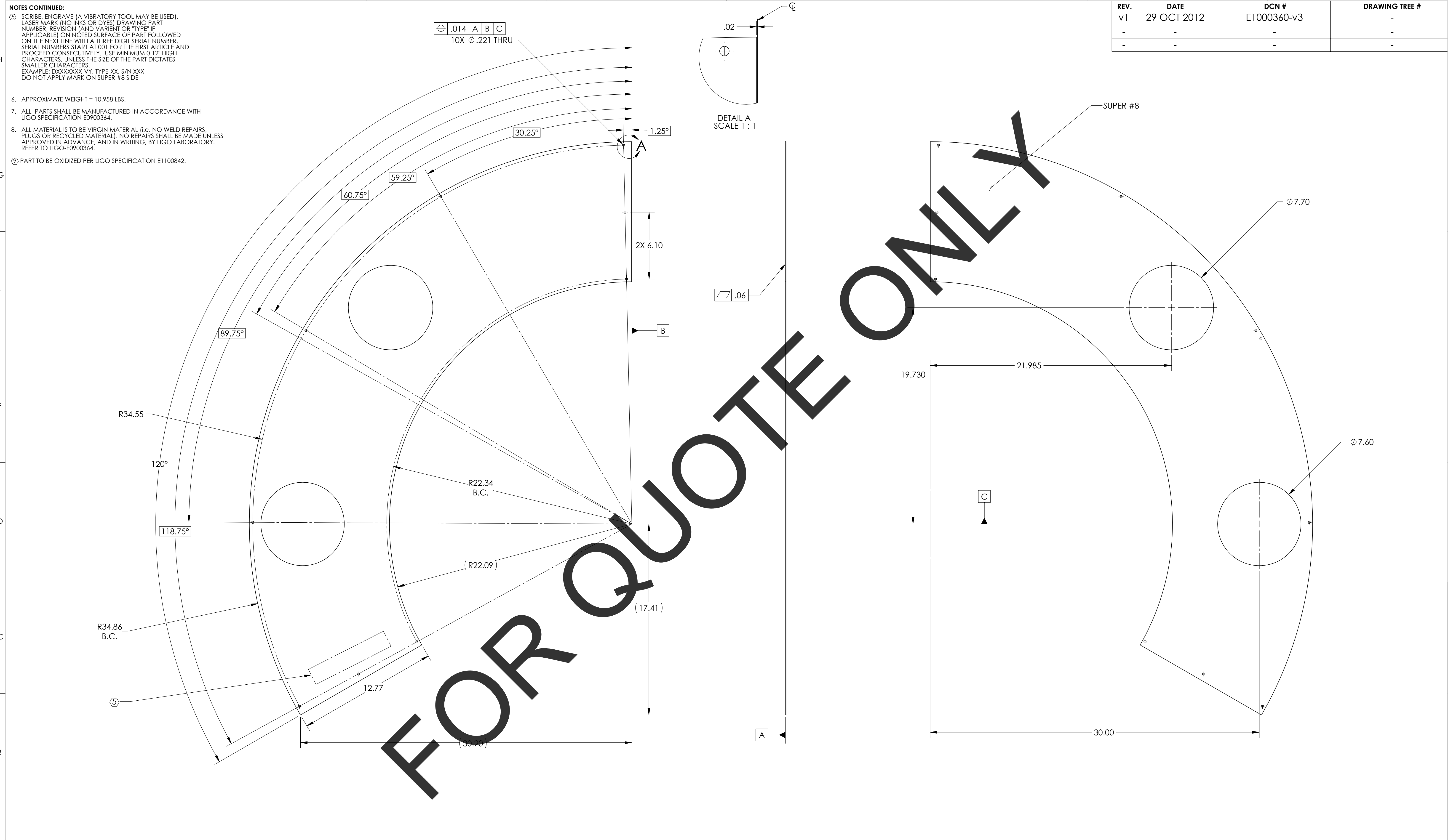


<p>DIMENSIONS ARE IN INCHES</p> <p>TOLERANCES: .XX ± .03 .XXX ±</p> <p>ANGULAR ± 0.5°</p>		<p>NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)</p> <p>1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES AND BURRS AND ROUND EDGES. FULL RADIUS ON ALL EDGES AND HOLES. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.</p>		<p><b>LIGO</b> CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY</p> <p>SYSTEM: ADVANCED LIGO      SUB-SYSTEM: AOS</p> <p>NEXT ASSY: D1003183</p>		<p>PART NAME: LOWER FACE PLATE, ETM X</p> <table border="1"> <tr> <td>DESIGNER</td> <td>TQ. NGUYEN</td> <td>27 JUL 2011</td> <td>SIZE</td> <td>DWG. NO.</td> <td>REV.</td> </tr> <tr> <td>DRAFTER</td> <td>TQ. NGUYEN</td> <td>27 JUL 2011</td> <td>D</td> <td>D1101502</td> <td>v2</td> </tr> <tr> <td>CHECKER</td> <td>M. SMITH</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>APPROVAL</td> <td>C. TORRES</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>		DESIGNER	TQ. NGUYEN	27 JUL 2011	SIZE	DWG. NO.	REV.	DRAFTER	TQ. NGUYEN	27 JUL 2011	D	D1101502	v2	CHECKER	M. SMITH					APPROVAL	C. TORRES				
DESIGNER	TQ. NGUYEN	27 JUL 2011	SIZE	DWG. NO.	REV.																										
DRAFTER	TQ. NGUYEN	27 JUL 2011	D	D1101502	v2																										
CHECKER	M. SMITH																														
APPROVAL	C. TORRES																														
<p>MATERIAL: 18 GAUGE 304 SSSL</p>		<p>FINISH: SUPER #8 (9)</p>		<p>SCALE: 1:4      PROJECTION: </p>		<p>SHEET 1 OF 1</p>																									

**NOTES CONTINUED:**  
 5. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION [AND VARIANT OR TYPE IF APPLICABLE] ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS.  
 EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX  
 DO NOT APPLY MARK ON SUPER #8 SIDE

6. APPROXIMATE WEIGHT = 10.958 LBS.  
 7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.  
 8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL), NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.  
 9. PART TO BE OXIDIZED PER LIGO SPECIFICATION E1100842.

REV.	DATE	DCN #	DRAWING TREE #
v1	29 OCT 2012	E1000360-v3	-
-	-	-	-
-	-	-	-



D:\200516\l1000\_MonField\_Cryo\_Baffle\_Levl\_Hall\_Face\_Plate\_ETMY\_PART\_PDM\_REV-X-008\_DRAWING\_PDM\_REV-X-006

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)				PART NAME	
1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015. FOR MACHINED PARTS. ROUND ALL EDGES APPROXIMATELY R.02 FOR SHEET METAL PARTS. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.				<b>LEFT HALF FACE, ETMY</b>	
DIMENSIONS ARE IN INCHES TOLERANCES: .XX ± .03 .XXX ± .010 ANGULAR ± 0.5°		MATERIAL: 18 GAUGE 304 SSTL FINISH: SUPER #8 (9)		DESIGNER: TQ. NGUYEN DRAFTER: TQ. NGUYEN CHECKER: L. AUSTIN APPROVAL: C. TORRIE	
LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		SYSTEM: ADVANCED LIGO SUB-SYSTEM: AOS NEXT ASSY: D1003227		SIZE: D DWG. NO.: D1200516 SCALE: 1:4 PROJECTION:	
				DESIGNER: TQ. NGUYEN DATE: 4 APR 2012 CHECKER: L. AUSTIN DATE: 3 APR 2012 APPROVAL: C. TORRIE	
				REV. v1 SHEET 1 OF 1	

REV.	DATE	DCN #	DRAWING TREE #
v1	29 OCT 2012	E1000360	-
-	-	-	-
-	-	-	-

**NOTES CONTINUED:**

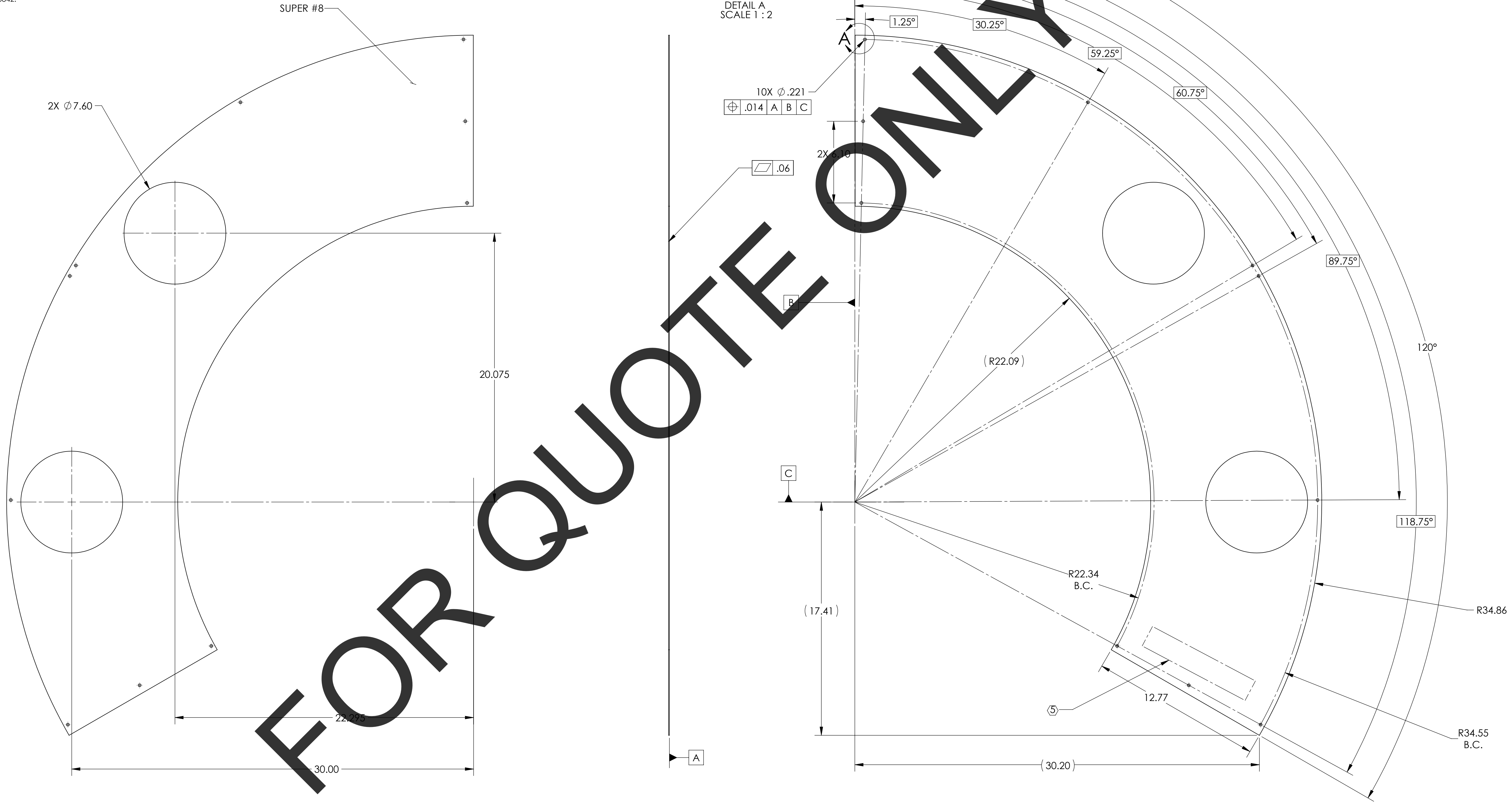
⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBERS, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBERS. SERIAL NUMBERS START AT 001 FOR FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM .12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPEXX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE.

6. APPROXIMATE WEIGHT = 11.074 LBS.

7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL), NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

⑦ PART TO BE OXIDIZED PER LIGO SPECIFICATION E1100842.



FOR QUOTE ONLY

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)				LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME						
DIMENSIONS ARE IN INCHES TOLERANCES: .XX ± .03 .XXX ± .010 ANGULAR ± 0.5°				1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015, FOR MACHINED PARTS. ROUND ALL EDGES APPROXIMATELY R.02 FOR SHEET METAL PARTS. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		SYSTEM <b>ADVANCED LIGO</b>		SUB-SYSTEM <b>AOS</b>		<b>RIGHT HALF FACE, ETRY</b>		
						MATERIAL 18 GAUGE 304 SSTL		FINISH SUPER #8 ⑦		NEXT ASSY D1003227		DESIGNER TQ. NGUYEN
						CHECKER L. AUSTIN		APPROVAL C. TORRIE		SCALE: 1:4	PROJECTION:	SHEET 1 OF 1



**NOTES CONTINUED:**

⑤ SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR TYPE IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXXXX-VY, TYPE-XX, S/N XXX. DO NOT APPLY MARK ON SUPER #8 SIDE.

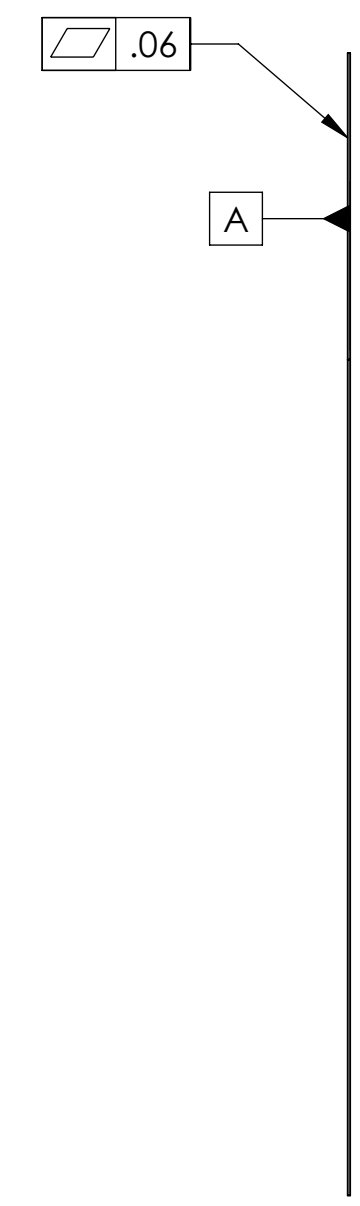
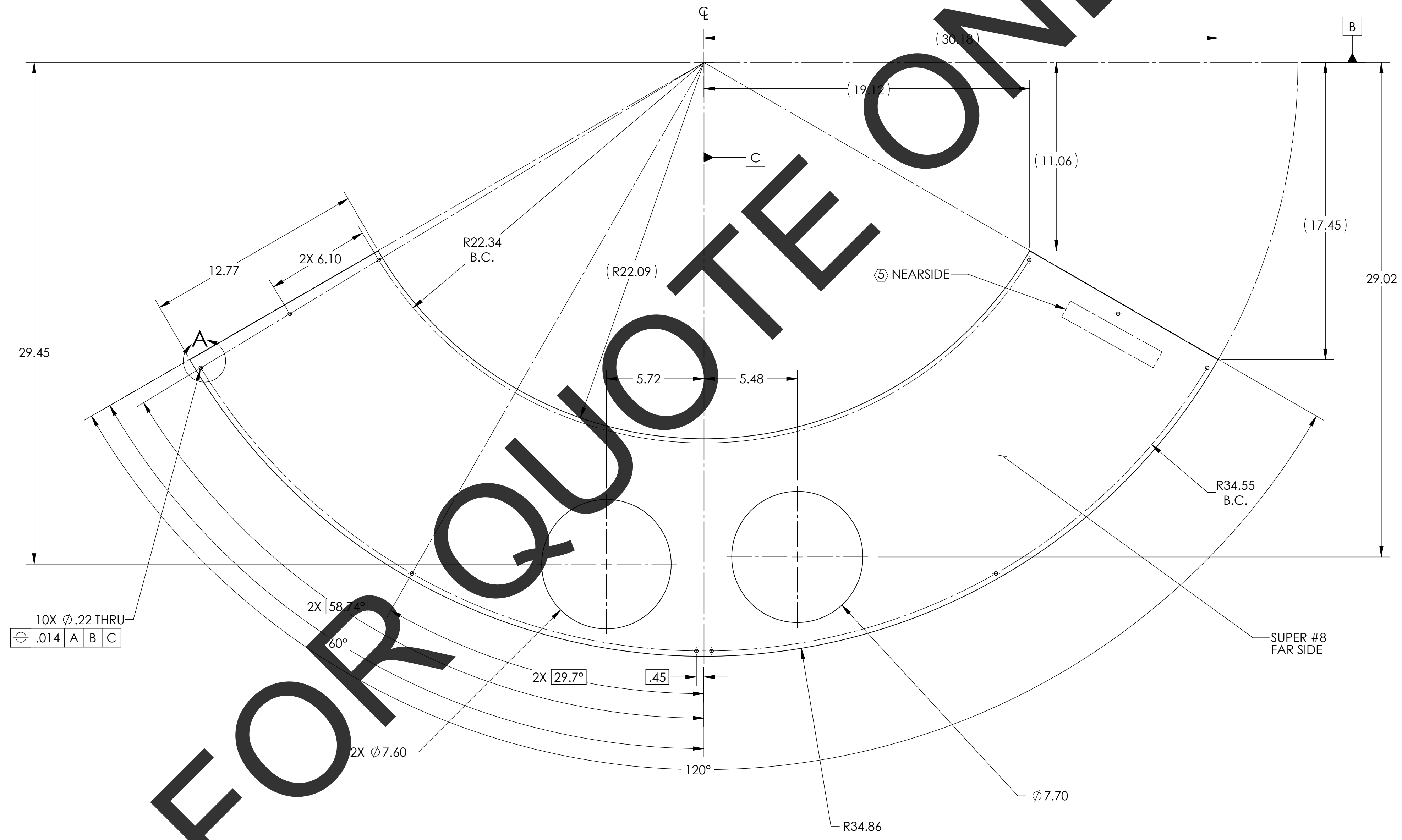
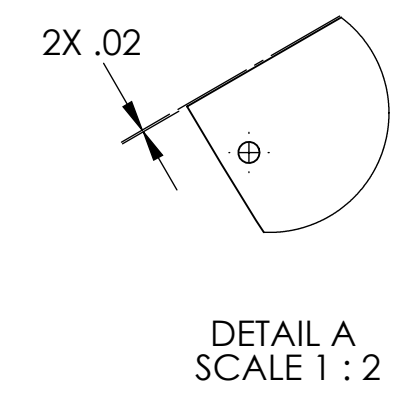
6. APPROXIMATE WEIGHT = 9.339 LBS.

7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

⑨ PART TO BE OXIDIZED PER LIGO SPECIFICATION E1100842.

REV.	DATE	DCN #	DRAWING TREE #
v1	30 OCT 2012	E1000360-v3	-
-	-	-	-
-	-	-	-



FOR QUOTE ONLY

DIMENSIONS ARE IN INCHES		TOLERANCES: .XX ± .03 .XXX ± .010		ANGULAR ± 0.5°	
NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)		MATERIAL		FINISH	
1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015, FOR MACHINED PARTS. ROUND ALL EDGES APPROXIMATELY R.02 FOR SHEET METAL PARTS. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		18 GAUGE 304 SSTL		SUPER #8 ⑨	

**LIGO** CALIFORNIA INSTITUTE OF TECHNOLOGY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO      SUB-SYSTEM: AOS

NEXT ASSY: D1003227

PART NAME		DESIGNER		SIZE		DWG. NO.		REV.	
LOWER FACE PLATE, ETM Y		TQ. NGUYEN		4 APR 2012		D		v1	
DRAFTER		CHECKER		APPROVAL		SCALE: 1:4		PROJECTION:	
L. NGUYEN		L. AUSTIN		C. TORRIE		1:4		FIRST ANGLE	
D1200518		SHEET 1 OF 1							

NOTES CONTINUED:  
 (9) SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), DO NOT STAMP OR LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX DO NOT APPLY MARK ON SUPER #8 SIDE

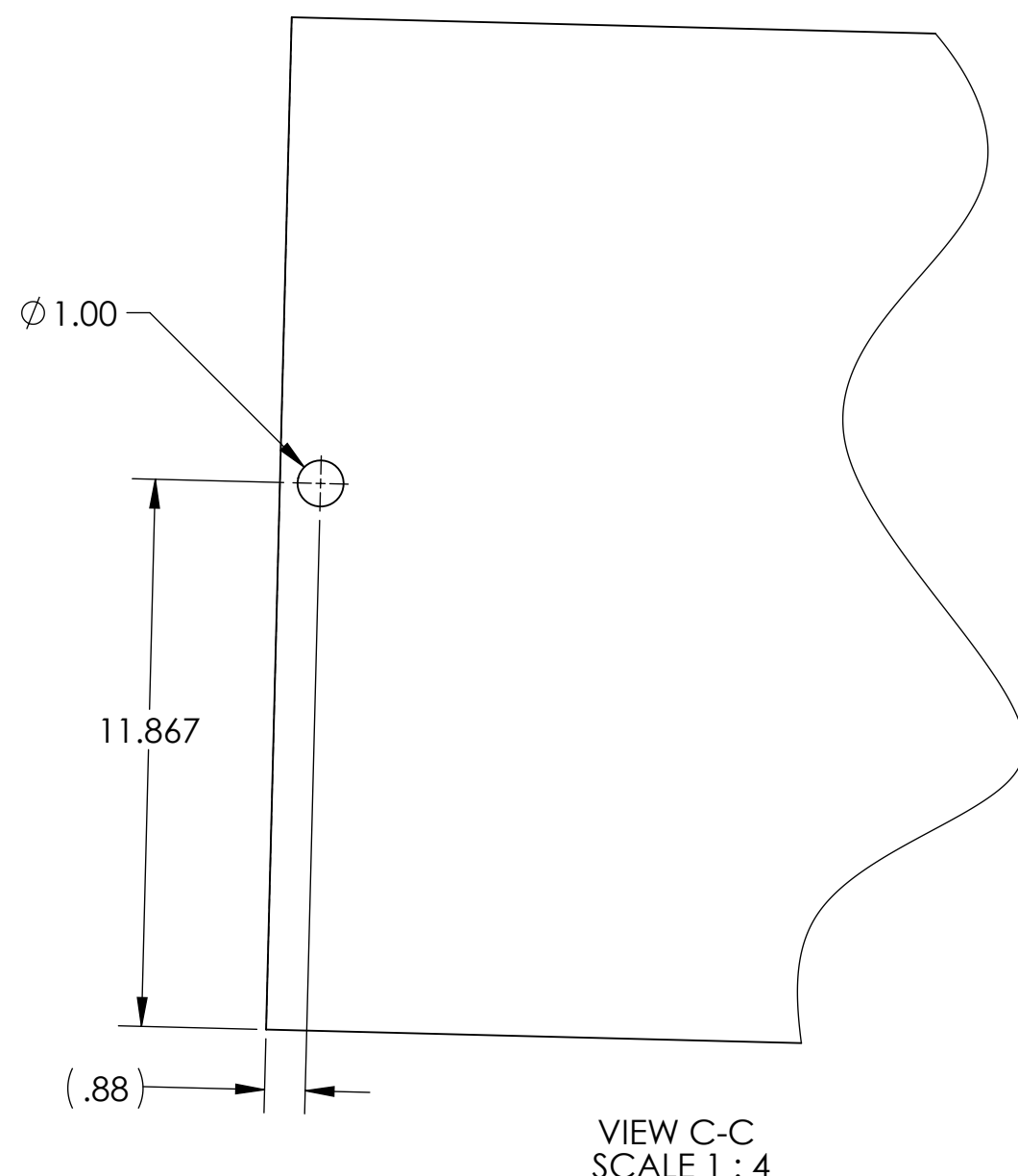
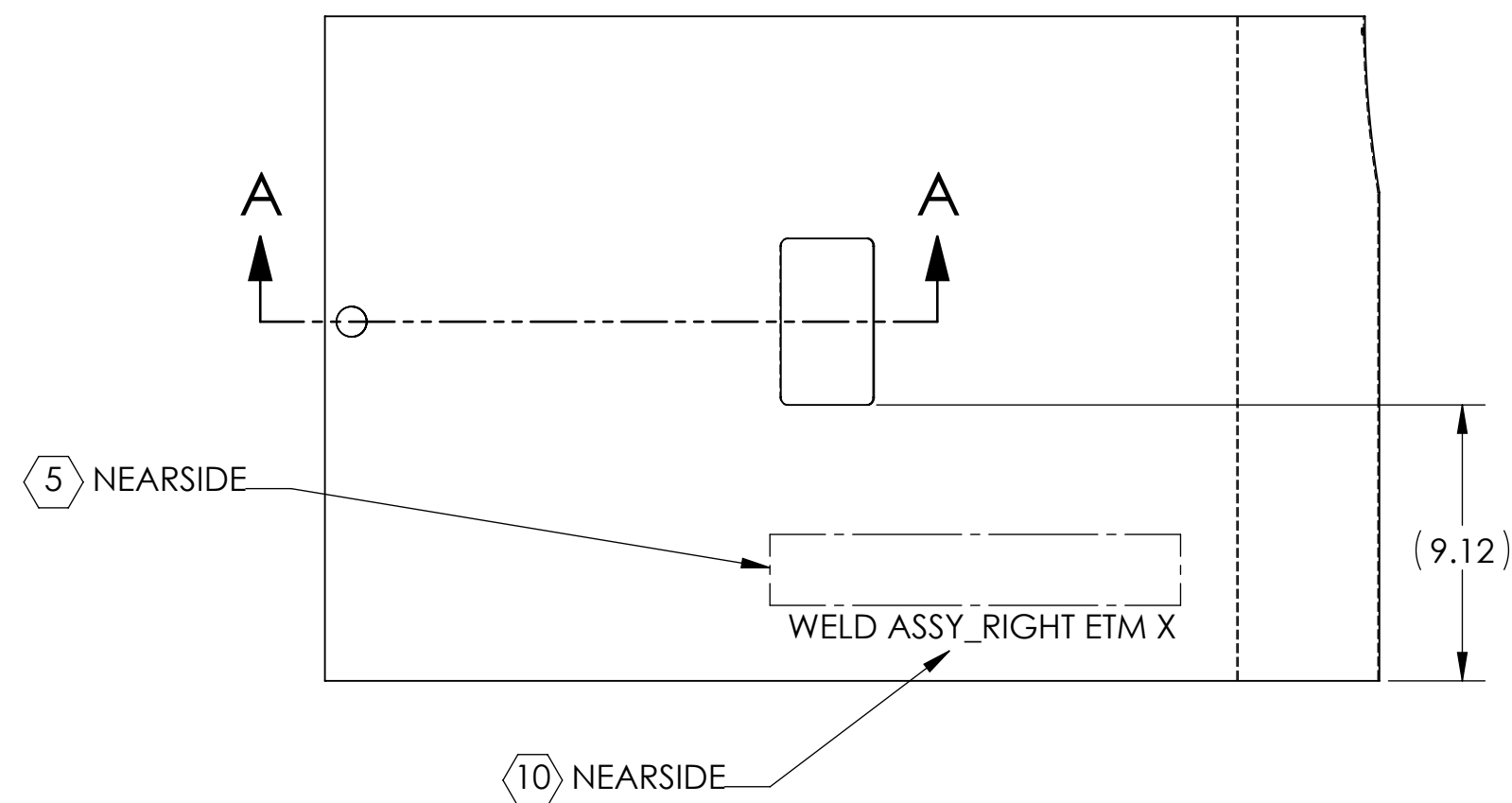
6. APPROXIMATE WEIGHT = 20.910 LBS  
 7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

(8) SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

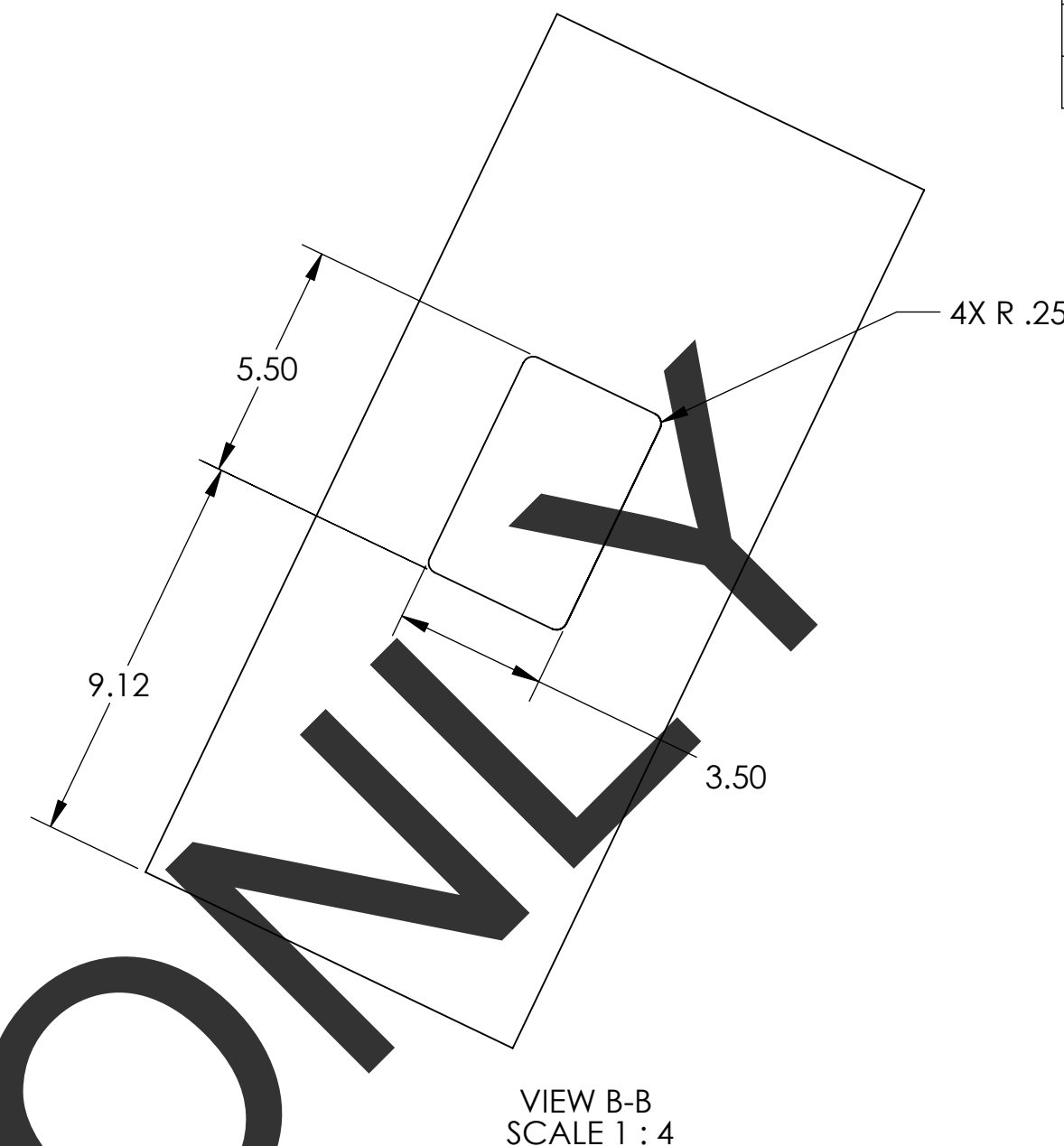
9. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL). NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

(10) SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), LASER MARK (NO INKS OR DYES) LETTERS AS SHOWN.

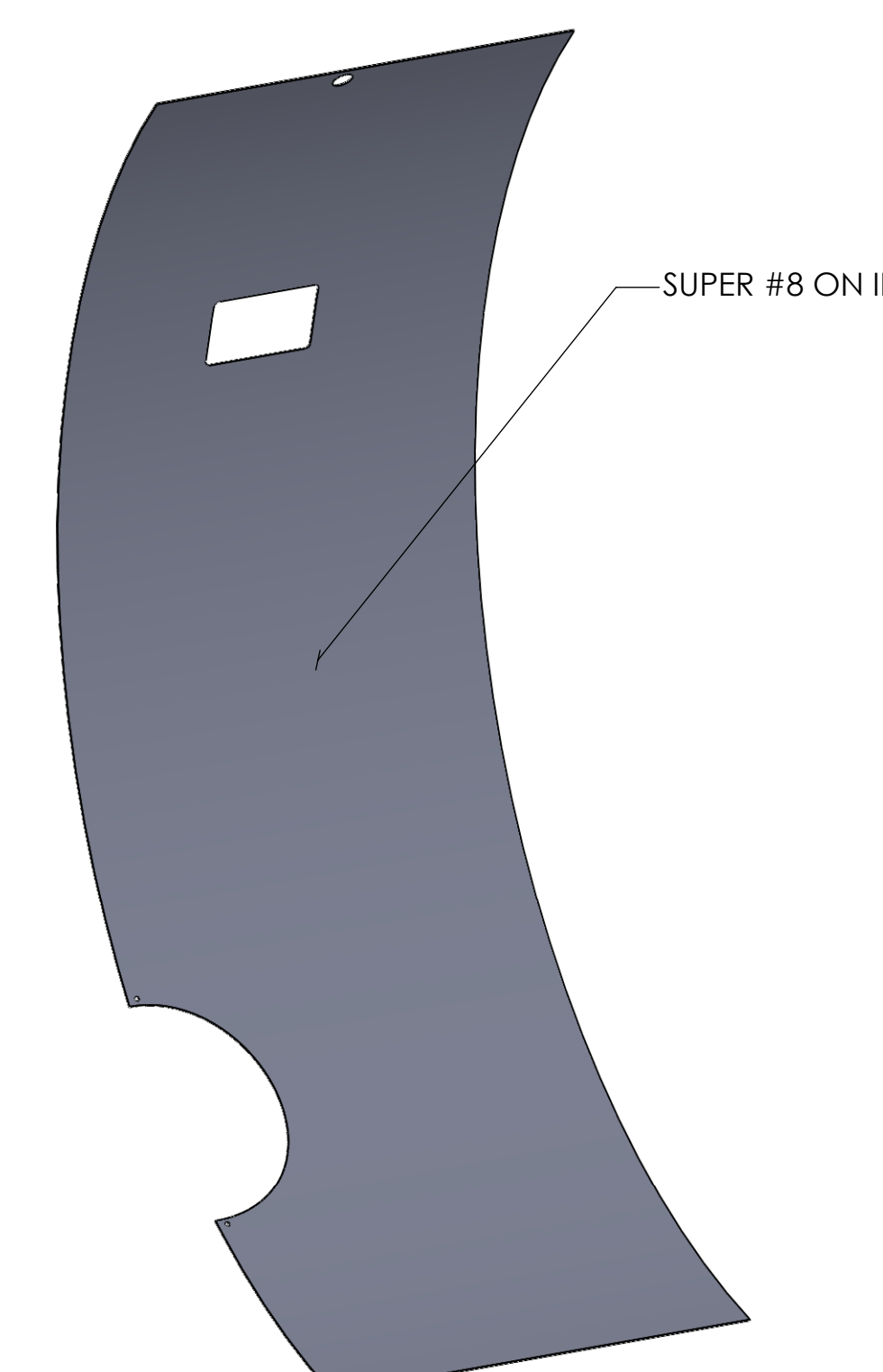
REV.	DATE	DCN #	DRAWING TREE #
v1	31 OCT 2012	-	-
v2	15 DEC 2012	E1000360	-
-	-	-	-



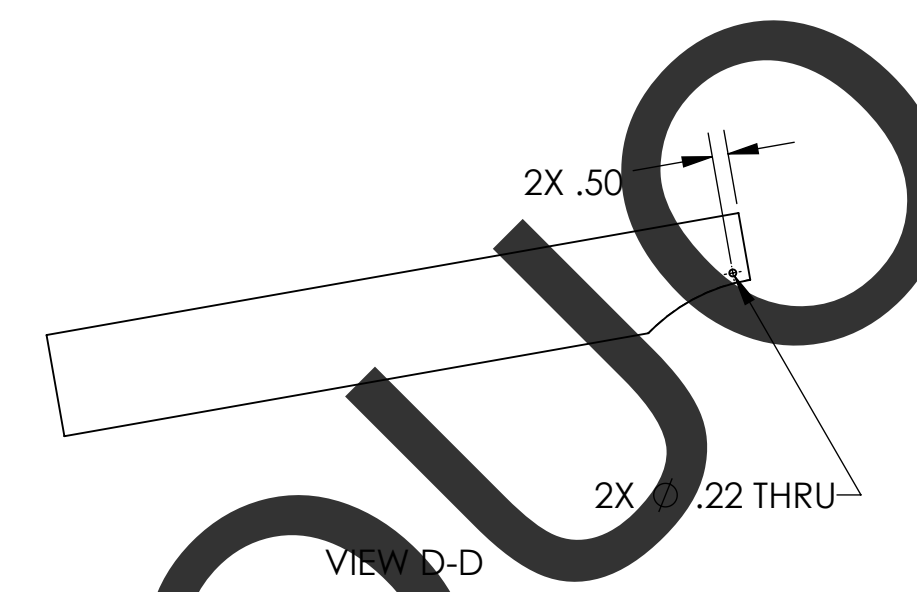
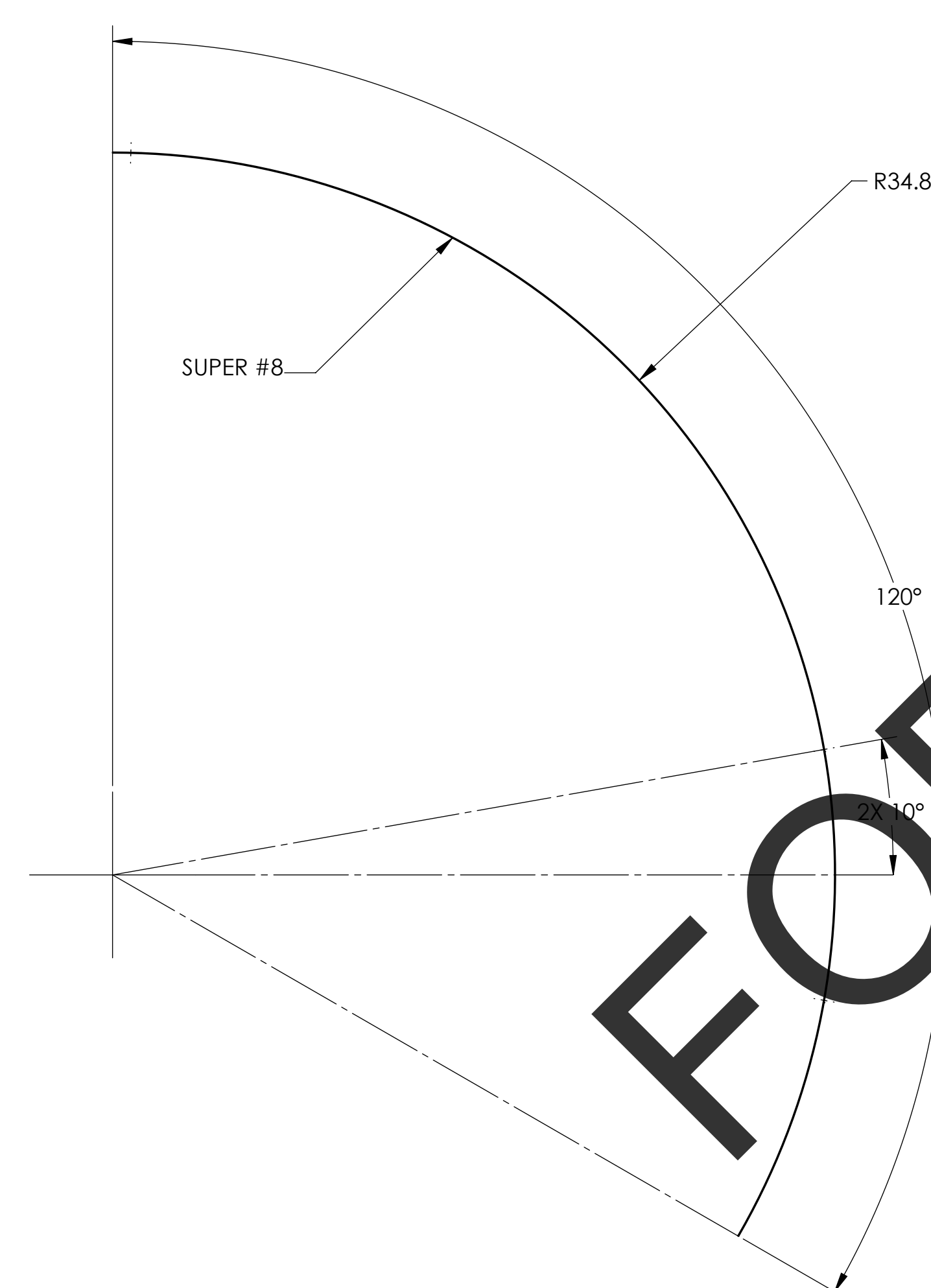
VIEW C-C  
SCALE 1 : 4



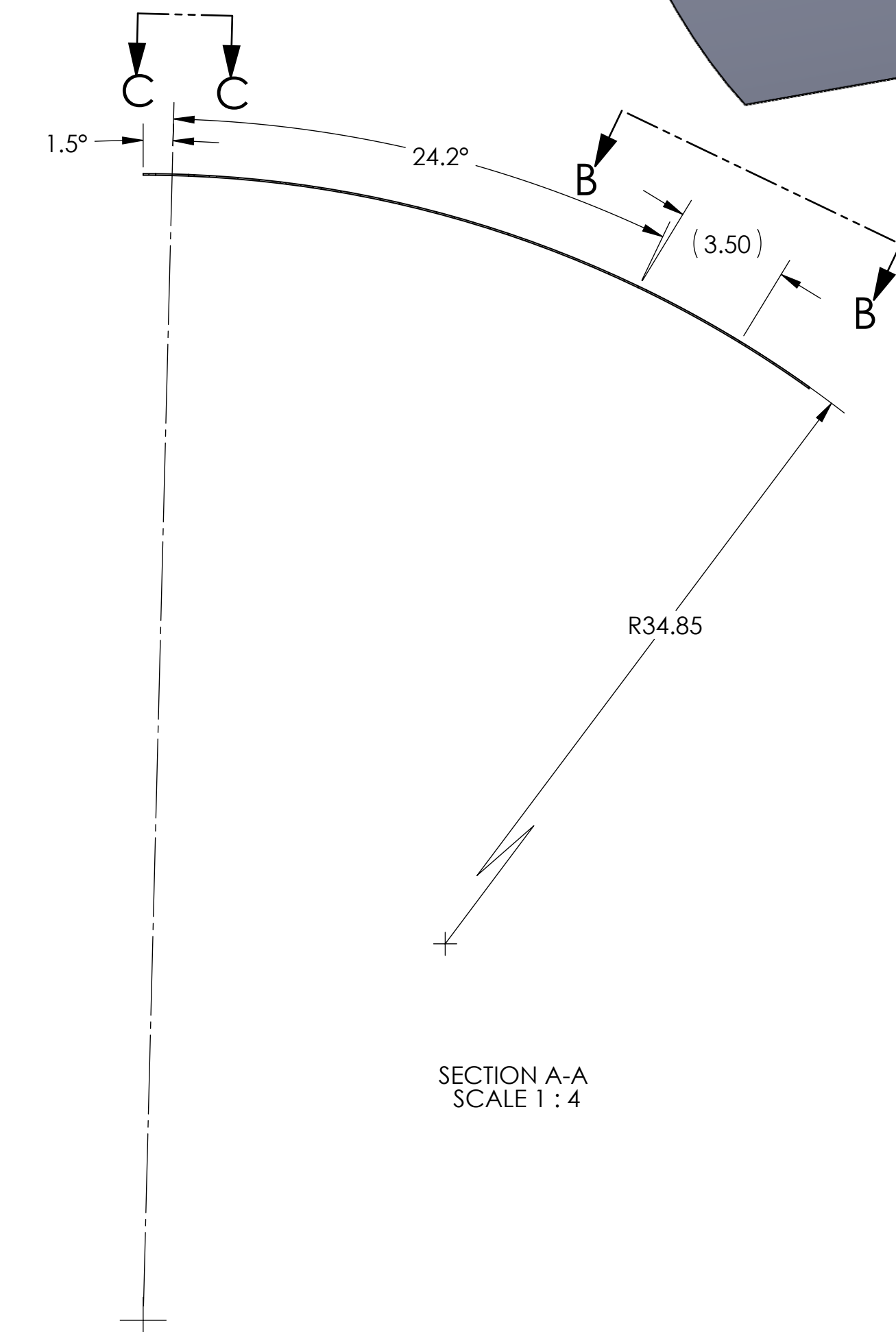
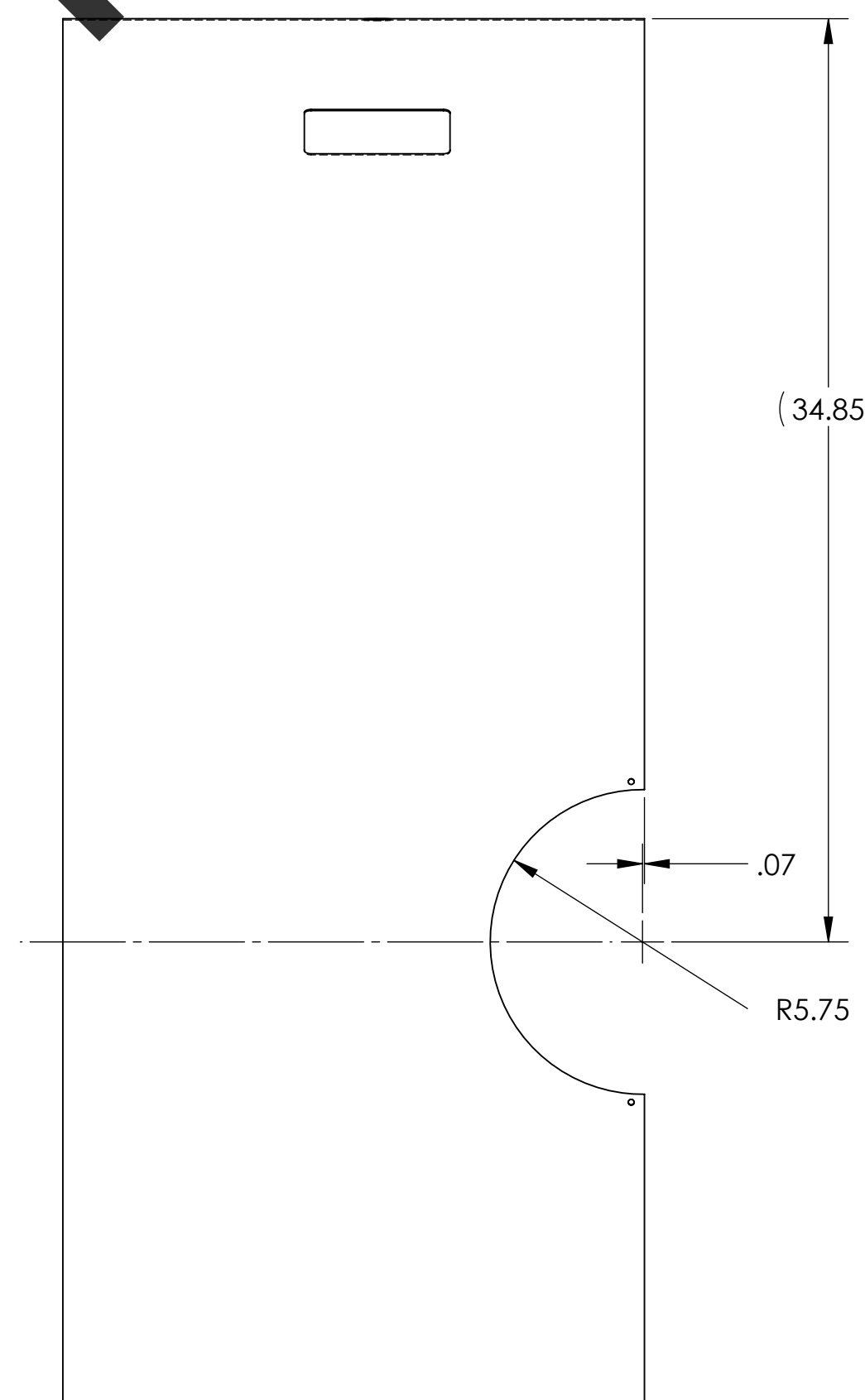
VIEW B-B  
SCALE 1 : 4



SECTION A-A  
SCALE 1 : 4



VIEW D-D



FOR QUOTE ONLY

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)				CALIFORNIA INSTITUTE OF TECHNOLOGY LIGO MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME						
DIMENSIONS ARE IN INCHES				1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015, FOR MACHINED PARTS. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		RADIAL SEGMENT, RIGHT ETM X						
TOLERANCES: .XX ± .03 .XXX ± .010 ANGULAR ± 1.0°						SYSTEM	SUB-SYSTEM	DESIGNER	TQ. NGUYEN	11 OCT 2012	SIZE	DWG. NO.
MATERIAL				ADVANCED LIGO	AOS	DRAFTER	TQ. NGUYEN	9 AUG 2012	D	D1201125		v2
FINISH				18 GAUGE 304 SSTL	NEXT ASSY	CHECKER	L. AUSTIN			SCALE: 1:6	PROJECTION:	SHEET 1 OF 1
				SUPER #8 (8)	D1003186	APPROVAL	M. SMITH					

D:\201125\_d1201125\_01.dwg - Radial Segment Right Part PDM REV: X014 DRAWING PDM REV: X010

NOTES CONTINUED:  
 3. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY BE USED), DO NOT STAMP OR LASER MARK (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS.  
 EXAMPLE: DXXXXXX-VY, TYPE-XX, S/N XXX  
 DO NOT APPLY MARK ON SUPER #8 SIDE

6. APPROXIMATE WEIGHT = 20.910 LBS.

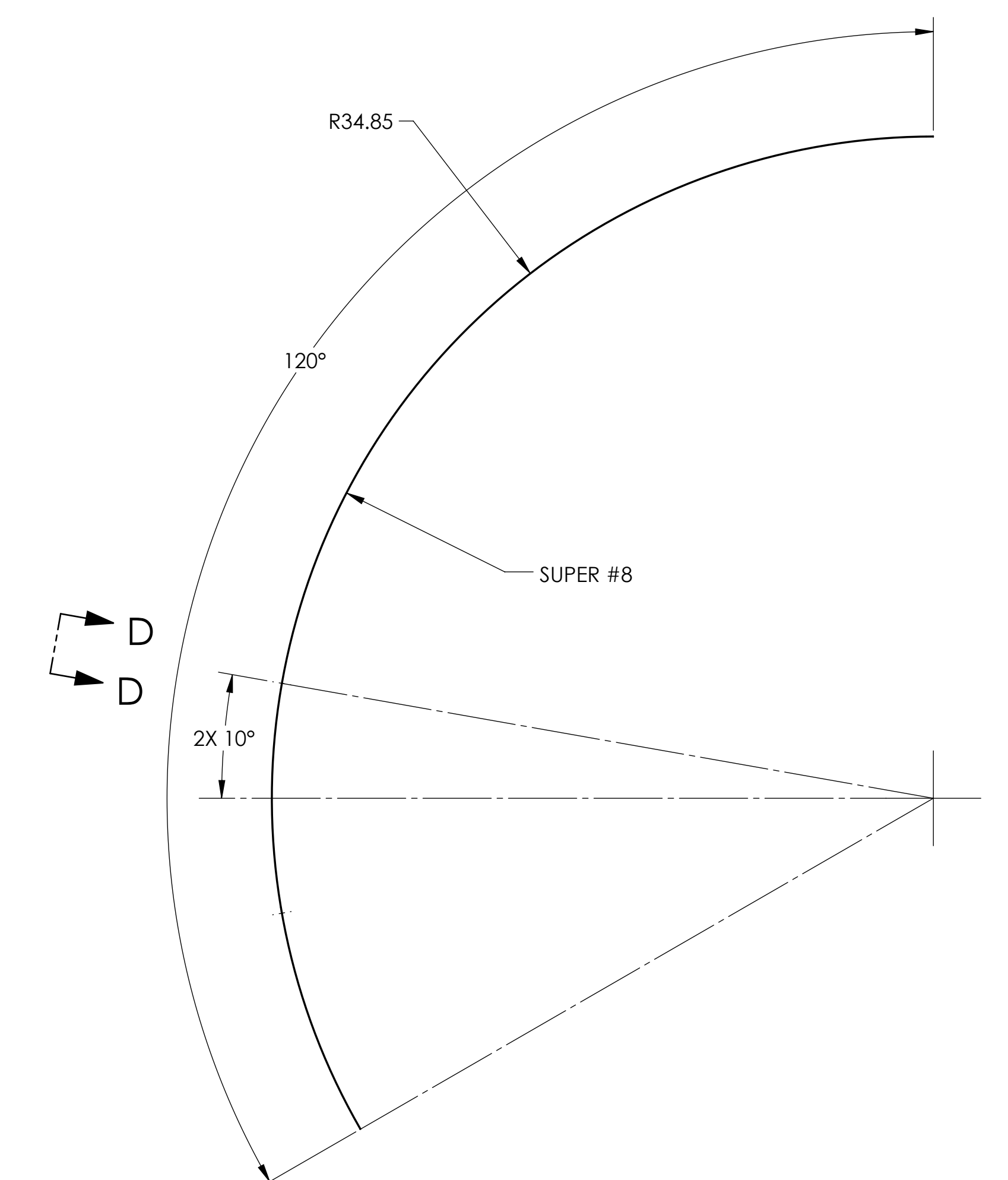
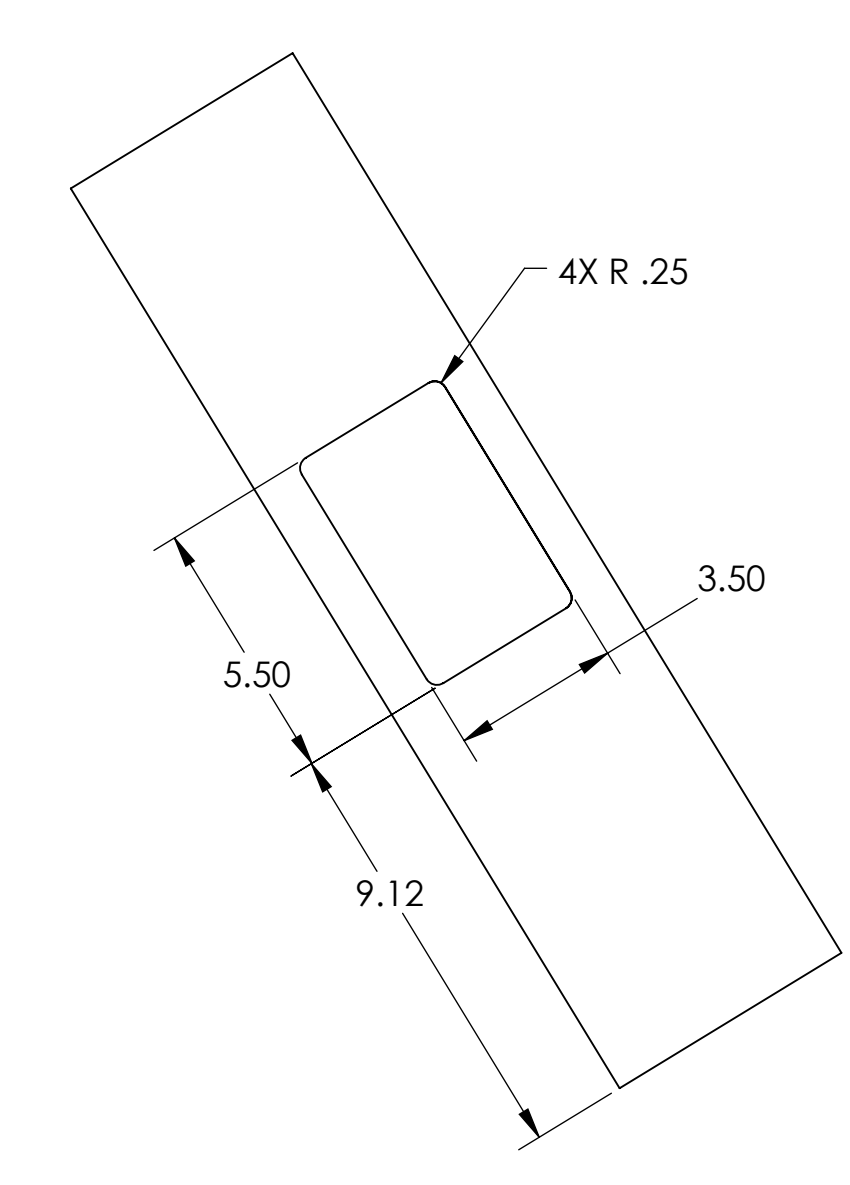
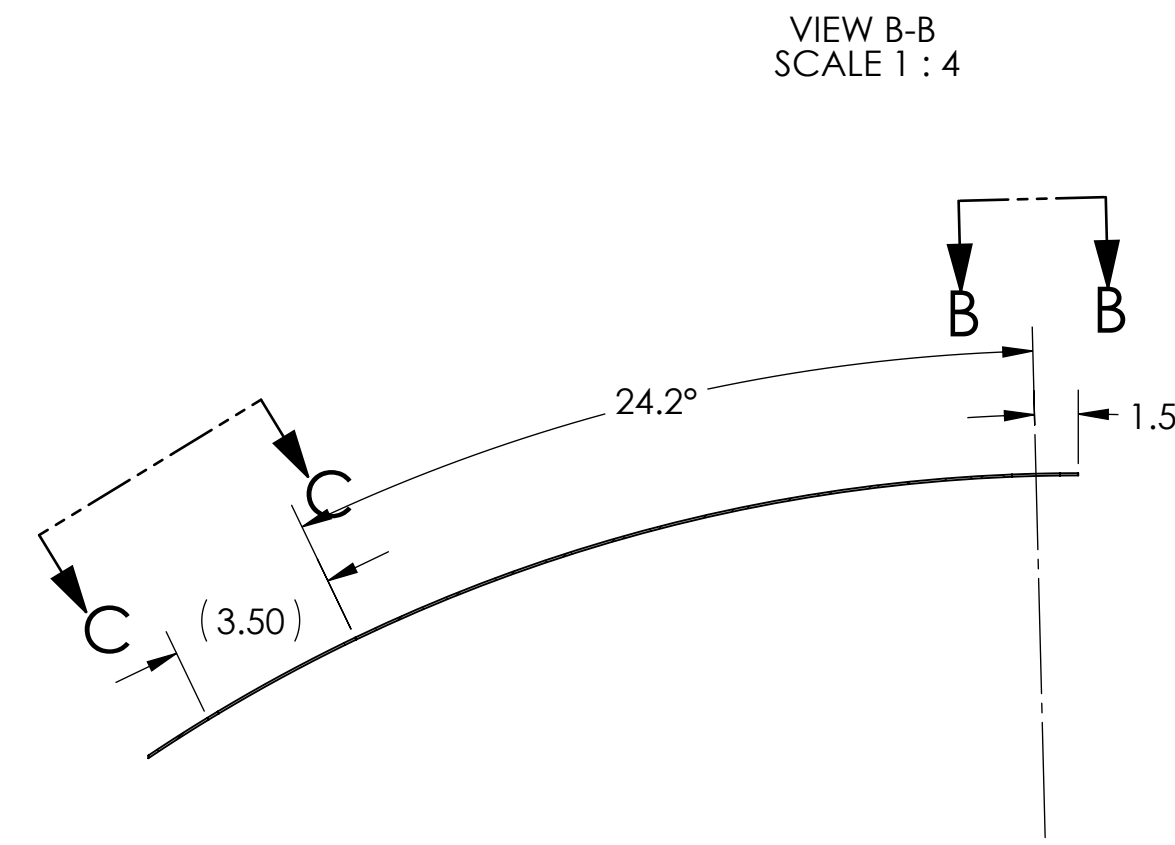
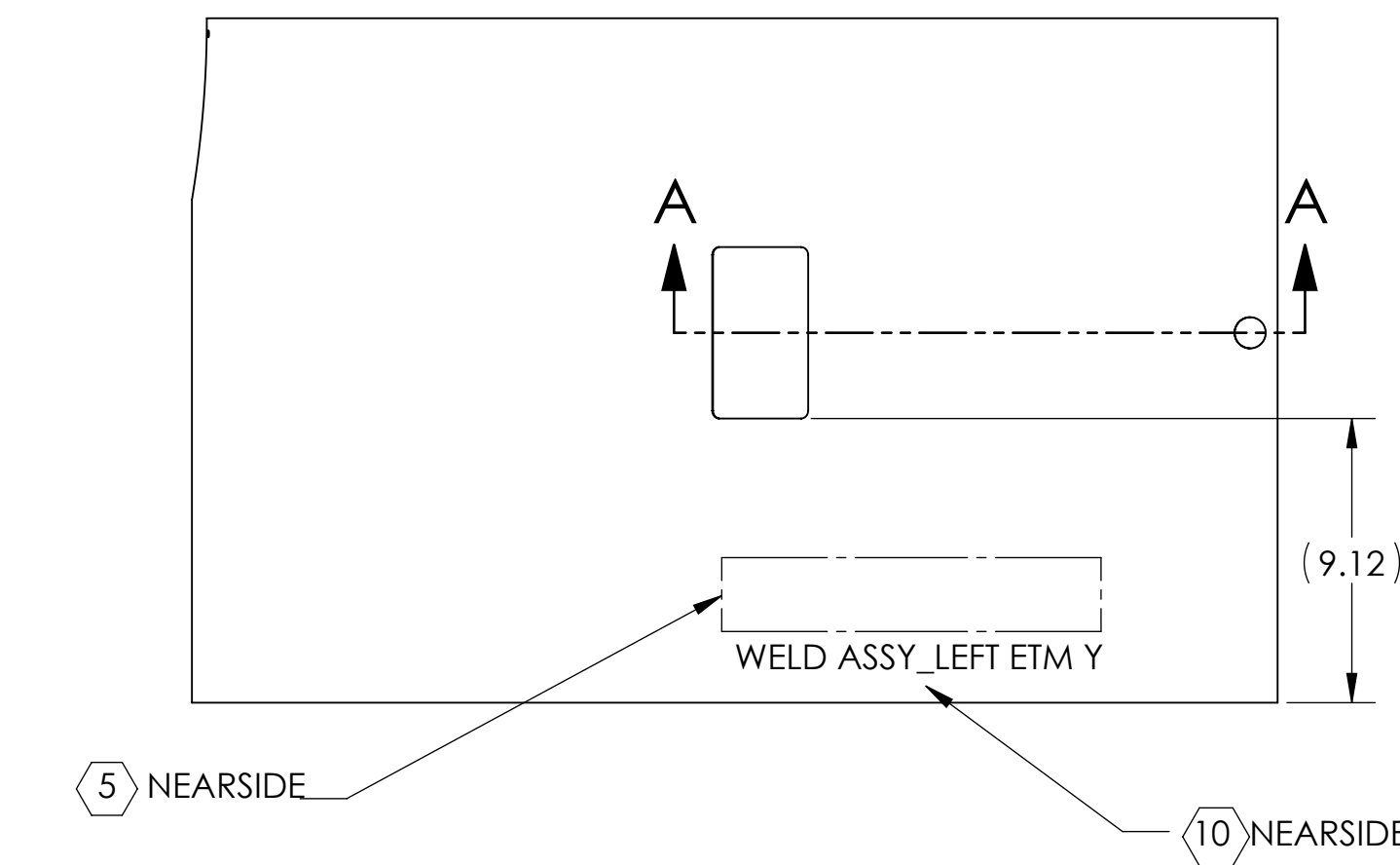
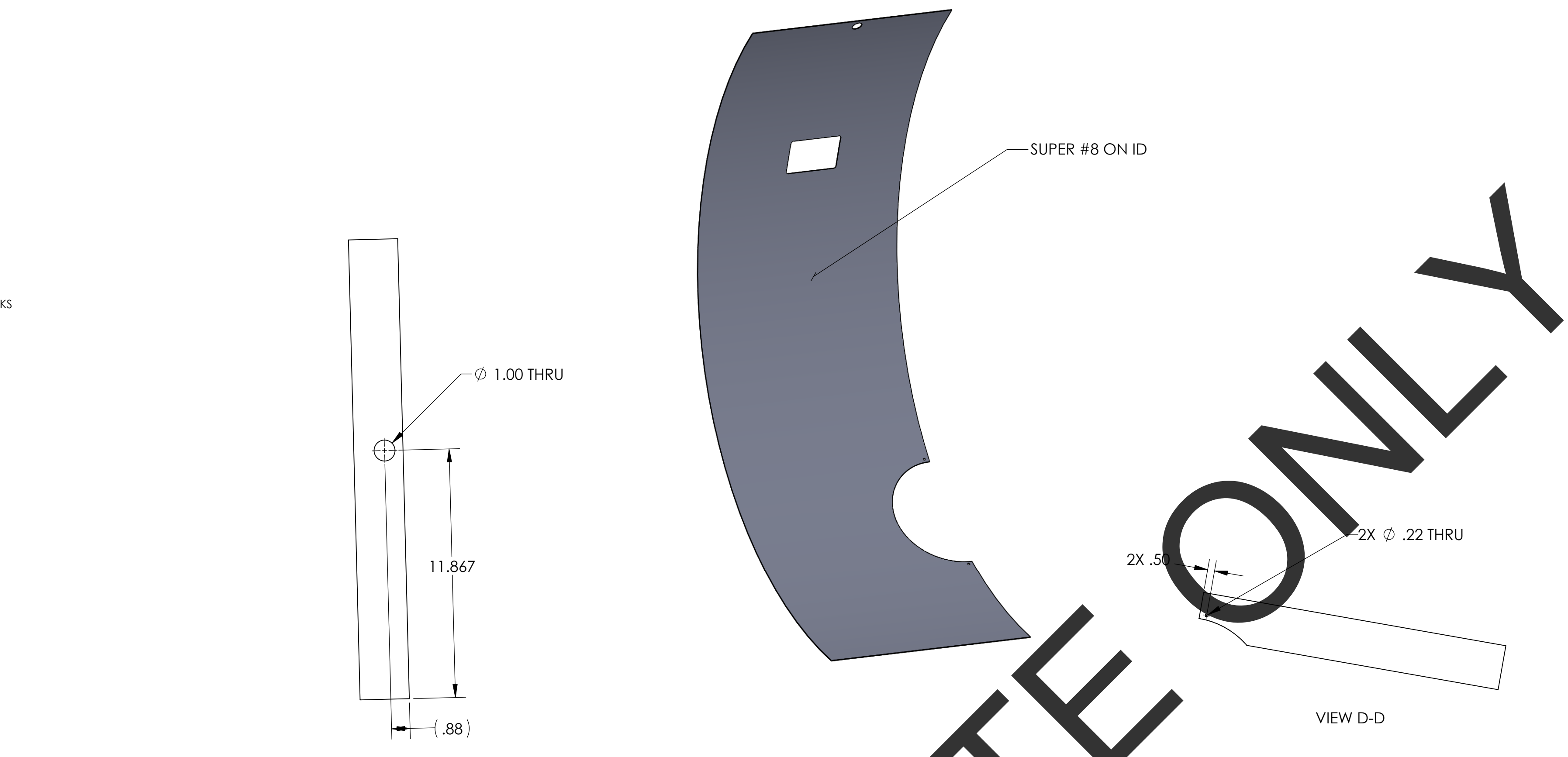
7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

8. ALL MATERIAL IS TO BE VIRGIN MATERIAL (i.e. NO WELD REPAIRS, PLUGS OR RECYCLED MATERIAL); NO REPAIRS SHALL BE MADE UNLESS APPROVED IN ADVANCE, AND IN WRITING, BY LIGO LABORATORY. REFER TO LIGO-E0900364.

9. SURFACE FINISH TO BE AS-PROCESSED FROM MILL/SUPPLIER, FREE FROM SCRATCHES OR GOUGES.

10. SCRIBE, ENGRAVE (A VIBRATORY TOOL MAY USED), LASER MARK (NO INKS OR DYES) LETTERS AS SHOWN.

REV.	DATE	DCN #	DRAWING TREE #
v1	1 NOV 2012	-	-
v2	15 DEC 2012	E1000360	-
-	-	-	-



**FOR QUOTE ONLY**

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)				CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME					
1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, .005-.015, FOR MACHINED PARTS. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.				<b>LIGO</b>		<b>ETM Y RADIAL SEGMENT, LEFT</b>					
DIMENSIONS ARE IN INCHES TOLERANCES: .XX ± .03 .XXX ± .010 ANGULAR ± 1.0°				<b>ADVANCED LIGO</b>		<b>AOS</b>		DESIGNER: TQ. NGUYEN 19 OCT 2012 DRAFTER: TQ. NGUYEN 1 NOV 2012 CHECKER: L. AUSTIN APPROVAL: M. SMITH		SIZE: D DWG. NO.: <b>D1201405</b> REV.: v2	
MATERIAL: 18 GAUGE 304 SSTL FINISH: SUPER #8				NEXT ASSY: D1003233		SCALE: 1:6 PROJECTION:		SHEET 1 OF 1			

D:\2014\05\aligo\_Monfield\_Cryo\_Baffle\_ETM\_Y\_Radial\_Segment\_Left\_PAFB.PDM.REV.X-003.DRAWING.PDM.REV.X-006

## Welding Specification for Weldments used within the Advanced LIGO Vacuum System

APPROVALS	DATE	Document Change Notice
AUTHOR(S): Calum Torrie, Dennis Coyne	27-Oct-2010	see DCC record Status: <b>APPROVED</b>

### 1 Scope

This specification controls the process of welding aluminum and stainless steel for parts (weldments) intended for service inside the Ultra-High Vacuum (UHV) for the Advanced LIGO project. Unless otherwise directed all weldments should be fabricated in compliance with this specification.

This specification does not cover welding elements of the vacuum envelope itself, but rather parts which are placed within the vacuum envelope.

### 2 Certification and End Item Data Package

The fabricator must provide the following certification or documentation:

1. To approve seamed tubing, if applicable, (see section 3.2) submit an inspection report confirmation on qualification of as received stainless steel seamed tubing, prior to starting production. As noted in section 3.2 this should include 100% inspection of flash removal if required (see section 3.2)
2. To approve welder and weld samples submit a Procedure Qualification Record (PQR) on welder and weld samples (see section 8), prior to starting production.
3. To approve method used for production weldments (see section 7) submit a Certified Welding Procedure Specification (WPS) on production weldments, this can be submitted with the PQR, prior to starting production.
4. To approve production weldments (see section 10) submit prior to final machining:
  - a. An inspection report confirming the qualification of the production weldments to Class C, as per section 7.1 and 7.2 should be submitted.
  - b. Certification that the requirements of the specification (WPS) have been met
  - c. Material certifications for all materials (filler rod and base material) which comprise the weldment.
5. To approve final machining (see section 12) submit dimensional inspection report on final machining, at the time of delivery.

## Welding Specification for Weldments used within the Advanced LIGO Vacuum System

### 3 Acceptable Materials

#### 3.1 Base Material

Only the material alloys defined in the associated drawings are acceptable. No substitutions shall be made without prior written consent from the LIGO Contracting Officer. All material should be selected and transported according to our requirements, for example for stainless steel tubing follow section 3.2.5 and 3.2.6 below. A similar specification should be followed and agreed with the LIGO Contractual officer for Aluminum or other materials.

No parts, including seamed tubing, shall be ground or cut off with grinding tools.

#### 3.2 Stainless steel tubing

Stainless steel seamed tubing, although an option, should not be the first choice if seamless tubing is available.

If seamed tubing is utilized, the weld seam and any weld flash must meet the requirements listed below. If the weld flash does not meet the requirements, then it must be removed. Details, including fixtures required to remove this flash and a method for removal should be included in this quote. The flash removal process must be inspected 100% visually and certified by the vendor and approved by LIGO.

With prior approval from a LIGO Contract Officer stainless steel seamed tubing can be used under the following conditions: -

1. Take a cross-sectional sample of the tube weld for every ~20 ft. of every continuous weld run (batch) and verify that the weld is Class B in Table V of Mil-Std-2219. The verification requires
  - (a) visual inspection for weld discontinuities, porosity and inclusions,
  - (b) x-ray for complete penetration and fusion and
  - (c) microstructural examination of weld samples cross-sections (refer to section 8.3 for further details)
2. Supply inspection report for approval to the LIGO contract officer confirming that the as-received seamed welds conform to class B prior to continuing.
3. Prior to welding all seamed tubing (inside and out) should be electropolished to ASTM B-912. (Scotch-Brite(TM) or similar products are prohibited.)
4. As per section 11 of ASTM A554-10 the finished tubes shall be free of injurious defects and have a workmanlike finish. Surface imperfections such as handling marks, shallow pits and scratches shall not be considered as serious defects provided they are within 10% of the specified wall or 0.002 inch (0.05mm), whichever is greater.
5. Each tube should be individually wrapped and protected from scratches, pitting and digs during transport and handling. Each tube should be inspected and handled appropriately.

If stainless steel seamless tubing is available items 3.2.4 and 3.2.5 still apply.

## Welding Specification for Weldments used within the Advanced LIGO Vacuum System

### 3.3 Filler Rod

The following Table shows the filler rod that should be used with various alloys:

**Table 1: Welding Filler Rod**

Material	Alloy	Filler
Stainless Steel	304	308, 308L
	304L	308L
	316	316, 316L
	316L	316L
	321	347
	347	347
Aluminum	6061	4043 (Linde H.Q.)

## 4 Cleaning and Preparation

1. Pre weld machining must be carefully controlled. All machines & fixtures are to be cleaned to avoid cross contamination before any machining takes place.
2. Weld preps must be machined and under no circumstances should weld preps be ground (due to risk of cross contamination). If machining is impractical use new carbide burrs.
3. Welds are not to be ground (due to risk of cross contamination); If welds need to be cleaned up, they must be cut.
4. Water soluble (not just water miscible) cutting fluid (lubrication) is to be used for all machining operations, such as weld prep, weld clean up or weld repair. The use of cutting fluids or lubricants, which contain sulfur, chlorine or silicone compounds is prohibited.
5. The contractor must define suitable methods for initial cleaning (oxide cleaning, degreasing, and dirt/soil removal), interpass cleaning and post-weld cleaning. An etchant (acid or basic) should be used, similar to the solutions defined in Annex G, "Solutions for Macroetching Aluminum Weldments" of AWS D1.2/D1.2M:2003 Structural Welding Code -- Aluminum. The contractor must define degreasing, deoxidizing, interpass and post-weld cleaning methods in the Weld Process Specification (WPS) and Process Qualification Record (PQR) which must be approved by LIGO before welding.
6. Prior to welding, clean the filler rod using lint- free tissue and analytical Reagent Grade isopropyl alcohol.

## 5 Handling and Storage

1. Latex gloves are to be worn for handling room temperature cleaned parts – parts to be welded or tools and fixtures.
2. If hot parts must be manipulated, clean tools are preferred rather than gloved hands. If hot parts or tools/fixtures need to be handled, then clean welding gloves should be used. A new pair of gloves should be dedicated to the LIGO work.

## **Welding Specification for Weldments used within the Advanced LIGO Vacuum System**

3. Tools and fixtures, which may contain cleaned parts in assembly or transport, are to be kept clean from oxides, oils, fingerprints, etc.
4. Parts are to be stored in a clean dry area until welding commences. Parts should not be stored for a long periods after cleaning, welding should commence as soon as possible and definitely within one work shift after parts are chemically cleaned.
5. Store filler metal in bonded storage and in a manner such that it is protected from oil and other contaminates. The package seal must not be broken until just prior to welding. Rod from an opened package must be kept in a cabinet or other area within the clean welding area.
6. Weldments and cleaned parts, tools and fixtures are to be covered between welding operations. The material used for covering can be UHV quality aluminum foil or clean stainless steel covers/boxes. If the parts are at room temperature, then cleanroom grade sheeting materials (low lint, low shedding), such as DuPont™ Tyvek®.
7. Welding should be performed in a clean, particulate and humidity (50% maximum relative) controlled environment.
8. Completed weldments are to be double wrapped and stored in a clean, controlled area prior to shipment. The inner wrap must be UHV quality aluminum foil. The outer wrapping, or bag, should be Ameristat® or similar class 100 cleanroom grade packaging material. No tape (adhesive) should be used to attach or close the inner wrapping. Heat sealing can not be performed with the part in the wrapping/bag.

## **6 Welding**

### **6.1 General Requirements**

1. All welding must take place in a clean, particulate and humidity (50% maximum relative) controlled environment. Welders must adhere to the contamination control practices described in these specifications.
2. Thin (less than 0.010 inch thick) stainless steel or beryllium-copper parts (e.g.: RF shields) may be spot welded using a resistance welding process. All other welding shall be by the tungsten inert gas (TIG) fusion process, unless specifically approved. Welding electrodes shall be 2 percent thoriated tungsten.
3. Prior to welding, all parts must be cleaned according to these specifications. Jigs, fixtures, chill rings (if used), and welding bench which contact the clean parts must also be cleaned according to these specifications.
4. The filler rod and must be kept clean at all times.
5. Leather welders gloves are of course used by the welder during welding. However, Latex gloves must be worn when clean “cold” parts are handled. If the gloves come in contact with anything other than clean surfaces, they must be replaced with new ones.



## **Welding Specification for Weldments used within the Advanced LIGO Vacuum System**

6. Appropriate brushes and high quality hand scrapers can be used for cleaning oxides off welds. Brushes and scrapers shall be degreased before use and kept free from oxides. Brass brushes and Scotch-Brite pads are prohibited.
7. Preheating is discouraged. If preheating the parts is necessary we would prefer that neither Propane nor Oxy-Acetylene be used as this will cause contamination in the weld. If Oxy-Acetylene is required please get prior written approval from the LIGO contracting officer.
8. All welds must be full penetration and full fusion welds. No trapped volumes are permitted. Weldments with crevices are considered non-cleanable since these crevices act as traps for cleaning solutions. Inspect the root weld before further passes, if remedial action is required only use clean Carbide burrs. Grinding (with abrasive wheels, cloth, or stones), or use of abrasive cloth or paper, is not permitted.
9. It can be difficult to achieve full penetration with a single-sided weld. Double-sided welds are permissible, as long as sectioning of weld samples indicate weld overlap and no voids (refer to section 7).
10. The welder shall protect material adjacent to the welds to prevent damage. In general final machining and machined details (tapped holes, etc.) are added after welding, but not in all cases. Care should be taken not to blemish or damage the part while welding.

### **6.2 Stainless Steel**

1. Careful control of the parts shall be imposed so that carbon steel contamination is prohibited. In the event of carbon steel contamination, skim with a carbide tool to remove any residual contaminant
2. Back purge stainless steel welds in all cases. Maintain gas flow until the metal cools to prevent oxidation. Use Argon or Nitrogen Commercial Grade 99.98 percent or mixture of these for cover and purge gas.
3. Stainless steel parts should be welded within 24 hours after they are chemically cleaned.

### **6.3 Aluminum**

1. For welding thick parts, the suggested procedure is to use D.C. straight polarity with Atomic Grade Helium as the cover gas. This method does not require pre-heating of the parts.
2. For parts of 1/8 inch thickness or less, use A.C. polarity with Argon cover gas.
3. Aluminum parts should be welded within 24 hours after they are chemically cleaned.

## **7 Weld Quality Requirements and Inspection**

1. All welds on production weldments must meet requirements for Class C in table V of Mil-Std-2219 verified by visual inspection. Note that dye penetrant may only be used on a practice weld configuration and never on a final weldment.
2. All Class C welds shall be 100% visually inspected for cracks and weld discontinuities, porosity and inclusions. This should be aided by a magnifying lens of [5X] or [10X] power



## Welding Specification for Weldments used within the Advanced LIGO Vacuum System

wherever required to discern indications or defects otherwise not clear. Measure size and contour of welds with suitable gages. Clean welds per section 6.1.6 for inspection.

3. Submit a copy of certified Welding Procedure Specification (WPS) for approval, describing how the welding will be carried out on the production weldments. This should be submitted for approval with the LIGO Contracting Officer's Technical Representative along with the Procedure Qualification Record (PQR) referenced below in section 8. Once all of this is approved work can start on the production weldments.

### 8 Weld & Welder Qualification

1. All welders should be certified to American Welding Society (AWS).
2. Qualify the weld preparation, cleaning process, welders and welds by creating sample welds representative of each type of weld in the final weldment. It is important to design the samples to mimic the weld access and heat path that will be present in the weldment.
3. The sample weldments must meet requirements for Class B in Table V of Mil-Std-2219 as verified by: -
  - (a) visual inspection for weld discontinuities, porosity and inclusions,
  - (b) x-ray for complete penetration and fusion and
  - (c) Cross-sections of weld samples, for microstructural examination, should be prepared by cutting in an orientation perpendicular to the direction of the weld bead so that the size and shape of the weld and the heat-affected zone (HAZ) can be observed. Each weld sample should be sectioned and polished by standard metallographic procedures (for example, mounted in an epoxy, polished with a 5 micron diamond paste and then be etched with Keller's reagent). The section samples should be examined and photo-micrographed at approximately 15x. Any weld discontinuities should be further examined and photographed at 50x to 200x magnification.
4. Submit a Procedure Qualification Record (PQR) and the sample welds to LIGO. The PQR should include all evidence of compliance with the Class B qualification including photographic evidence of samples and documentation on the weld preparation, parts cleaning process, welding process, and preparation and qualification of the welder(s). All welds, and associated photographs and micrographs, must be labeled and presented in the form of a test or inspection report.
5. Prior to a new welder producing a LIGO weldment. They must be qualified for the welding process(es) and weld joints used on the LIGO weldment. Copies of the welder's certification for the LIGO weldment, in the form of a Performance Qualification Record on the weld samples outlined above, must be kept on file and available for LIGO inspection.

## **Welding Specification for Weldments used within the Advanced LIGO Vacuum System**

6. Vendors should qualify the welding procedures, welders and welder operators in accordance with Section 3 of AWS D1.2/D1.2M:2003 and Section 4 of AWS D1.1/D1.1M:2008.

### **9 Weld Repair**

1. If a weld has surface blemishes, high porosity, hairline cracks or incomplete penetration then the weld should be re-flowed and then re-inspected.

### **10 Weld approval**

Once the production weldments have been satisfactorily completed and prior to completing the remaining steps in this specification the contractor must have the welds accepted and approved by the LIGO Contracting Officer's Technical Representative. The approval step should include a visit by the LIGO Contracting Officer's Technical Representative. At the time of the visit the following items should be delivered to the LIGO Contracting Officer's Technical Representative: -

1. An inspection report confirming the qualification of the production weldments to Class C, as per section 7 (points one and two) should be submitted.
2. Certification that the requirements of the specification (WPS) have been met
3. Material certifications for all materials (filler rod and base material) which comprise the weldment.

The approval step can also be done without a visit and via e-mail, if approved by the LIGO Contracting Officer's Technical Representative and only if photographs of all of the welds are added to the report.

Once approval is obtained the contractor should continue with the following steps.

### **11 Post-Weld Stress Relief**

After welding and approval all weldments must go through a stress relief heat treatment prior to any final machining.

### **12 Final Machining**

Any features on the weldment which are dimensionally critical are machined after welding and post-welding stress relief. These features will be called out in the associated drawing package. Any dimensional inspection required will be called out in the associated RFQ / RFP / SOW.

### **13 Post-weld Cleaning**

The weldment must be cleaned as per the following specification. (Scotch-Brite(TM) or similar products are prohibited.)



## Welding Specification for Weldments used within the Advanced LIGO Vacuum System

### 13.1 Aluminum

1. First the parts or assemblies are de-burred, and cleaned, removing all possible machining and weld process residue. Use only clean Carbide burrs. Grinding (with abrasive wheels, cloth, or stones), or use of abrasive cloth or paper, is not permitted.
2. The part(s) are then washed with Alkaline Soak Cleaner and inspected for cleanliness using the water break test.
3. The weldment is then to be chemically cleaned / etched by acid and / or caustic process. At this step in the process Scotch-Brite™ or similar mildly abrasive pads can be used. This is the only step where Scotch-Brite™ is permitted.
4. The acid formulation, time and temperature should be chosen to achieve slight chemical etching (<0.0005 inch).
5. Under no circumstances should the weldments be anodized.
6. The weldment is then thoroughly rinsed with clean water. After rinsing, a full visual inspection is performed, to assure a satisfactory surface finish has been achieved uniformly, over the entire weldment
7. The parts are then dried, re-inspected and un-racked.
8. In order to remove any weld stain, left behind after this process, use acetone and fine Stainless Steel wire brushing, the brush bristles should be .004"/.006" in diameter.
9. No LIGO weldments intended for use within the vacuum system shall be anodized.

### 13.2 Stainless Steel

1. First the parts or assemblies are de-burred, and cleaned, removing all possible machining and weld process residue. Use only clean Carbide burrs. Grinding (with abrasive wheels, cloth, or stones), or use of abrasive cloth or paper, is not permitted.
2. The part(s) are then cleaned and inspected for cleanliness using the water break test. The water-break test is performed by withdrawing the surface to be tested, in a vertical position, from a container overflowing with water, refer to ASTM A380-06 and in particular ASTM F22 for further information on this step.
3. Stainless steel parts are to be pickled and passivated at room temperature, with special attention paid to sufficiently agitate the solution or flush the inside of the box section used in the particular design. The pickling and passivation process formulation, time and temperature should be chosen to achieve slight chemical etching (<0.0005 inch).
4. The weldment is then thoroughly rinsed with clean water. After rinsing, a full visual inspection is performed, to assure a satisfactory surface finish has been achieved uniformly, over the entire weldment
5. The parts are then dried, re-inspected and if appropriate un-racked.

## 14 Delivery and receipt

After post-weld cleaning (section 13) re-inspect all welds. Refer to RFQ / RFP / SOW for information on acceptance and deliver criteria.



**Welding Specification  
for Weldments used within the Advanced LIGO Vacuum System**

**15 Subsequent Processing Steps**

Any subsequent processing steps are not performed by the manufacturing/welding contractor, but listed here for completeness.

**15.1 Ultra-High Vacuum (UHV) Cleaning & Baking**

LIGO will inspect, clean and bake in preparation for Ultra-High Vacuum (UHV) service in accordance with E960022.

**16 References**

- |                        |   |
|------------------------|---|
| 1. Mil-Std-2219        | Fusion Welding for Aerospace Applications   |
| 2. AWS D1.2/D1.2M:2003 | Structural Welding Code - Aluminum  |
| 3. AWS D1.1/D1.1M:2008 | Structural Welding Code - Steel   |
| 4. ASTM E-165          | Standard Test Method for Liquid Penetrant Examination   |
| 5. ASTM B-912          | Standard Specification for Passivation of Stainless Steels Using Electropolishing                           |
| 6. LIGO-E960022-v2     | LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures                                    |
| 7. ASTM A380 - 06      | Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems |
| 8. ASTM F22            | Test Method for Hydrophobic Surface Films by the Water-Break Test   |



**Welding Specification  
for Weldments used within the Advanced LIGO Vacuum System**

**17 Supply Sources**

Item	Description	Supplier
Ameristat®	Clean room sheeting Class 100 stratogrey, single wound, rollstock	Bay Stat 3575 Haven Avenue Menlo Park, CA 94025-1009 (650)364-3205 Voice (650)363-8079 Fax
UHV Aluminum Foil	Part # ASTM B 479 0.015" x 24" x 500' and 0.015" x 48" x 500' UHV Certified Aluminum Foil	All Foil 4597 Van Epps Road Brooklyn Heights, Ohio 44131 (216)661-0211 Voice (216)398-4161 Fax



# REQUIREMENTS

## Metal Components for use in the Advanced LIGO Vacuum System

APPROVALS	DATE	Document Change Notice
AUTHOR(S): Calum Torrie, Dennis Coyne, Ken Mailand	27-Oct-2010	see DCC record Status:

### 1 Introduction

All metal components intended for vacuum service shall have quality finishes on all surfaces, suitable for service in an Ultra-High Vacuum (UHV) system. These requirements define the restrictions and practices which must be followed for parts to be used in the LIGO UHV system.

Exceptions, additions or clarifications shall be obtained in writing from the LIGO Contractual Officer or the Contractual Officer's Technical Representative.

### 2 Scope

These requirements apply to metal components intended for in-vacuum service.

These requirements do not apply to cantilever blade springs. For this application please refer to LIGO-E0900023, Process for Manufacturing Cantilever Spring Blades

### 3 Purchase Order Specific Requirements

In addition to the requirements defined in this specification, additional requirements, specific to a particular procurement or part, may be defined in the Statement of Work (SOW) or Request for Quotation (RFQ).

### 4 General Requirements for Metal parts for use in Vacuum

#### 4.1 Materials

The following requirements apply to all raw materials used for LIGO UHV components. **Substitutions and exceptions to these requirements must be in obtained in writing from LIGO in advance of manufacturing any components.**

- Only materials specified on the drawing may be used.
- Material Certifications are required for all materials. Tooling plate grade materials are not permitted.
- Materials must be of domestic (United States) origin.
- All materials are to be virgin material (i.e. no weld repairs or plugs; see also section 4.7))
- No cast or molded parts are permitted.

##### 4.1.1 Welded (Seamed) Stainless Steel Tubing

Stainless steel seamed tubing, although an option, should not be the first choice if seamless tubing is available. The use of seamed steel tubing requires prior approval from LIGO.

If seamed tubing is utilized, the weld seam and any weld flash must meet the requirements listed below. If the weld flash does not meet the requirements, then it must be removed. Details, including fixtures and/or tooling required to remove this flash and a method for removal should be included in the quotation. The flash removal process must be inspected 100% visually and certified by the vendor and approved by LIGO.

With prior approval from a LIGO Contract Officer stainless steel seamed tubing can be used under the following conditions: -

1. Take a cross-sectional sample of the tube weld for every ~20 ft. of every continuous weld run (batch) and verify that the weld is Class B in Table V of Mil-Std-2219. The verification requires:
  - a) Visual inspection for weld discontinuities, porosity and inclusions,
  - b) X-ray for complete penetration and fusion and



## REQUIREMENTS

### Metal Components for use in the Advanced LIGO Vacuum System

- c) Weld flash must not extend into the interior of the tube more than .02". The weld flash must not be so rough or porous as to prevent adequate cleaning.
  - d) Microstructural examination of weld samples cross-sections. Cross-sections of weld samples, for microstructural examination, shall be prepared by cutting in an orientation perpendicular to the direction of the weld bead so that the size and shape of the weld and the heat-affected zone (HAZ) can be observed. Each weld sample shall be sectioned and polished by standard metallographic procedures (for example, mounted in an epoxy, polished with a 5 micron diamond paste and then be etched with Keller's reagent). The section samples shall be examined and photo-micrographed at approximately 15x. Any weld discontinuities shall be further examined and photographed at 50x to 200x magnification.
2. Supply inspection report for approval to the LIGO contract officer confirming that the as-received seamed welds conform to class B prior to continuing.
  3. Note: Prior to welding, all seamed tubing (inside and out) must be electro-polished per ASTM B-912- (reference LIGO E0900048 Welding Spec)

#### 4.2 Final Surface Finishes

All final surfaces of all parts are to be machined. Machined surfaces must not have smeared metal or galling because these conditions can trap contaminants which could out-gas when the part is in service in the vacuum environment. No as-received or as-rolled rough surfaces will be accepted unless otherwise noted on the drawing or as an exception here:

##### 4.2.1 Exceptions (allowable non-machined surfaces)

###### 4.2.1.1 Extruded Sections (seamless tubes, angles, etc.) and Welded Stainless Steel Tubing

If extruded tubular sections (or angles or other stock shapes) are to be used, then machining the interior surfaces is not practical and machining the outer radius on the corners is prohibitive. In this case either

- a) All surfaces of all parts are to be machined, except those not practical to machine. In this case the inner surface and outer radius will be accepted "as extruded" or "as rolled", or
- b) The part is electro-polished to remove all surface oxides and potentially embedded contaminants refer to section 5.2.1.2 or 5.2.2.2.
- c) (For aluminum) The part is chemically cleaned / etched by acid or caustic process, refer to 5.2.1.
- d) As per section 11 of ASTM A554-10 the finished tubes shall be free of injurious defects and have a workmanlike finish. Surface imperfections such as handling marks, shallow pits and scratches shall not be considered as serious defects provided they are within 10% of the specified wall or 0.002 inch, whichever is greater.
- e) Each tube shall be individually wrapped and protected from scratches, pitting and digs during transport and handling. Each tube shall be inspected and handled appropriately.

###### 4.2.1.2 Thin Sheet

Sheet metal shall be purchased in the 2B finish condition which should normally have a surface finish of 12-20 Ra. However, if the surface finish exceeds 32 Ra then:

- a) the surface finish should be discussed with LIGO Contractual office prior to acceptance, or
- b) the sheet shall be electro-polished as per section 5.2.2.2
- c) the sheet shall be chemically cleaned / etched by acid and / or caustic process, refer to section 5.2.1

Further questions related to machining all surfaces can be discussed with the LIGO Contractual officer or the Contracting Officer's Technical Representative. Under no circumstances shall the parts be anodized.



## REQUIREMENTS

### Metal Components for use in the Advanced LIGO Vacuum System

#### 4.2.2 Surface Roughness

The required surface roughness is defined in the drawing block entitled "finish". Please note if finish is called out on the drawing it is in Ra. If no call-out is included in this block, then the maximum surface finish shall default to:

- 63 micro-inch (Ra) for stainless all surfaces
- 63 micro-inch (Ra) for aluminum all surfaces
- 32 micro-inch (Ra) for sheet metal. See section 4.2.1.2.

Localized scratches, digs and blemishes should be minimized and addressed through visual inspection and QA. If such blemishes compromise the function or performance of the part (e.g. a stray light control baffle), then limits on acceptable scratches and digs should be defined in the drawing or associated process specification.

#### 4.3 Machining Fluids / Coolant

All machining, and tapping, fluids must be fully synthetic, water soluble (not simply water miscible) and free of sulfur, chlorine, and silicone. Reference LIGO document [LIGO-E0900237-v5](#) for a list of approved coolants. If this is difficult or expensive please talk to LIGO staff about an exemption.

#### 4.4 Abrasive Removal Techniques

##### 4.4.1 Grinding

No grinding or lapping with abrasive wheels, cloth or stones is permitted for the final surface, unless otherwise noted on the drawing. Grinding (e.g. Blanchard grinding) is acceptable if all ground surfaces are machined afterwards.

##### 4.4.2 Sanding

No parts are to be sanded with abrasive techniques e.g. sanding, grinding. Stainless steel wool can be used.

##### 4.4.3 Scotch-Brite™

The use of Scotch-Brite™ or similar products is not permitted at any time.

##### 4.4.4 Water Jet Cutting

The use Water Jet Cutting is permitted on sheet metal parts which will later be porcelain coated. For all other parts, the Water Jet Cut surface must be removed by traditional machining methods. Electro-polishing may be used to remove the Water Jet Cut surface if a written exemption is granted by LIGO.

#### 4.5 Electrical Discharge Machining (EDM)

The use of EDM is not permitted unless the porous re-cast layer is removed by conventional machining techniques. Removal of the re-cast layer by electro-polishing may be used if a written exemption is granted by LIGO.

#### 4.6 De-burring

All sharp edges and corners shall be rounded or chamfered per the drawing. De-burring should be done on the lathe or mill as much as possible or with de-burring tools, filing and / or stainless steel wire brushes. Tumbling or use of standard steel wool is not acceptable for de-burring, however clean stainless steel wool is okay. All de-burring tools, files and stainless wire brushes must be clean and free of oils and contaminants.





## REQUIREMENTS

### Metal Components for use in the Advanced LIGO Vacuum System

#### 4.7 Repairs

No repairs shall be made unless approved in advance, and in writing, by LIGO Laboratory. In general weld repairs and press fit insert repairs are never acceptable. The material shall be virgin material. Special circumstances can be reviewed if/when brought to the attention of LIGO. Complete LIGO form [Q110001 Request for Deviation](#) and email to [quality@ligo.org](mailto:quality@ligo.org).

#### 4.8 Heli-Coil Holes

All Heli-Coil holes are to be machined according to the steps specified in the Emhart Heli-Coil Product catalog, HC2000 Rev. 4 page 17. These steps include drilling, countersinking, tapping, and gauging the holes to sizes specified on the LIGO part drawings. All Heli-Coil threaded holes shall be 100% gauged with appropriate gauge tools according to the [Emhart catalog](#).

### 5 Cleaning

#### 5.1 Standard Cleaning of Metal Components before delivery to LIGO

- Unless otherwise specified on the drawing, SOW, or RFQ the standard requirement is for all components to be thoroughly cleaned to remove all ink, oil, grease, dirt, and chips.
- All inks (stamping, Sharpie, etc) should be removed with solvent such as acetone or isopropanol.
- Use Soap (such as Simple Green) and water to remove machining fluids.
- Thoroughly rinse soap with clean water (DI or distilled preferred).
- Parts should be dried thoroughly with clean air, nitrogen, or lint-free cloth.
- Wrap parts to protect from damage and to maintain cleanliness during shipment. Avoid the use of materials that shed particulates such as newspaper. Bubble wrap is recommended for many parts.

#### 5.2 Further Cleaning (only if specified)

These cleaning steps only apply if called out in the individual SOW and/or RFQ and/or drawing or other LIGO Specification. Additional questions related to this section on further cleaning can be discussed with the LIGO Contractual officer or the Contracting Officer's Technical Representative.

##### 5.2.1 Aluminum

###### 5.2.1.1 Chemical cleaning of Aluminum

- Standard clean parts per 5.1 above.
- Wash parts with Alkaline Soak Cleaner and inspected for cleanliness using the water break test (refer to ASTM A380-06 and ASTM F22).
- Acid etch the parts to achieve less than 0.0005 material removal. Under no circumstances should the parts be anodized. Section 10 of LIGO document [E960022](#) can be referred to for additional information.
- Thoroughly rinse parts with DI or distilled water and inspect all surfaces for cleanliness.
- Thoroughly dry parts with clean air, nitrogen, or lint-free cloth.
- Wrap parts to protect from damage and to maintain cleanliness during shipment. Avoid the use of materials that shed particulate such as newspaper. Bubble wrap is recommended for many parts.

###### 5.2.1.2 Electro-polishing of Aluminum

Aluminum may be electro-polished to achieve a material removal of .001 inch per surface. Due to the lack of commonly recognized industry standards, please talk to LIGO about proposed suppliers and processes before proceeding.



## REQUIREMENTS

### Metal Components for use in the Advanced LIGO Vacuum System

#### 5.2.2 Stainless Steel

##### 5.2.2.1 Pickling & Passivation of Stainless Steel

1. Clean parts per section 5.1 above, inspect for cleanliness using the water break test (refer to ASTM A380-06 and ASTM F22).
2. Stainless steel parts shall be pickled and passivated (citric acid preferred) at room temperature, with special attention paid to sufficiently agitate the solution or flush the inside of the box section. The pickling and passivation process formulation, time and temperature should be chosen to achieve slight chemical etching (<0.0005 inch). (Ref. ASTM A380 for pickling and ASTM A967 for passivation)
3. Rinse parts with DI or distilled clean water. After rinsing, visually inspect the surfaces for cleanliness.
4. Dry Parts using dry nitrogen blow-off or bake at approximately 130°F. Re-inspect for cleanliness.
5. Wrap parts to protect from damage and to maintain cleanliness during shipment. Avoid the use of materials that shed particulate such as newspaper. Bubble wrap is recommended for many parts.

##### 5.2.2.2 Electro-polishing of Stainless Steel

Electro-polishing of Stainless Steel parts is allowed. If using electro-polishing on a part, follow similar steps to those outlined in section 5.2.2.1 Pickling and Passivation of Stainless Steels. The use of Scotch-Brite™ or similar products is never permitted.

## 6 Coatings

- No coatings are to be applied unless specified on the drawing or associated process specification. In particular, no aluminum parts are to be anodized.
- The Statement of Work should define if the machining vendor is responsible to apply coatings specified on the drawing. If in doubt, ask.
- As applicable, refer to the process specification for coatings as defined on drawings (for example, LIGO E1000083 Specification for Enameled Steel to be used in the LIGO Ultra High Vacuum System).
- Autocatalytic (Electroless) Nickel Plating, when required, should be applied per ASTM B733-97 Type III (2-4 wt% Phosphorus). Due to the outgassing concerns for UHVV service, the specific cleaning/etching and plating process steps proposed by the plating company shall be submitted to LIGO for approval. Refer to section 2.5 of [LIGO-E0900023-v10](#) for suggested process steps.



*LIGO Laboratory / LIGO Scientific Collaboration*

LIGO-Q0900001-v5

3 February 2010

**Advanced LIGO Supplier Quality Requirements**

Jeff Lewis, Bob Anderson, Calum Torrie

Distribution of this document:  
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## 1. Scope

This document is intended for Suppliers and potential Suppliers to LIGO when specified on the Statement of Work (SOW). Supplier requirements are defined, including: the Supplier's Quality System; inspection, material handling, packaging and shipping procedures.

## 2. Supplier Quality System

### 2.1. Certified or Compliant

During the Request for Proposal (RFP) or Request for Quote (RFQ) process, preference will be given to potential and current suppliers who are currently ISO 9001, AS9100, or TS16949 certified. LIGO can still contract with suppliers who are not certified but those suppliers typically have ISO 9001 compliant Quality Systems. Potential suppliers having neither an ISO 9001 certified nor compliant Quality System will be required to create a quality document addressing the main points of ISO 9001 with respect to the LIGO work. Only potential suppliers lacking certification shall submit a copy of their Quality System along with the bid package for consideration.

### 2.2. Calibration Program

The supplier shall maintain an ISO 9001 compliant calibration program of all instruments and tools required for the inspection of all LIGO production parts and assemblies manufactured by the supplier or sub-contractor.

## 3. Procurement Process

### 3.1. Pre-RFP/RFQ Supplier Visit

A LIGO representative may conduct a visit or audit to gage a potential supplier's Quality System, facilities, equipment and personnel capabilities, and capacity. The LIGO representative can explain any LIGO specific requirements that are not clear.

### 3.2. LIGO Procurement Documentation

LIGO will provide the supplier with the following documentation in support of the bid process (if applicable):

- 3.2.1. Statement of Work (SOW)
- 3.2.2. Technical documents, drawings, and specifications, identified by revision. Solid Models are available on request.
- 3.2.3. On-line access to all applicable LIGO specifications

### 3.3. Pre-Award Inspection

Prior to contract award LIGO staff may perform an audit of the prospective supplier's Quality System. The audit scope includes but is not limited to:

- Understanding of the various LIGO requirements and specifications. This should be an opportunity for both parties to communicate.
- Supplier QA/QC program and how it will be implemented for Advanced LIGO contracts.
- Manufacturing methodologies, especially as regards cleanliness and use of approved materials and fluids.
- Cleaning and packaging methodologies compared to RFP/RFQ requirements.
- Critical worker certification levels (i.e., welding, electrical, CNC, etc.).

- Calibration program review.

## 4. Manufacture, Assembly, and Inspection Requirements

### 4.1. Manufacturing Planning / Traveler

Unless otherwise instructed, the supplier shall create planning for each manufacturing job which identifies the following components. This planning shall be available for review by LIGO before, during, or after manufacturing.

- The schedule of operations, including the type of process to be performed (ie, mill, lathe, deburr, outside processing, etc.)
- Machinist sign-off and date, including quantity conforming and non-conforming
- Identification and definition of the inspection points during the manufacturing process
- Inspector sign-off and date, including quantity conforming and non-conforming
- Identification of process specifications, as applicable, for internal and external processes
- Identification of operational constraints, as appropriate (ie, no abrasive metal removal techniques for parts destined for Ultra High Vacuum use.)

### 4.2. First Article Inspection

LIGO may wish to witness or inspect the First Article part before the rest of the order is completed. The requirement for this will be defined on the Statement of Work if applicable.

### 4.3. In-Process Inspection

In-process inspections shall be performed where subsequent assembly stages will prevent/limit inspection access, and to detect defects early in the process. In-process inspections shall be identified in the manufacturing planning (see Section 4.1 above).

### 4.4. Final Inspection

The Supplier shall conduct a Final Inspection of all component parts and assemblies to verify completion and conformance of the following items:

- Conformance to all applicable drawings, SOW, and specifications.
- End Item Data Package review (refer to SOW for complete list)
- LIGO property control documentation, when LIGO materials are in possession of a supplier.
- Evidence of safety requirements compliance, if applicable.
- Shipping documentation such as the manifest or shipper.
- Verification of the adequacy of the shipment packaging and weather protection.
- Verification that transportation environmental controls and monitoring requirements will be satisfied.

### 4.5. Source Inspection

Source inspection by LIGO personnel may be required. The supplier will be notified of this in advance of shipping the components.

### 4.6. Discrepant Material

Discrepant parts must be identified and segregated immediately upon detection. If the discrepant parts are required to complete an order and the parts can be reworked to comply with the drawing and/or specifications and with no effect on the delivery date

then LIGO does not need to be notified. If the parts can be reworked to comply with the drawing and/or specifications but the rework process will adversely affect the delivery date, then the LIGO Contracting Officer must be notified.

Please immediately contact LIGO to discuss discrepant parts that cannot be reworked to comply with the drawing and/or specification. Suppliers should use the LIGO form [Q110001 Request for Deviation](#) to formalize a request to submit or rework discrepant parts which will not comply to the drawing and/or specifications. Email the completed form to [quality@ligo.caltech.edu](mailto:quality@ligo.caltech.edu) for a disposition.

The supplier must retain records of any rework processes as part of the job traveler package.

#### **4.7. Drawing and Specification Change Control**

All drawings and specifications will be controlled by the suppliers Quality Assurance Department, including receipt and distribution. Upon receiving the order/contract, all drawings will be verified as to correct number and revision.

Controlled documents must be kept updated at every document change or engineering change. The contract administrator under the guidance of QA will insure that all controlled documents, whether in house or out, will be updated.

Occasionally, LIGO may need to revise drawings for design or manufacturing reasons after the purchase order has been issued. These changes are normally discussed with the supplier in advance of official notification to come to a common agreement on the feasibility and implications of the desired changes. When the change will have no adverse effect on the cost or delivery of the part(s) then a Technical Directive Memorandum will be issued by LIGO to formally document the change. If the change is estimated to affect either cost or delivery of the part(s), then a Change Request will be initiated and sent to the supplier, followed by a revised Purchase Order.

Upon receipt of drawing and specification changes, the supplier Quality Assurance or other appropriate personnel will remove obsolete drawing and/or specifications and issue the latest drawing and/or specification to proper personnel. Obsolete drawings shall either be marked "obsolete" if needed for records or destroyed.

#### **4.8. Welding Certifications**

Suppliers of parts or assemblies requiring welding which will be used in an Ultra High Vacuum environment must refer to LIGO specification [E0900048 Welding Specification for Weldments used within the Advanced LIGO Vacuum System](#). This specification details numerous welding specific requirements. The SOW will state if this specification is invoked for a certain part or order.

#### **4.9. End Item Data Package**

The end item data package is the set of required documents to be supplied to LIGO upon delivery of ordered parts or services. Refer to the Statement of Work (SOW) for the complete list of documents to be included.

**Acceptable Quality Level (AQL) for Inspection of LIGO Components**

AUTHOR(S)	DATE	Document Change Notice, Release or Approval
Jeff Lewis, Bob Anderson	2/11/2011	see LIGO DCC record Status

**1 Scope**

This document defines the number of components to be 100% inspected from a manufacturing lot of a particular size based on a specified AQL number.

**2 Definition**

The maximum percent defective (or the maximum number of defects per 100 units) that, for the purposes of sampling inspection, can be considered satisfactory as a process average.

**3 Procedure**

AQL Number

Lot Size	0.25	0.4	0.65	1.0	1.5	2.5	4.0	6.5	10
2 to 8	*	*	*	*	*	5	3	2	2
9 to 15	*	*	*	13	8	5	3	2	2
16 to 25	*	*	20	13	8	5	3	3	2
26 to 50	*	32	20	13	8	5	5	5	3
51 to 90	50	32	20	13	8	7	6	5	4
91 to 150	50	32	20	13	12	11	7	6	5
151 to 280	50	32	20	20	19	13	10	7	6
281 to 500	50	48	47	29	21	16	11	9	7
501 to 1200	75	73	47	34	27	19	15	11	8
1201 to 3200	116	73	53	42	35	23	18	13	9
3201 to 10,000	116	86	68	50	38	29	22	15	9

\* Denotes inspection of entire lot. Acceptance Criteria (C) = 0

Table 1. AQL Inspection Frequency.

Use Table 1. to determine the number of pieces from a manufacturing lot to 100% inspect for a specified AQL number. For example: a lot of 100 parts with an AQL number of 1.0 signifies that 13 parts shall be 100% inspected. With the Acceptance Criteria (C) = 0, then if one feature on one part is found to be non-conforming then the entire lot shall have that feature inspected.

The first and last part of a manufacturing lot must always be inspected.





## **LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY (LIGO)**

### **COMMERCIAL ITEMS OR SERVICES CONTRACT**

#### **GENERAL PROVISIONS CALIFORNIA INSTITUTE OF TECHNOLOGY "INSTITUTE"**

##### GENERAL PROVISION TITLE

1. Offer and Contract
2. Time of Delivery
3. Improper Delivery
4. Assignment
5. Authority of Institute Representative and Required Notices
6. Changes
7. Force Majeure
8. Existing Commercial Computer Software – Licensing
9. Export Licenses
10. Disputes and Governing Law
11. Inspection and Acceptance
12. Insurance
13. Indemnification
14. New Material
15. Order of Precedence
16. Payment
17. Use of Name
18. Title and Risk of Loss
19. Government Title to Property Purchased or Fabricated with Contract Funds
20. Taxes
21. Termination
22. Warranty
23. Audit and Records
24. Site Visits
25. Nondiscrimination
26. Equal Employment Opportunity
27. Anti-Kickback
28. Clean Air Act and the Federal Water Pollution Contract Act
29. Debarment and Suspension
30. Byrd Anti-Lobbying Amendment
31. Copeland "Anti-Kickback" Act
32. Davis Bacon Act
33. Surety Bonds
34. Rights to Inventions – 37 CFR part 401
35. Patent Rights - Bayh-Dole Act [35 U.S.C. 200 et seq.]

(See Page 2 for Individual General Provision Applicability)

## APPLICABILITY OF INDIVIDUAL GENERAL PROVISIONS

### APPLICABLE TO ALL TRANSACTIONS IN THE UNITED STATES

The term *United States* includes the several States of the United States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, American Samoa, Guam, Wake Island, the Canal Zone, and all other territories and possessions of the United States, and the term *States* includes any one of the forgoing.

- |  |   |
|--|---|
| 1. Offer and Contract  | 16. Payment   |
| 2. Time of Delivery  | 17. Use of Name   |
| 3. Improper Delivery   | 18. Title and Risk of Loss  |
| 4. Assignment  | 19. Government Title to Property Purchased or Fabricated with Contact Funds |
| 5. Authority of Institute Representatives and Required Notices | 20. Taxes   |
| 6. Changes   | 21. Termination   |
| 7. Force Majeure   | 22. Warranty  |
| 8. Existing Commercial Computer Software – Licensing           | 23. Audit and Records   |
| 10. Disputes and Governing Law                                 | 24. Site Visits   |
| 11. Inspection and Acceptance                                  | 25. Nondiscrimination   |
| 13. Indemnification  | 26. Equal Employment Opportunity  |
| 14. New Material   | 28. Clean Air Act and the Federal Water Pollution Control Act               |
| 15. Order of Precedence  |   |

### TAXES

20. The applicability of State sales tax is addressed on the face of the Purchase Order  
**[For imports]** Value Added Tax (VAT) is addressed on the face of the Purchase Order

### APPLICABLE IN SPECIAL CIRCUMSTANCES ACCORDING TO THEIR TERMS

9. **[For exports]** Compliance with Export Regulations  
12. **[Suppliers Working on Site]** Insurance  
27. **[For Contracts in excess of \$100,000]** Anti-Kickback Enforcement Act of 1986  
29. **[For Contracts in excess of \$25,000]** Debarment and Suspension  
30. **[For Contracts of \$100,000 or More]** Byrd Anti-Lobbying Amendment  
31. **[For designated Construction/Repair Contracts in excess of \$2,000]** Copeland “Anti-Kickback” Act  
32. **[For designated Construction/Repair Contracts in excess of \$2,000]** Davis-Bacon Act  
33. **[For designated Construction/Repair Contracts in excess of \$500,000]** Surety Bonds  
34. **[For designated Experimental, Development or Research Work]** Rights to Inventions- 37 CFR part 401  
35. **[For designated Experimental, Development or Research Work]** Patent Rights - Bayh-Dole Act [35 U.S.C. 200 et seq.]

### APPLICABLE TO ALL TRANSACTIONS IN THE UNITED STATES

These provisions **do not apply to foreign suppliers** performing outside the United States.

- |                                  |   |
|----------------------------------|---|
| 25. Nondiscrimination            | 32. Clean Air Act and the Federal Water Pollution Control Act |
| 27. Equal Employment Opportunity |   |

This agreement is a subcontract pursuant to an NSF Cooperative Agreement (CA) between the NSF and the Institute, [PHY-0328418](#).

1. **OFFER AND CONTRACT** The following terms, together with such terms, plans, specifications or other documents as attached or incorporated by reference as set forth on the face of this purchase order, constitute the offer of the Institute to Supplier and shall, when accepted, constitute the entire agreement ("Contract") between the Institute and Supplier. Institute hereby gives notice of its objection to any different or additional terms. This Contract is valid only as written. If price, terms, shipping date or other expressed condition of this Contract are not acceptable, the Institute must be notified and any variation must be accepted in writing prior to shipment or delivery. This Contract shall be deemed to have been accepted (a) in the absence of written notification of non-acceptance by the Supplier within a reasonable time, or (b) upon timely delivery of the products identified to the shipping address specified on the face of the order.
2. **TIME OF DELIVERY** Time is of the essence in this Contract. If delivery dates cannot be met, Supplier must notify the Institute immediately. Such notification shall not, however, constitute a change to the terms of this Contract except as the order may be modified in writing by the Institute.
3. **IMPROPER DELIVERY** In addition to other remedies provided by law, the Institute reserves the right to refuse any goods or services and to cancel all or any part of this Contract if Supplier fails to deliver all or any part of the goods or services in accordance with the terms and conditions of this Contract. Acceptance of any part of this order shall not bind the Institute to accept any future shipments nor deprive it of the right to return goods already accepted.
4. **ASSIGNMENT** The Supplier shall have no right to assign this Contract or any benefits from this Contract without prior written consent of the Institute.
5. **AUTHORITY OF INSTITUTE REPRESENTATIVES AND REQUIRED NOTICES; FACSIMILE AND ELECTRONIC SIGNATURES ACCEPTABLE**
  - (a) No order, notice, or direction received by the Supplier and issued pursuant to this Contract shall be binding upon either the Supplier or the Institute, unless issued or ratified in writing by the Institute Purchasing Agent, the Director of Procurement Services, or by representatives designated in writing by either of them.
  - (b) The parties agree that facsimile (fax) or electronic signature copies of contract documents are just as binding as originally-executed documents.
6. **CHANGES** The Institute may at any time, by a written order to the Supplier, make changes within

the general scope of this Contract in any one or more of the following: (a) drawings, designs, or specifications; (b) method of shipment or packing; and (c) time or place of delivery. If any such change causes an increase or decrease in the cost of, or the time required for, the performance of any part of the work under this order, an equitable adjustment may be made in the order price or delivery schedule or both, and the order shall be modified in writing accordingly. Any claim by Supplier for adjustment under this Article must be asserted within 30 days from the date of receipt by Supplier of the notification of change; provided, however, that the Institute, if it decides that the facts justify such action, may receive and act upon any such claim asserted at any time prior to final payment under this purchase order. Nothing in this clause shall excuse Supplier from proceeding with this order as changed.

7. **FORCE MAJEURE** Each party shall not be liable for damages arising out of either its failure to deliver or any delay in delivery caused by strikes, lockouts, fires, war, or acts of God. The Supplier shall notify the Institute in writing as soon as it is reasonably possible after the commencement of any event triggering a delayed delivery or inability to deliver.
8. **EXISTING COMMERCIAL COMPUTER SOFTWARE – LICENSING** (This Article is applicable to the acquisition of any existing commercial computer software under this Contract.)
  - a) Where the Supplier proposes its standard commercial software license, only those applicable portions that comply with the provisions of this Contract are incorporated into and made a part of this Contract.
  - (b) If the Supplier does not propose its standard commercial software license until after this Contract has been issued, or at or after the time the computer software is delivered, such license shall nevertheless be deemed incorporated into and made a part of this Contract under the same terms and conditions as in paragraph (a) above. For purposes of receiving updates, correction notices, consultation, and similar activities on the computer software, any authorized user may acknowledge receipt of a registration form or card and return it directly to the Supplier; however, such signing shall not add to or alter any of the terms and conditions of this Contract.
  - (c) If the specified computer software is shipped or delivered to the Institute, it shall be understood that the Supplier has unconditionally accepted the terms and conditions set forth in this Article, and that the terms and conditions of this Contract (including the incorporated license) constitute the entire agreement between the parties concerning rights in the computer software.
  - (d) Supplier understands and agrees that the computer software may be: (1)

Used, or copied for use, in or with any computer owned or leased by, or on behalf of the Institute provided that the software is not used, nor copied for use, in or with more than one computer simultaneously, unless otherwise permitted; (2) Reproduced for safekeeping (archives) or backup purposes; (3) Modified, adapted, or combined with other computer software, provided that the modified, combined, or adapted portions of the derivative software incorporating restricted computer software shall be subject to the same restricted rights; and (4) Disclosed and reproduced for use by Institute designees in accordance with this Article. (e) Supplier agrees that the software may be used by the Institute in support and furtherance of any of its obligations to the US Government or other funding organization. (f) Supplier warrants that it has the right to sell, license, or transfer the license for the software furnished to the Institute under this Contract in accordance with the terms of this Contract.

9. **EXPORT LICENSES** The Supplier shall comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this Contract. In the absence of available license exemptions/exceptions, the Supplier shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data, and software, or for the provision of technical assistance.

10. **DISPUTES AND GOVERNING LAW** (a) Any dispute or claim arising out of, in connection with, or relating to this Contract shall be submitted for resolution to ascending levels of management of the parties. If the dispute cannot be resolved after such negotiations, either party may pursue any appropriate legal recourse not inconsistent with the provisions of this Contract. (b) Pending any decision, appeal or judgment or the settlement of any dispute, Supplier agrees to proceed diligently with the performance of the requirements of this Contract. (c) This Contract shall be construed and enforced in accordance with the laws of the State of California. Disputes will be adjudicated in Los Angeles, California.

11. **INSPECTION AND ACCEPTANCE** The Institute shall have the right to inspect the work and activities of the Supplier under this Contract in such manner and at all reasonable times as are deemed appropriate. Final inspection shall be at the Institute's premises unless otherwise agreed in writing. The Institute, at its option, may reject any non-conforming items and (i) return such non-conforming items to the Supplier at the Supplier's

risk and expense for credit to the Institute at the full invoice price plus all transportation and other related costs, or (ii) hold them for disposition in accordance with the Supplier's instructions at the Supplier's expense, including storage and handling. If the Institute rejects items as nonconforming, the quantities under this Contract will automatically be reduced unless the Institute otherwise notifies the Supplier. The Supplier will not replace quantities so reduced without written instruction by the Institute. Payment for nonconforming goods shall not constitute an acceptance thereof, limit, or impair the Institute's right to assert any legal or equitable remedy, or relieve the Supplier's responsibility for latent defects. The Institute may also opt for a refund of the amount paid under this Contract.

12. **INSURANCE** (This Article is applicable when the Supplier will be entering Institute-controlled premises.) (a) The Supplier shall, at its own expense, provide and maintain during the entire performance period of this Contract at least the following types and minimum amounts of insurance with the Institute named as an additional insured in policies for comprehensive liability insurance with a licensed carrier authorized to do business in the State of California: (1) Workers' Compensation and Employer's Liability Insurance, as required by applicable Federal and State workers' compensation and occupational disease statutes. The Employer's Liability coverage shall be at least \$100,000, except in states with exclusive or monopolistic funds that do not permit worker's compensation to be written by private carriers. (2) Comprehensive Liability Insurance, including automobiles (owned, non-owned, or leased), completed operations, products, and contractual liability, for a combined single limit of not less than \$1,000,000 for all deaths, injuries, and property damage arising from one accident or occurrence. (b) Insurance Certificates and Endorsements. Before commencing work under this Contract, the Supplier shall furnish (i) certificates of insurance for the coverages specified in paragraph (a) above, and (ii) an additional insured endorsement naming the Institute as an additional insured to the Contract for the coverage specified above. Such certificates and the endorsement shall provide that any cancellation or material change in the insurance policies shall not be effective (i) for such period as the laws of the State in which this Contract is to be performed, or (ii) until 30 days after the insurer or the Supplier gives written notice to the Institute, whichever period is longer. Also, such certificates and the endorsement shall (i) cover contractual liability assumed under this Contract, and (ii) be primary and noncontributing to any insurance procured by the Institute. The Supplier agrees to

permit the Institute to examine its original policies, should the Institute so request. Should the Supplier at any time neglect or refuse to provide the insurance required herein, or should such insurance be canceled, the Institute shall have the right to procure same and the costs thereof shall be deducted from monies then due or thereafter to become due to the Supplier.

13. **INDEMNIFICATION** The Supplier agrees to defend, indemnify and hold harmless the Institute from and against all claims, liability and expenses, including reasonable legal fees, arising from any actual or claimed: (i) injury to any person or property resulting from any act or omission of Supplier, its employees or agents, excepting such liability as may result solely from the negligent acts or omissions of the Institute or its employees; and (ii) infringement of any patent, copyright, or trademark by reason of the sale or use of the goods provided by Supplier hereunder. The Supplier's obligations hereunder shall survive acceptance of the goods and payment thereof by the Institute.
14. **NEW MATERIAL** Unless this Contract specifies otherwise, the Supplier represents that the supplies are new and are not of such age or so deteriorated as to impair their usefulness or safety. If the Supplier believes that furnishing other than new material will be in the Institute's interest, the Supplier shall so notify the Purchasing Agent in writing and request authority to use such material.
15. **ORDER OF PRECEDENCE** To the extent there is inconsistency among any documents relating to this order, the inconsistency will be resolved in the following order of priority: (a) These General Provisions; (b) The details specified on the order, or description of products or services; (c) any other documents the Institute agrees in writing to incorporate by reference.
16. **PAYMENT** (a) Invoices shall be submitted in duplicate to the attention of the Institute's Accounts Payable Department, unless otherwise specified, and shall contain the following information as applicable: (i) Contract number, (ii) item number, (iii) description of supplies or services, (iv) size, (v) quantity, (vi) unit price, (vii) extended totals and (viii) any other information which may be specified on the face of this Contract. Any applicable state sales or use taxes or Federal excise taxes shall be shown separately on the invoice. (b) The Institute shall pay the Supplier, upon the submission of proper invoices, the prices stipulated in this Contract for supplies delivered and accepted or services rendered and accepted, less any deductions provided in this Contract. (c) The Institute shall make its best effort to make payments within the net period, if any, specified in the Contract, measured from the date of receipt of

the goods or services at the destination or the date of receipt of the invoice, whichever is later. Discount time periods will be measured from the same date. Payment shall be deemed to have been made on the date the check is mailed or on the date on which an electronic funds transfer was made. In no event will the Institute be liable for or pay a surcharge, interest, or any kind of penalty as a result of the Institute's payment not being made within the net period, if any, specified in the Contract or the date of payment by electronic funds transfer. (d) Payment for goods or services in accordance with this paragraph will not waive or otherwise affect the right of the Institute to inspect such goods or services or to reject, or revoke acceptance of, nonconforming goods.

17. **USE OF NAME** Supplier agrees not to use the name or trademarks of the Institute or any member its staff in sales promotional work or advertising, or in any form of publicity, without the prior written permission of the Institute.
18. **TITLE AND RISK OF LOSS** (a) Unless otherwise provided in Section 19 or elsewhere in this Contract, title to tangible property (property of any kind except intangible property and debt instruments) furnished under this Contract shall pass to the Institute upon formal acceptance by the Institute, regardless of when or where the Institute takes physical possession, unless the Contract specifically provides for earlier passage of title. (b) Risk of loss shall not pass to the Institute until the tangible property called for in this Contract has been actually received and accepted by the Institute at the destination specified. Supplier assumes all responsibility for packing, crating, marking, transportation and liability for loss or damage in transit, notwithstanding any agreement by Institute to pay freight, express or other transportation charges. Supplier agrees to trace lost or delayed shipments at the request of the Institute.
19. **GOVERNMENT TITLE TO PROPERTY PURCHASED OR FABRICATED WITH CONTRACT FUNDS** Title to tangible property shall vest in the Government upon acquisition when the tangible property is intended to be installed at, incorporated into, built, or necessary for the construction or operation of either the Hanford or Livingston Observatories. All Government property acquired in accordance with this Section 19 shall be subject to the requirements set forth below:
  1. Title.

(a) Tangible Property means property of any kind except intangible property and debt instruments. Title to all tangible property procured with funds provided through this Contract, and subject to this Section 19, shall vest in the Government as follows:

1) If this Contract contains a provision directing the Supplier to purchase material which the Government will reimburse as a direct item of cost under the Institute's primary Award, title to property shall pass to and vest in the Government upon delivery of such property to the Government, to the Institute, to the Supplier, to any subcontractor, or to any agent of the Government, of the Supplier, or of any subcontractor; and

2) Title to all other property shall pass to and vest in the Government upon the earliest to occur of the following:

(i) issuance of the property for use in contract performance pursuant to this Contract;

(ii) commencement of processing of the property or its use in contract performance pursuant to this Contract; or

(iii) reimbursement of the cost of the property by the Institute on behalf of the Government.

2. Legal title to all tangible property furnished by the NSF or acquired from other Government agencies shall remain with the Government, unless otherwise specified in this Contract.

3. Title to Government property shall not be affected by the incorporation or attachment thereof to any property not owned by the Government, nor shall any Government property lose its identity by reason of affixation to any reality.

4. All subcontracts issued or awarded with respect to the performance of this Contract shall include provisions regarding the determination of title to tangible property acquired by the subcontractor in accordance with Sections 18 and 19.

5. Should Supplier purchase tangible property pursuant to this Contract and subject to this Section 19, Supplier shall be a limited agent of the NSF solely for the purpose of transferring and vesting title to such tangible property in the Federal Government. The agent shall be solely responsible for the payment of the purchase price of tangible property acquired, and the agent shall have no authority to bind or obligate the Institute, NSF or the Federal Government for payment of the purchase price to any third party. Such agents shall be and shall remain liable for the risk of loss of, destruction of, or damage to tangible property acquired until such tangible property is transferred to the possession of the Government or acceptance by the Institute.

20. **TAXES** (a) **Except as may be otherwise provided on this order**, the contract price includes all applicable Federal, State, and local taxes and duties. With respect to transactions for which the

Institute may be exempt from any tax or duty, the Institute will provide, upon request, evidence to support its claim to such exemption. (b) The Institute will comply with all Federal and State income tax laws with respect to withholding and year-end tax reporting. (c) The Internal Revenue Service (IRS) requires the Institute to have on file a Taxpayer Identification Number (TIN) for every US person or US business that receives a payment, regardless if the payment is tax reportable or not. This information is provided on IRS Form W-9. US Citizens and Resident Aliens are required to complete a Form W-9 before receiving any payments from the Institute. A TIN can be any of the following: a Social Security Number (SSN) an Individual Taxpayer Identification Number (ITIN) or an Employer Identification Number (EIN). Failure to provide a TIN will result in delay of payment and/or backup withholding. (d) Foreign businesses providing services in the US for the Institute are required to provide the appropriate IRS Form W-8 (i.e., Form W-8BEN, W-8ECI, or W-8IMY). (e) Foreign individuals providing services in the US for the Institute are required to provide an IRS Form W-8BEN or IRS Form 8233 depending on the appropriate tax withholding treatment.

21. **TERMINATION** (a) **For Cause.** The Institute may terminate this Contract, or any part of it, for cause in the event of any default by the Supplier, or if the Supplier fails to comply with any Contract terms and conditions, or fails to provide the Institute, upon request, with adequate assurances of future performance. In the event of termination for cause, the Institute shall not be liable to the Supplier for any amount for supplies or services not accepted, and the Supplier shall be liable to the Institute for any and all rights and remedies provided by law. If it is determined that the Institute improperly terminated this Contract for cause, such termination shall be deemed a termination for convenience. (b) **For Convenience.** The Institute reserves the right to terminate this Contract, or any part hereof, for its sole convenience. In the event of such termination, the Supplier shall immediately stop all work hereunder and shall immediately cause any and all of its subcontractors to cease work. Subject to the terms of this Contract, the Supplier shall be paid a percentage of the Contract price reflecting the percentage of the work performed prior to the notice of termination, plus reasonable charges the Supplier can demonstrate to the satisfaction of the Institute, using its standard record keeping system, have resulted from the termination. The Supplier shall not be paid for any work performed or costs incurred which reasonably could have been avoided.

22. **WARRANTY** Supplier expressly warrants all goods and services delivered under this Contract to be free from defects in material and workmanship and to be of the quality, size and dimensions ordered. This express warranty shall not be waived by reason of the acceptance of the goods or services or payment by Institute. The Supplier shall provide the Institute with a copy of any standard warranty which is normally offered on a commercial product deliverable under this Contract. The commercial product warranty shall be deemed to be incorporated by reference and the Institute shall be entitled to all rights under such warranty.
23. **AUDIT AND RECORDS** Financial records, supporting documents, statistical records, and other records pertinent to this Contract shall be retained by the Supplier for a period of five years from acceptance by the Institute. Supplier agrees that the Institute, the National Science Foundation, the Comptroller General of the United States, or any of their duly authorized representatives, shall have access to any books, documents, papers and records of the Supplier which are directly pertinent to this Contract, for the purpose of making audits, examinations, excerpts and transcriptions.
24. **SITE VISITS** NSF and the Institute, through authorized representatives, have the right, at all reasonable times, to make site visits to review project accomplishments and management control systems and to provide such technical assistance as may be required. If any site visit is made by NSF or the Institute on the premises of the Supplier or a contractor under a subcontract, the Supplier shall provide and shall require its contractors to provide all reasonable facilities and assistance for the safety and convenience of the Institute or Government representatives in the performance of their duties. All site visits and evaluations shall be performed in such a manner that will not unduly delay the work.
25. **NONDISCRIMINATION** The Contract is subject to the provisions of Title VI of the Civil Rights Act of 1964 [42 U.S.C. § 2000d], Title IX of the Education Amendments of 1972 [20 USC §§ 1681 et seq.], the Rehabilitation Act of 1973 [29 U.S.C. § 794], the Age Discrimination Act of 1975 [42 U.S.C. §§ 6101 et seq], and all regulations and policies issued by NSF pursuant to these statutes. In accordance with these statutes, regulations, and policies, no person on the basis of race, color, national origin, sex, disability, or age shall be excluded from participation in, be denied the benefits of, or otherwise be subjected to discrimination under the Contract.
26. **EQUAL EMPLOYMENT OPPORTUNITY** This Contract is subject to the requirements of Executive Orders 11246 and 11375 and the rules and regulations or the Secretary of Labor (41 CFR Chapter 60) in promoting Equal Employment Opportunities.
27. **ANTI-KICKBACK ENFORCEMENT ACT OF 1986** This Contract is subject to the provisions of the Anti-Kickback Enforcement Act of 1986, Public Law 99-634 (41 U.S.C. 51-58). By accepting this order, Seller certifies that it has not paid kickbacks directly or indirectly to any Institute employee for the purpose of obtaining this or any other Institute purchase order or to obtain favorable treatment in an Institute matter.
28. **CLEAN AIR ACT AND THE FEDERAL WATER POLLUTION CONTROL ACT** – Should this Contract be for an amount in excess of \$100,000, Supplier agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act (42 U.S.C. 7401 et seq.) and the Federal Water Pollution Control Act as amended (33 U.S.C. 1251 et seq.). Further, Supplier agrees as follows:
- To comply with all the requirements of Section 114 of the Clean Air Act [42 U.S.C. §7414] and Section 308 of the Clean Water Act [33 U.S.C. § 1318], respectively, relating to inspection, monitoring, entry, reports and information, as well as other requirements specified in Section 114 and Section 308 of the Clean Air Act and the Clean Water Act, respectively, and all regulations and guidelines issued thereunder before the Contract.
  - That no portion of the work required by the Contract will be performed in a facility listed on the Environmental Protection Agency List of Violating Facilities on the date that the Contract was awarded unless and until EPA eliminates the name of such facility or facilities from such listing.
  - To use its best efforts to comply with clean air standards and clean water standards at the facility in which the Contract is being performed.
  - To insert the substance of the provisions of this article into any nonexempt subcontract.
29. **DEBARMENT AND SUSPENSION** – (a) Supplier shall fully comply with the requirements stipulated in 2 CFR Part 180, as modified by 45 CFR 620.330 and shall ensure that any lower tier covered transaction, as described in 2 CFR 180.220 and modified by 45 CFR 620.200 and 620.220 includes a term or condition requiring compliance with these requirements. The Supplier acknowledges that failing to disclose the information required under 45 CFR § 620.335 may result in the termination of the Contract, or pursuance of other available remedies, including suspension and debarment. Supplier may access the Excluded Parties List System at <http://epls.arnet.gov>. (b) No contract at any tier shall be made to parties listed on the General Services Administration's List

of Parties Excluded from Federal Procurement or Nonprocurement Programs in accordance with E.O.s 12549 and 12689, "Debarment and Suspension." This list contains the names of parties debarred, suspended, or otherwise excluded by agencies, and contractors declared ineligible under statutory or regulatory authority other than E.O. 12549. Supplier, whose Contract exceeds the small purchase threshold, shall provide the required certification regarding its exclusion status and that of its principal employees.

30. **[FOR CONTRACTS OF \$100,000 OR MORE] BYRD ANTI-LOBBYING AMENDMENT** - Supplier warrants that Supplier has applied or bid on a Contract of \$100,000 or more and has filed the required certification. Each subcontracting tier must certify to the tier above that it will not and has not used Federal appropriated funds to pay any person or organization for influencing or attempting to influence an officer or employee of any agency, a member of Congress, officer or employee of Congress, or an employee of a member of Congress in connection with obtaining any Federal contract, grant or any other award covered by 31 U.S.C. 1352. Each tier shall also disclose any lobbying with non-Federal funds that takes place in connection with obtaining any Federal award. Such disclosures are forwarded from tier to tier up to the recipient.
31. **[FOR CONSTRUCTION/REPAIR CONTRACTS >\$2000] Copeland "Anti-Kickback" Act (18 U.S.C. 874 and 40 U.S.C. 276c)** Supplier shall comply with the Copeland "Anti-Kickback" Act (18 U.S.C. 874), as supplemented by Department of Labor regulations (29 CFR part 3, "Contractors and Subcontractors on Public Building or Public Work Financed in Whole or in Part by Loans or Grants from the United States").
32. **[FOR CONSTRUCTION/REPAIR CONTRACTS >\$2000] Davis-Bacon Act, as amended (40 U.S.C. 276a to a-7)** Supplier shall comply with the Davis-Bacon Act (40 U.S.C. 276a to a-7) and as supplemented by Department of Labor regulations (29 CFR part 5, "Labor Standards Provisions Applicable to Contracts Governing Federally Financed and Assisted Construction").
33. **[FOR CONSTRUCTION/REPAIR CONTRACTS >\$500,000] Surety Bonds - If so directed**, the Supplier shall furnish separate bid guarantees, performance and payment bonds to the Institute. Each bond shall set forth a penal sum in an amount not less than the Contract Price. Each bond furnished by the Supplier shall incorporate by reference the terms of this Contract as fully as though they were set forth verbatim in such bonds. In the event the Contract Price is adjusted by Change Order executed by the Contractor, the

penal sum of both the performance bond and the payment bond shall be deemed increased by like amount. The performance and payment bonds furnished by the Supplier shall be in form suitable to Institute and shall be executed by a surety, or sureties, reasonably acceptable to the Institute.

34. **[For designated Experimental, Development or Research Work] Rights to Inventions** - For non-profit organizations and small business firms, patent rights shall be governed by 37 CFR part 401, titled "Rights to Inventions Made by Non-Profit Organizations and Small Business Firms under Government Grants, Contracts and Cooperative Agreements".
35. **[For designated Experimental, Development or Research Work] Patent Rights** – Bayh-Dole Act [35 U.S.C. 200 et seq.]