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DOCUMENTATION PAGE

SR-2005-19 August 2005 REPORT SECURITY CLASSIFICATION DISTRIBUTION Unclassified Unlimited TITLE THE NEW WATERPROOF HOUSING - 2005 (for the Victoria Sub Model) AUTHOR(S) AUTHOR(S) Tim Osmond CORPORATE AUTHOR(S)/PERFORMING AGENCY(S) Institute for Ocean Technology, National Research Council, St. John's, NL PUBLICATION SPONSORING AGENCY(S) Institute for Ocean Technology, National Research Council, St. John's, NL PUBLICATION KEY WORDS PAGES FIGS. TABLES
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housing in the process. This report documents these modifications. It also shows the
relevant calculations that ensure integrity and functionality of the housing. The engineering
drawings for the housing and a presentation to the Institute are included.
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THE NEW WATERPROOF HOUSING - 2005 (for the Victoria Sub Model)

SR-2005-19

Tim Osmond

August 2005

Abstract

This report documents the design of the New Waterproof Housing, designed May – August 2005 for the Institute for Ocean Technology. The new waterproof housing was designed to allow for enough space to implement the PHINS (Inertial Navigation System) in the Victoria sub. Several modifications and improvements have been made to the old waterproof housing in the process. This report documents these modifications. It also shows the relevant calculations that ensure integrity and functionality of the housing. The engineering drawings for the housing and a presentation to the Institute are included.

Document Contents

1. Background – An explanation of the reason for building the new waterproof housing

- 2. Components A list of components that make up the housing
- 3. Design Criteria Factors and features that are designed into the housing
- 4. Calculations Relevant calculations to housing design
- 5. Figures As referenced throughout document
- 6. Appendices As referenced throughout document
- 7. Drawings Engineering drawings required to fabricate housing
- 8. Attachments Various pieces of information used in designing housing
- 9. Presentation Presented to the Institute, August 2005

Background

Institute for Ocean Technology owns a piece of equipment listed in this document as the old waterproof housing. The old waterproof housing is an aluminum, cylindrically shaped housing that seals via a rubber gasket and a plate that bolts to the front face of the housing. It contains ample space for a motion pak, two inclinometers and little else. The equipment inside the housing rests on an internal plate (see figure 1).

The old waterproof housing was used in the Victoria sub model that was tested during 2004. A cantilevered frame bolted to the front of the internal sub balance and the housing was attached to the frame using two threaded rods that bent around the cylinder and bolted to the frame. The motion pak and inclinometers require accurate positioning. The threaded rods were intended to give the housing a high degree of adjustability. To adjust the internal base plate, it was intended that it was simply a matter of tightening the threaded rods on either corner of the frame. Testing however, showed this was not the case. It was found that tightening the threaded rods around the housing causes the housing to twist unpredictably. It was very difficult to position the internal plate of the housing in the desired plane and hold it there. Disassembling the frame and housing, reassembling it and returning it to its original position was also impossible. While these problems are correctable there are other issues with the old waterproof housing

One problem with the old housing is that it has limited space inside. A new piece of IOT equipment called the PHINS (inertial navigation system) could potentially be used in further testing of the Victoria sub model. The PHINS does not fit in the old waterproof housing nor will most other equipment taller than 4 inches. The old waterproof housing is small and the cylindrical shape renders much of its internal space unusable. This is because in order to mount the internal equipment on a flat plate, much of the space under the plate is left inaccessible (see figure 2). It is also difficult to screw the equipment into the plate with access from only an 8-inch hole in the front of the housing. At IOT, there is always the potential for situations to arise where there is excess water and a waterproof housing is needed. The old waterproof housing offers little flexibility as most other equipment will not fit inside. For these reasons it was decided by the design and fabrication group in a preliminary meeting that a new waterproof housing would be needed. A waterproof housing that would both correct the problems of the old waterproof housing and offer more flexibility for future applications.

Components

The CAD file for the waterproof housing is available under Projects/42_945_10_Victoria/Tosmond/Water Housing.ckd

The new waterproof housing is composed of the following components:

- The base plate (13.5 x 10.5 x 0.25 aluminum plate, 8 aluminum upper pads, 3 aluminum lower pads, 1 aluminum reinforcing plate, an exit pipe)
- The inner plate (12.5 x 9.5 x 0.375 aluminum plate)
- The top frame (1 x 1 x 0.25 aluminum angle bar, 5 aluminum plates)
- A rubber gasket
- 23 0.25-20 F593C steel screws, 0.625 inch length
- 4 0.125-inch steel dowel pins, 0.5 inch length

A mounting frame has also been designed to mount the housing to the Victoria sub model $(1.5 \times 1.5 \times 0.25 \text{ HSS}, 3 \text{ aluminum pads})$.

Other optional components include:

- An inclinometer platform
- 3 0.138-32 steel screws, 0.625 inch length

Design Criteria

The design criteria for the new waterproof housing is listed below:

- The new waterproof housing must be completely waterproof
- The equipment contained within the new waterproof housing should be more accessible than the old housing
- The housing should be repeatable
- The housing should be larger than the old waterproof housing
- The housing should be flexible in it's ability to accommodate unforeseen types of equipment
- The housing should be adjustable
- The housing must also provide a perfectly flat surface to mount equipment to it

The new waterproof housing must be completely waterproof. This is because the equipment contained in the housing can easily be over 100 000 CAD in value. Exposure to water to a damaging degree would be detrimental to the Institute. The housing is designed to be waterproof up to the deepest location within the IOT facilities (7 meters in the tow tank). The waterproof housing has a number of features designed to ensure it does not leak.

First of all the frame for the top of the housing is built with 0.25-inch aluminum angle bar. This design gives the housing strength to withstand the 12 psi of pressure applied to the housing at the deepest point in the tow tank. All connections are first chamfered at the edges and then welded with watertight welds (see figure 3). The plates that make up the five walls of the housing are 0.1875-inch thick aluminum plates, thick enough to easily withstand the pressure of the 12 psi (see calculations – Deflection and Stress of Top). The plates are sealed to the top frame again using watertight welds around the frame (see figure 4).

The base plate of the housing is a 0.25-inch thick aluminum plate. Only one hole is cut into this plate, the hole for the equipment wires to exit. The wires exit through a pipe that is welded watertight to the base plate (see figure 5).

The top frame and the base plate seal together via a rubber or neoprene gasket (see figure 6). The rubber is cut to fit around the outside of the base plate and clamped down with the top frame using 18 0.25-inch steel bolts (see figure 7).

The equipment inside the housing does not attach to the base plate but to an inner plate that rests on 8 small pads, 0.25 inches offset from the base plate. This gap or offset between the base plate and the inner plate offers several advantages:

- Should there be any leakage in the housing, the offset allows more water to enter before the level of water will reach the equipment. A certain amount of water will run down into the exit pipe before it begins to back up

and rise to the level of the equipment. This should provide more time for any leaks to be noticed.

- Absorption packs can be placed in the lower space to absorb any water that should enter the housing via condensation or leakage.

Any leaks noticed in the testing phase are to be corrected. The above features allow the housing to be completely waterproof.

With the new waterproof housing, design considerations have been given to allowing the equipment contained in the housing to be easily accessible. The new waterproof housing is easier to use than its predecessor; it is simpler and faster to take equipment in and out of it. The housing rests on lower mounts as oppose to the upper mount system of the old housing. This allows those working with the housing to easily access the equipment. The top is removable by loosening the 18 bolts and handles are designed into the top to allow it to be easily lifted off (see figure 8). At such time that the top is removed all equipment becomes easily accessible.

Due to the thickness of the inner plate, equipment can be easily attached to the housing by screwing, bolting or pinning it. It is also strong enough to deflect less than 0.001 inch when fully loaded with equipment (see Calculations – Deflection of Inner Plate). Multiple footprints may be drilled into one inner plate so that many different types of equipment may be attached or multiple inner plates may be fabricated with different footprints and attached as desired. The inner plate allows the new waterproof housing to accommodate many different types of equipment and the offset design prevents it from deflecting due to external water pressure. Because the base plate does not contact the inner plate at a central location deflection transferred from the base plate to the inner plate is minimized. This translates in to better repeatability, as the inner plate will not move with respect to the machined pads even during submersion.

The waterproof housing is designed to be highly repeatable. The housing has three pads welded to the bottom that mount on three pads on the mounting frame. The three pads on the mounting frame are machined to be perfectly coplanar with the horizontal plane of the vessel being tested. The three pads on bottom of the housing are also machined to be coplanar. Two to three highly accurate steel dowel pins are used to pin the housing to the mounting frame. There are 8 small pads on the upper side of the base plate. These pads are machined to be parallel with the three lower pads on the base plate. This ensures that the inner plate that mounts to the 8 upper pads is perfectly parallel with the three pads on the mounting frame and is thus parallel to the horizontal plane of the vessel being tested. The inner plate is both dowel pinned and bolted to the base plate. The inner plate is now precisely positioned with respect to the mounting frame.

As mentioned above the old waterproof housing has little space and will not accommodate equipment much taller than 4 inches. Maximum internal surface area is 13.5 inches long by 8 inches wide. Although the internal volume of the housing is 678.6 in², only between 30 to 70% of this space is usable depending on equipment size and shape as well as accessibility. The new waterproof housing contains over 800 in² of space. Of this space over 95% is usable and the new housing can accommodate equipment as tall as 7 inches, 12.5 inches long and 9.5 inches wide. The new housing fits the PHINS system, the Motion Pak, 2 inclinometers and a temperature/humidity gauge, all completely accessible with room to spare. The exterior dimensions of the housing are 14.5" x 11.5" x 7.5". Empty, the waterproof housing weighs approximately 25 lbs (see appendix A) indicating the housing is a balanced design between size and weight.

The new housing also has the ability to change from being repeatable to adjustable. Because the housing mounts via a three-pad system with one in the front and two on the rear, it is particularly amiable to shimming. If the pins are removed from the lower mounts, shimming under the two rear pads will control the roll angle of the housing and shimming under the forward pad will control the pitch of the housing. This way minor adjustments can be made if necessary.

Calculations

The follow calculations were made for the new waterproof housing.

Pressure of Water at Maximum Depth Maximum Depth: d = 7 meters = 275.6 inches Density of Water: ρ = 62.4 lbs/ft³ = 0.03611 lbs/in³ Safety Factor: SF = 1.2 Pressure: P = d * ρ * SF P = 275.6 inches * 0.03611 lbs/in³ * 1.2 = 11.94 lbs/in² ≈ 12 psi

Deflection and Stress of Top

Using the deflection and stress of plates equations taken from the Machinery's Handbook 26, pgs 268 – 270.

Using the equations for a rectangular plate, uniformly distributed load, supported at all ends. Supported was selected over fixed because the values are more conservative and there is some ambiguity between how the welded plates will react. Only calculations for the top plate are presented here because it is the largest and will experience highest deflections and stresses. Calculations for the four walls are not necessary.

Pressure: P = 12 psiArea: A = 11" * 8" = 88"² Modulus of Elasticity: $E = 10.0 * 10^6$ psi Thickness of plate: t = 0.1875 inches Long side: L = 11 inches Short side: l = 8 inches Deflection: D = $(0.1422 \text{ P}^*\text{A}) / [\text{Et}^3 (\text{L}/l^3 + 2.21/\text{L}^2)]$ = (0.1422 * 12 psi * 88"²) / $[10.0 \times 10^{6} \text{ psi} \times 0.1875^{3} (11^{7}/8^{3} + 2.21/11^{2})]$ = 0.0573 inches Safety Factor: 1.2 Stress: $\sigma = (SF * 0.75 P*A) / [t^2 (L/l + 1.61*l^2/L^2)]$ = (1.2 * 0.75 * 11" * 8" *12 psi) / $[0.1875''^{2} * (11''/8'' + 1.61*8^{2}/11^{2}]$ = 12 141 psi Ultimate Tensile Stress: S_{ult} = 45 000 psi Machinery's Handbook pg 554 - AI 6061-T6 Yield Stress: $S_v = 40\ 000\ psi$

S_y / σ * 100% = 12 141 psi / 40 000 psi * 100% = 30.35%

Because the deflection of the wall is approximately 0.06 inches and the stress is only 30% of the yield stress given very conservative estimates, we have a safe

and comfortable margin of error and we can say that the walls will not fail due to pressure stress nor due to fatigue given numerous immersions to a maximum depth of 7 meters.

Deflection of Base Plate

The objective in designing the base plate was to support it to bring deflection to less than 0.005"

Using equation for rectangle, uniformly distributed load, fixed edges. Machinery's Handbook 26, pg 269. Area: A = 12.5" * 9.5" = 119"² Long side: L = 12.5" Short side: l = 9.5" Deflection: D = (0.0.284 P*A) / [Et³ (L/l³ + 1.056 l²/L²)] = (0.1422 * 12 psi * 119") / [10.0 * 10⁶ psi * 0.25"³ (12.5"/9.5"³ + 1.056 9.5"²/12.5"⁴)] = 0.0140 inches

```
D = P*k = 12 psi * 0.0011667
k<sup>-1</sup> = 857.14
```

 $0.005 / 857.14 = P_1 = 4.2857$ $P_2 = 12 - 4.286 = 7.714 \text{ psi}$ Load per inch: w = 7.714 psi * 12.5" = 96.429 lbs/in

Using a sectional method approximating the uniform load across the center of the bottom plate.

 $v_{max} = -5w L^4 / 384 E I$ $0.005" = (96.429 lbs/in) * 9.5^4 / [384 * 10 * 10^6 * I]$ Solving for I Moment of inertia: I = 0.040907 = 1/12 * b * (0.5)³ Width: b = 3.927 I will use 4.5" width of supporting bar to prevent deflection more than 0.005".

<u>Properties of Housing</u> See excel spreadsheet Projects/42_945_10_Victoria/Tosmond/Properties of Housing.xls or Appendix A

Weight: $W = \Sigma$ (Volume * Specific Weights) or $W = \Sigma$ (Length/weight * Length) Weights – reference densities and weight per length from Russel Metals Inc.

Moment of Inertia: I = $\Sigma I_x + Ad_y^2$

Centroid: $x_c = \Sigma m_i x_i / \Sigma m_i$ $y_c = \Sigma m_i y_i / \Sigma m_i$ $z_c = \Sigma m_i z_i / \Sigma m_i$

Buoyancy Forces: F_{bouy} = Volume of water displaced * ρ_{water}

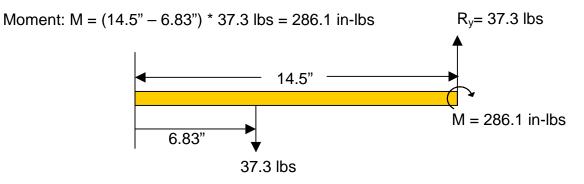
Deflection of Inner Plate

Using the equation for a uniform load, simply supported, rectangular plate.

Load: W = 13.3 lbs
Long Side: L = 12.5"
Short Side:
$$l = 9.5$$
"
Deflection: D = (0.1422 W) / [Et³ (L/ l^3 + 2.21/L²)]
= 0.1422 * 13.3 / [10.0 * 10⁶ * 0.375"³ (12.5/9.5³ + 2.21/12.5²)]
= 1.24586 * 10⁻⁴ inches

Because this value is much less than 0.001 we know that there is no appreciable deflection due to loading within the housing.

<u>Deflection of Frame</u> Center of Gravity: (6.826, -0.002, 5.095) Modulus of Elasticity for Steel: 29 * 10^6 psi Moment of Inertia: I = 0.4368 in⁴



Calculating deflection due to bending in horizontal portion of frame Reference Hibbler "Mechanics of Materials, 5th ed", chapter 12, pg. 591

EI * $d^2v/dx^2 = -286.1 < x - 0 >^0 + 37.3 < x - 0 >^1 - 37.3 < x - 7.67 >^1$ EI * $dv/dx = -286.1x + 37.3/2 x^2 - 37.3/2 < x - 7.67 >^2 + c_1$ EI v = -286.1/2 x² + 37.3/6 x³ - 37.3/6 < x - 7.67 >^3 + c_1x + c_2 v(0) = 0 dv(0)/dx = 0 Therefore c₁ = 0 and c₂ = 0 EI v = -286.1/2 x² + 37.3/6 x³ - 37.3/6 < x - 7.67 >^3 Maximum Deflection: v(14.5) = -0.00103

Calculating deflection due to bending in vertical portion of frame Reference Hibbler "Mechanics of Materials, 5th ed", appendix C $\Theta_{max} = ML/EI = 286.1 \text{ in-lbs } * 9.5" / [29 * 10^6 \text{ psi } * 0.4368 \text{ in}^4] = 2.1457 \ 10^{-4} \text{ rads} = 0.0123 \text{ degrees}$ Deflection: 14.5 sin(0.0123) = 0.00311

Μ

θ

 $D_{tot} = 0.00311 + 0.00103 = 0.00414$

Frequency of Frame See algor results

Figures Figure 1



Figure 2

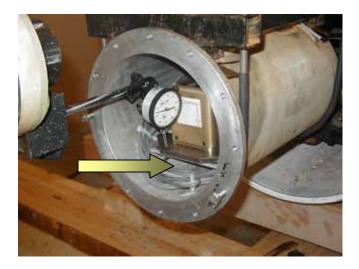


Figure 3

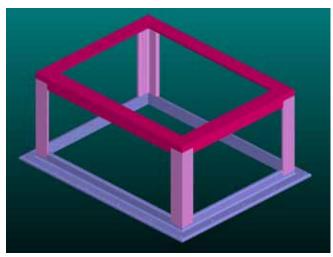


Figure 4

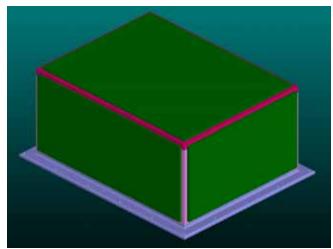


Figure 5

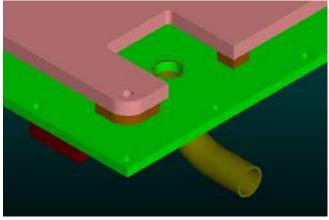


Figure 6

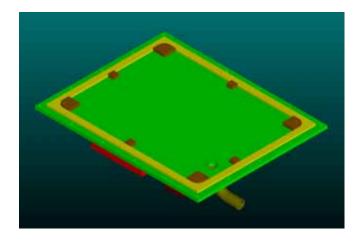


Figure 7

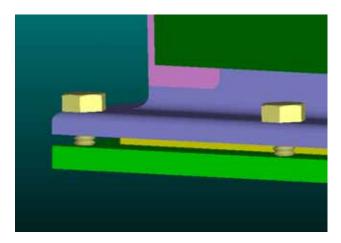
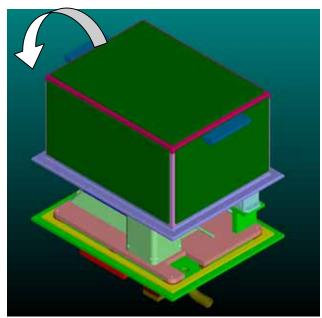


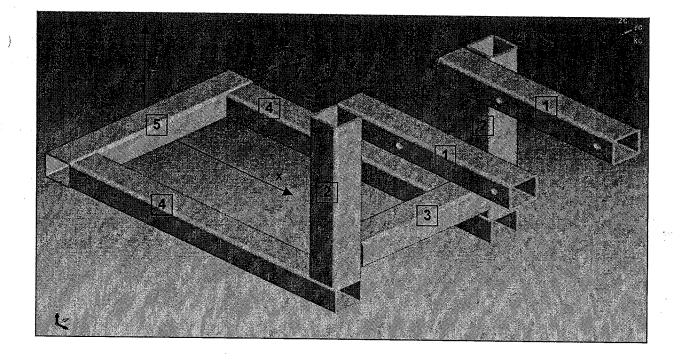
Figure 8



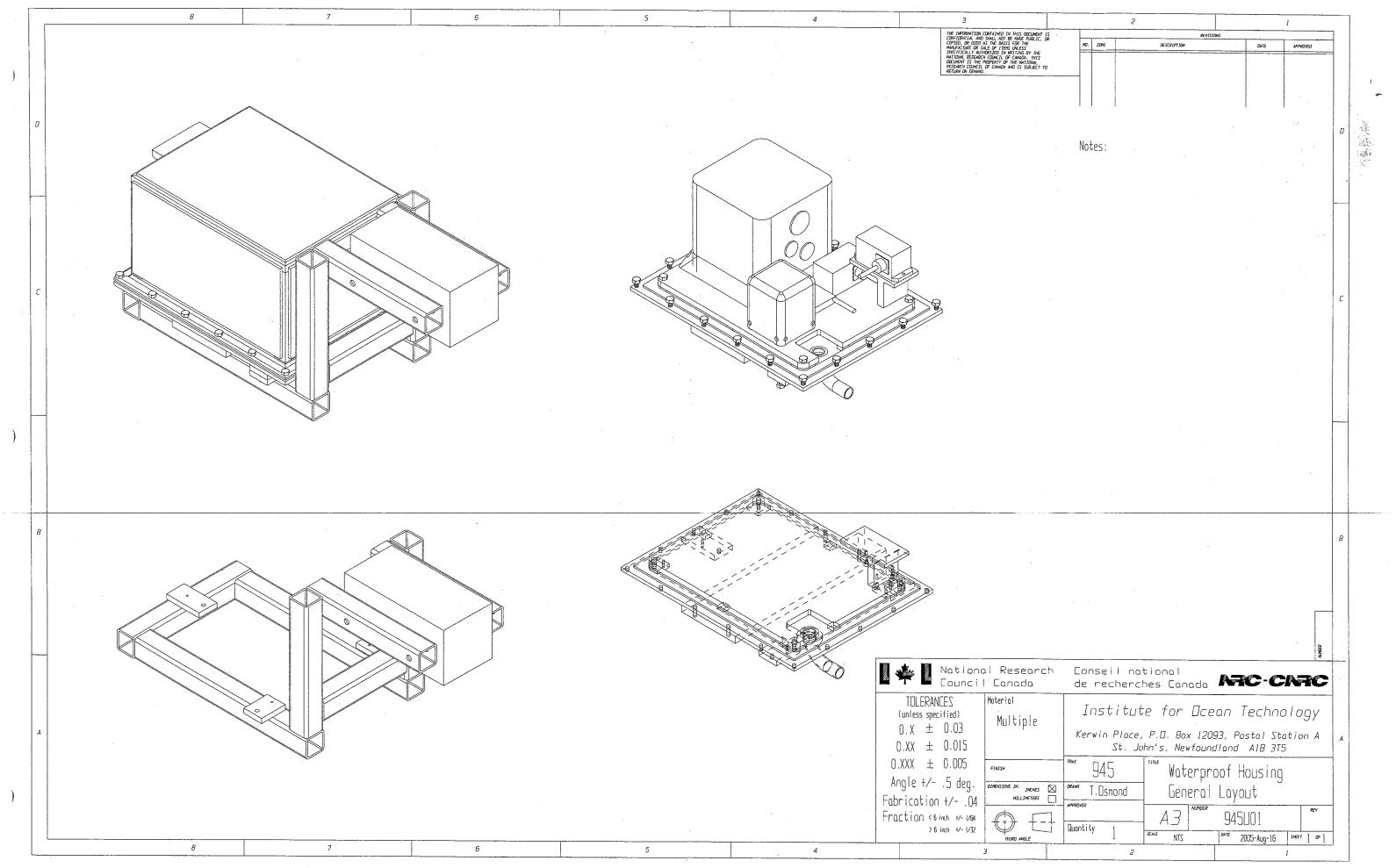
Appendix A

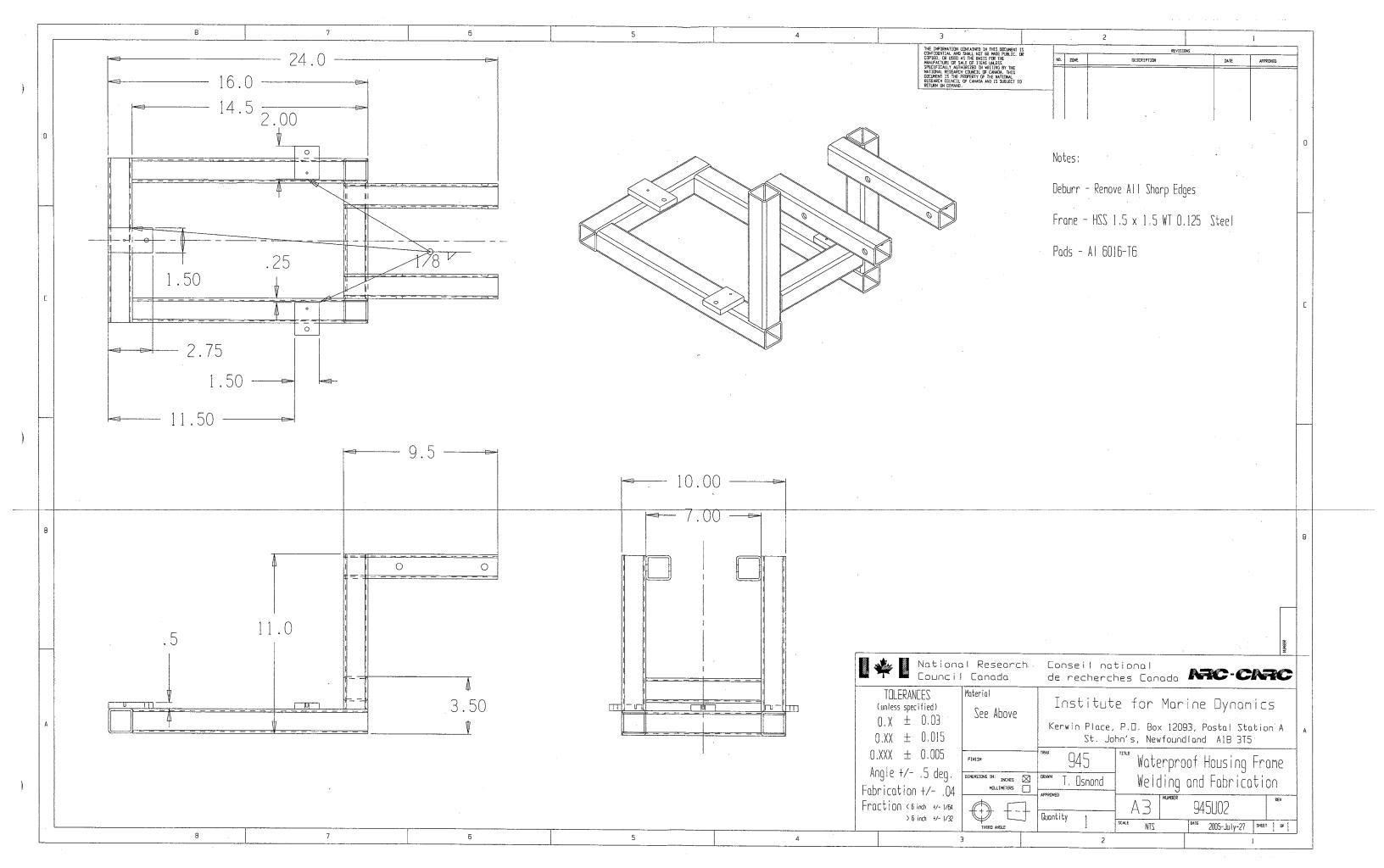
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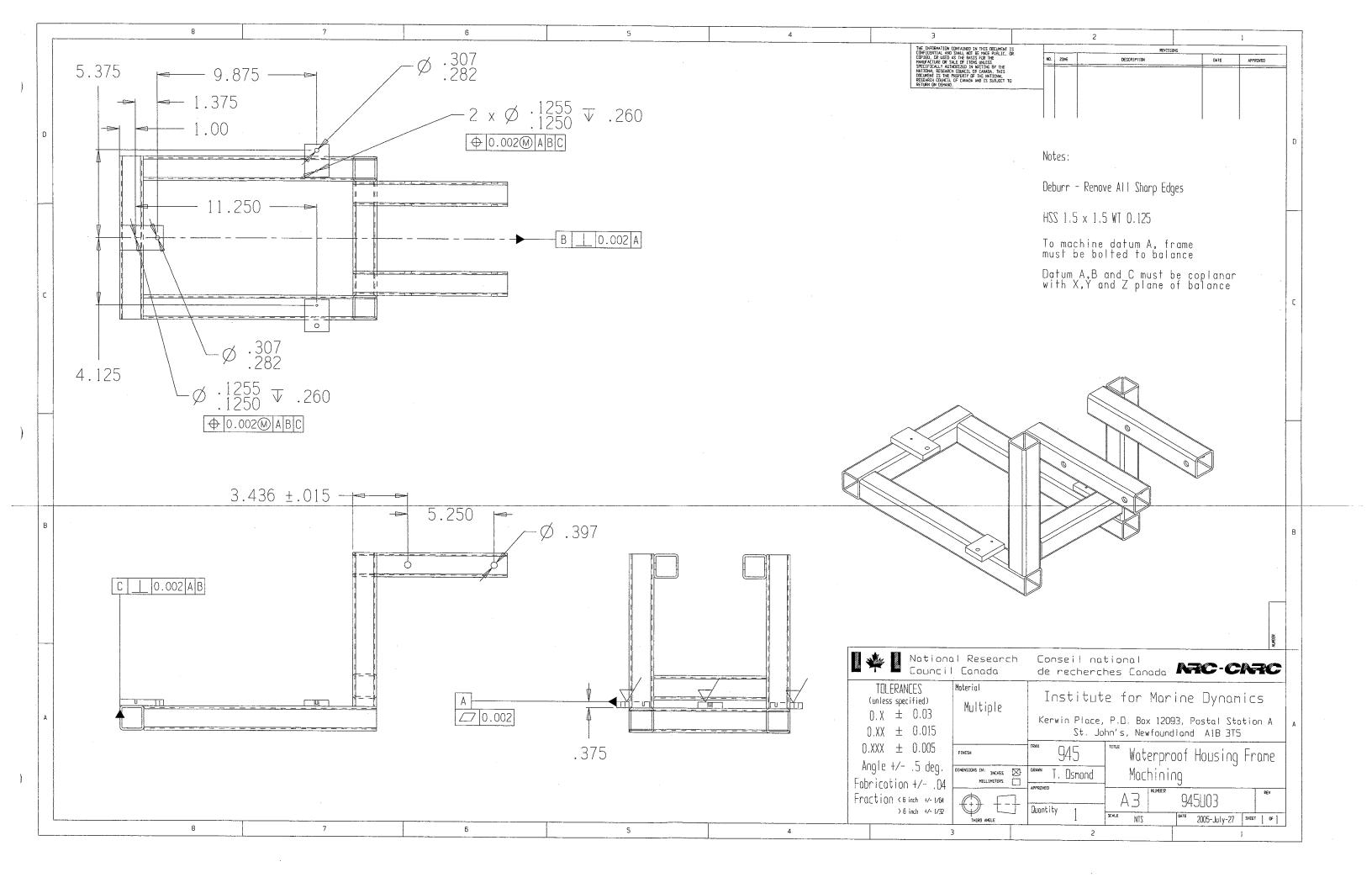
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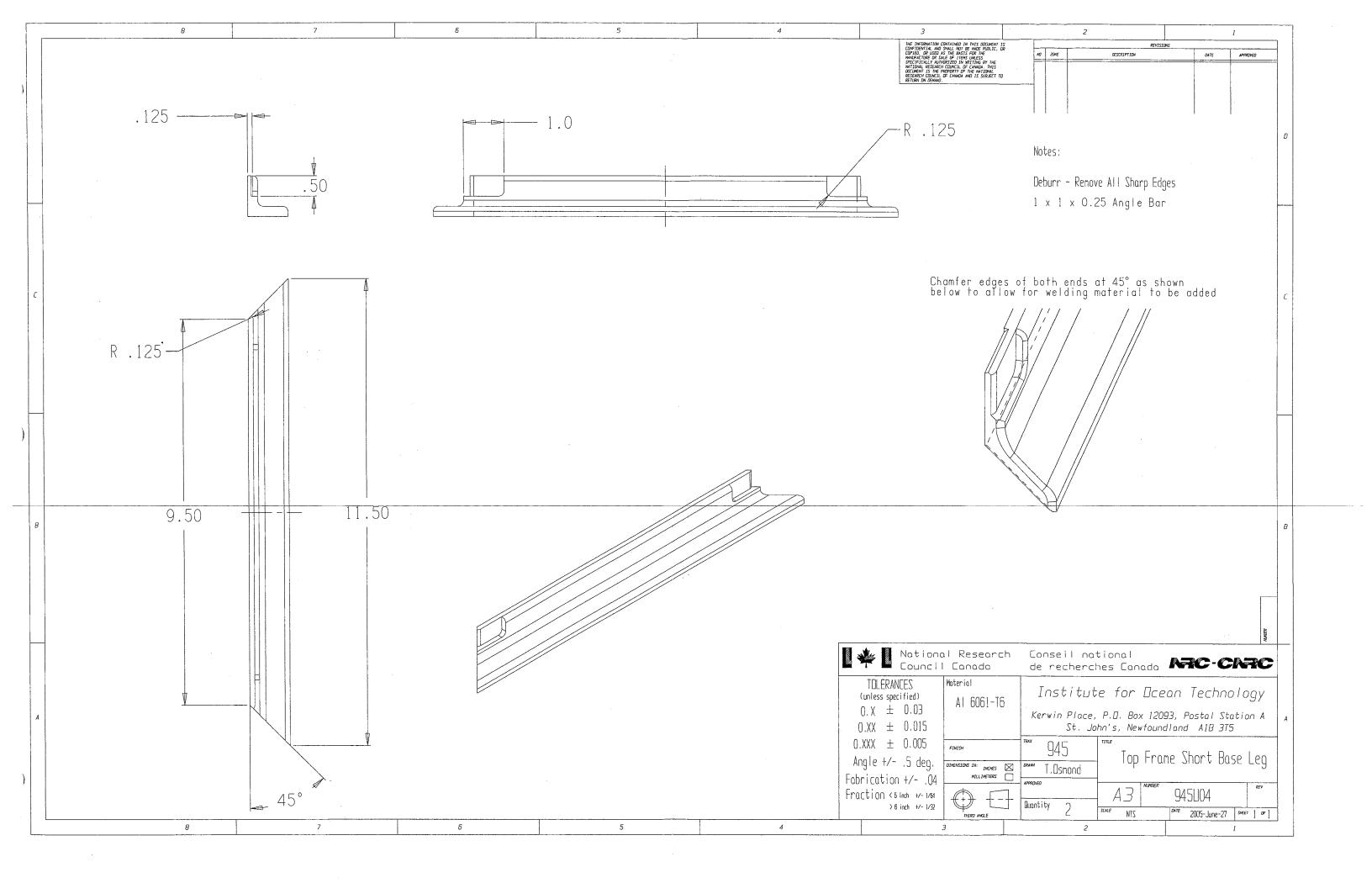


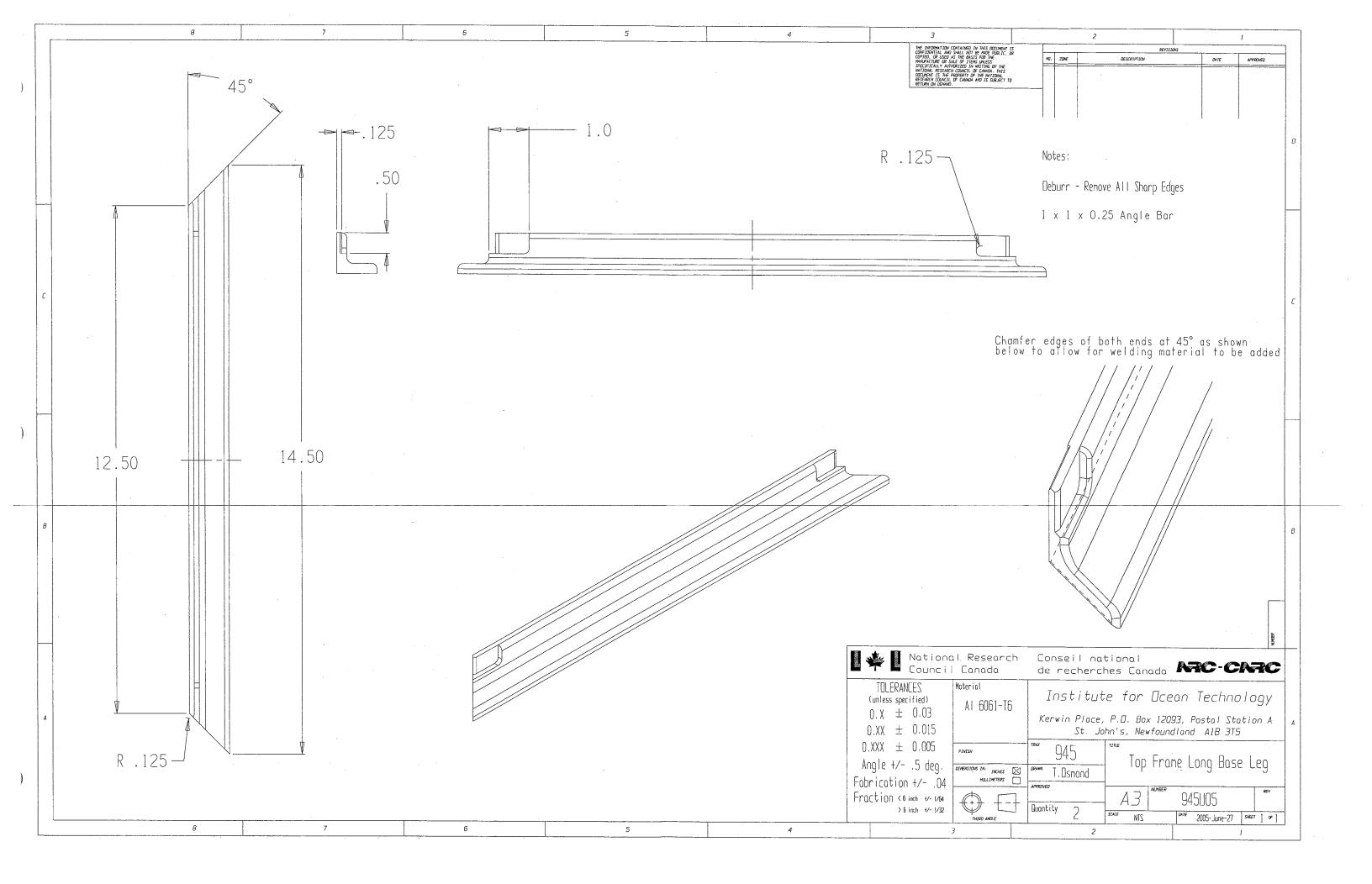
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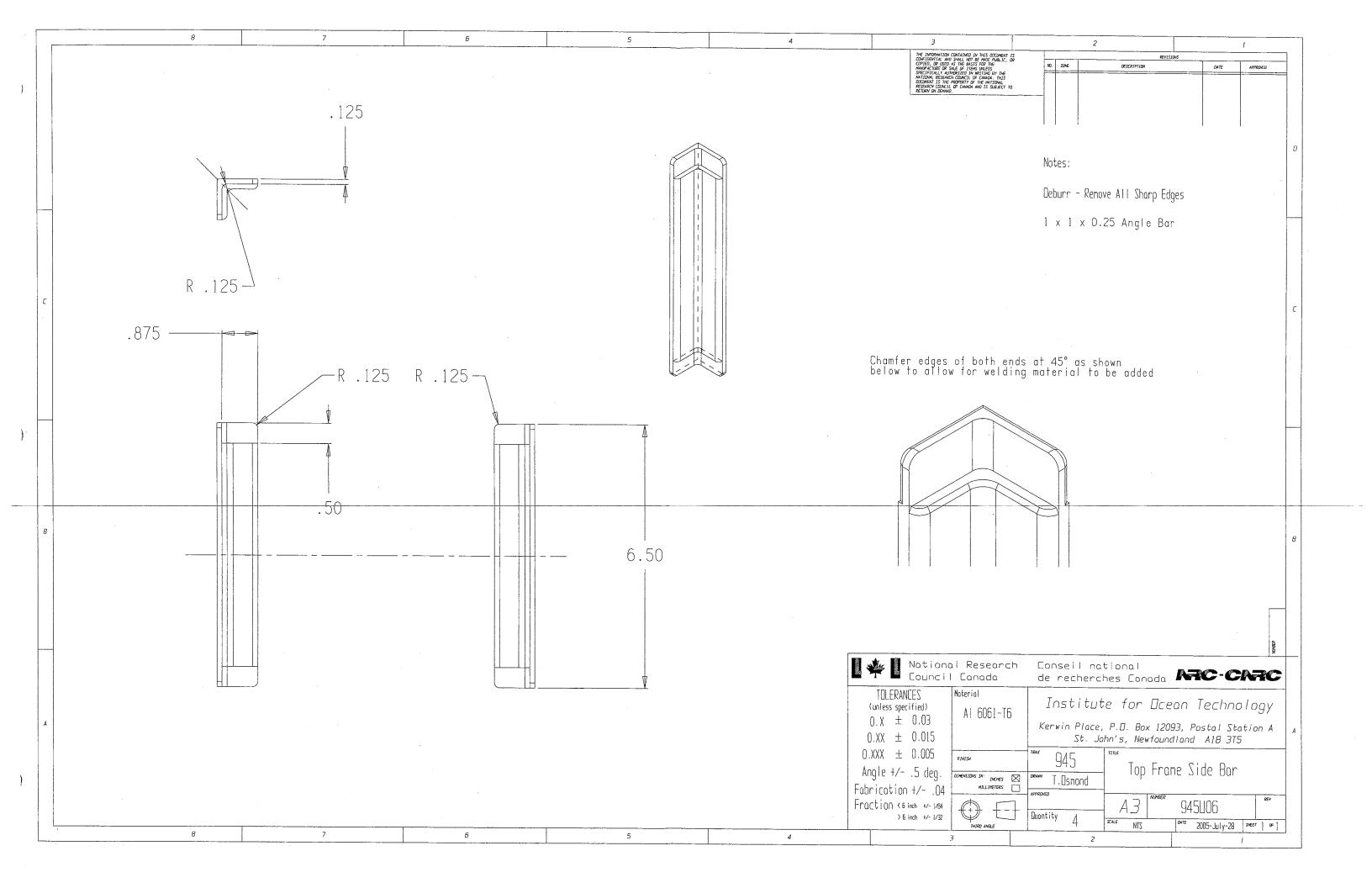


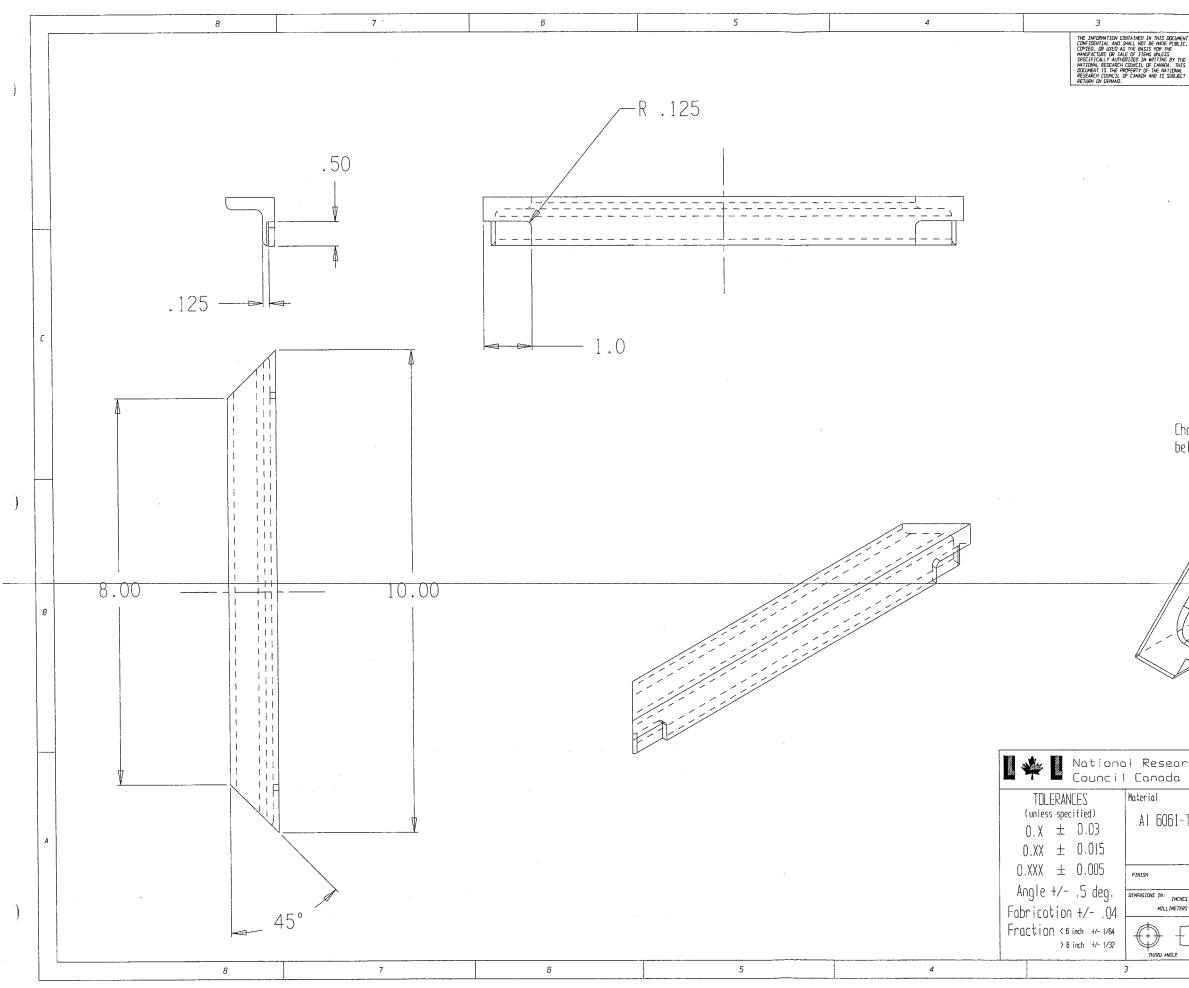




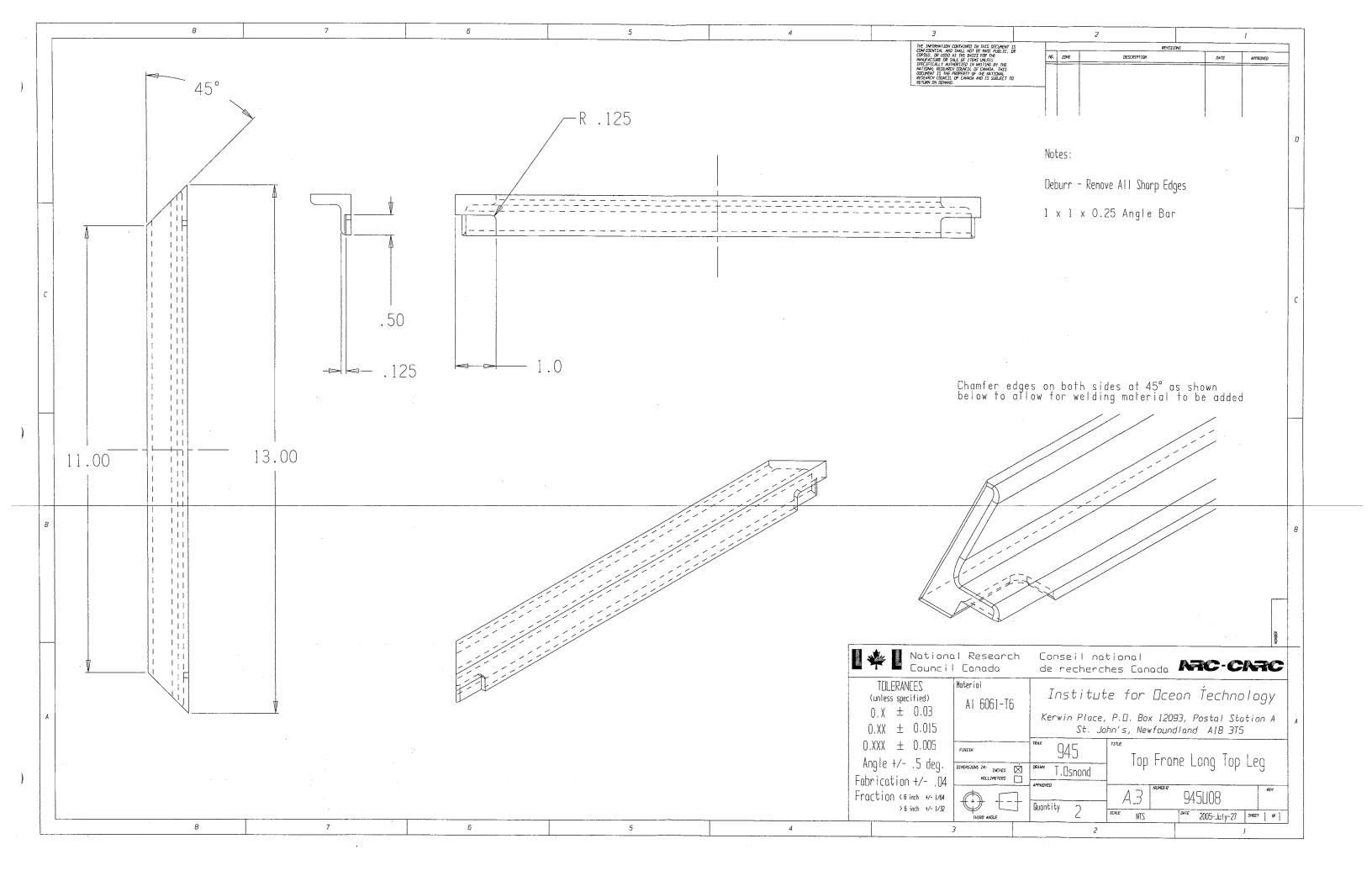


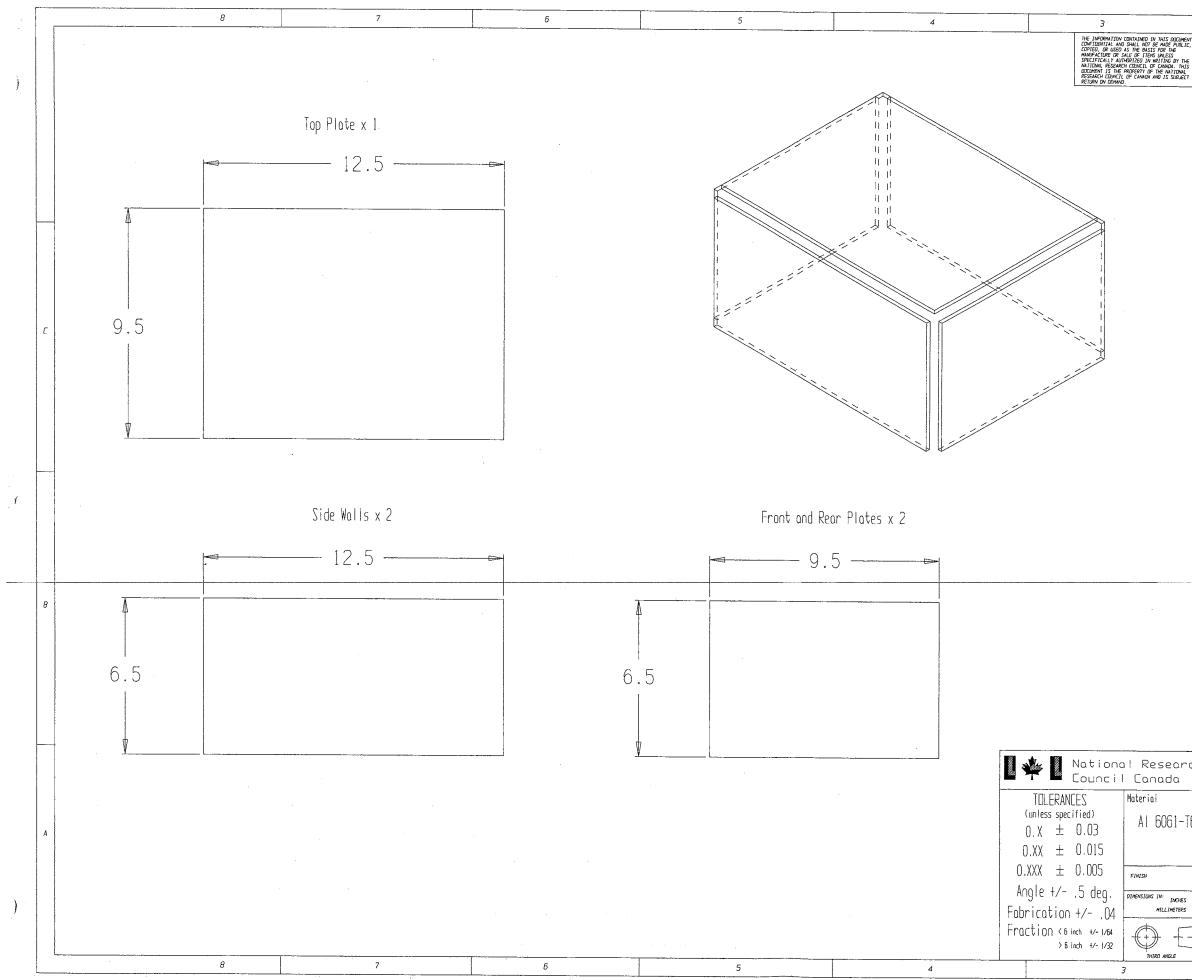




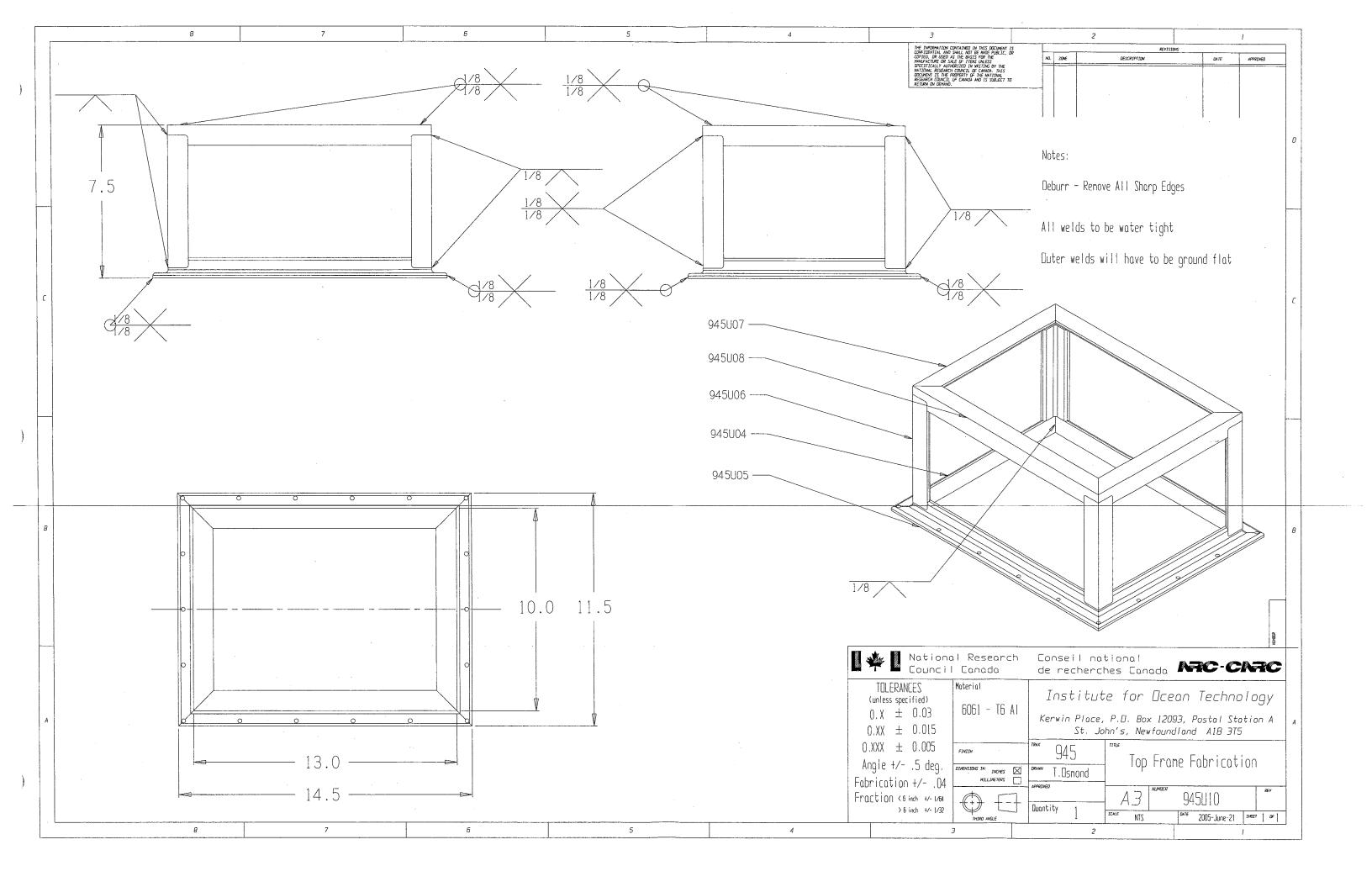


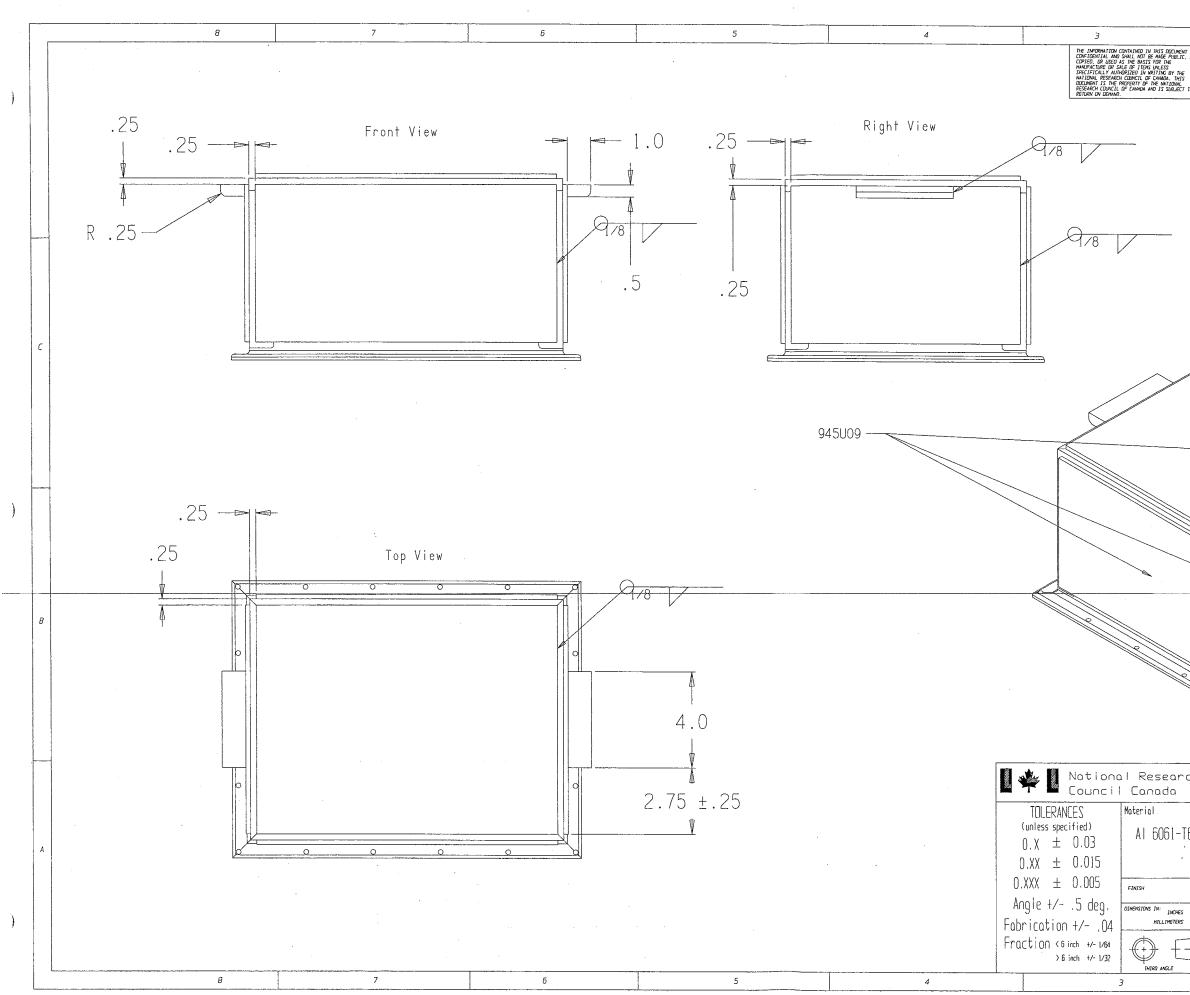
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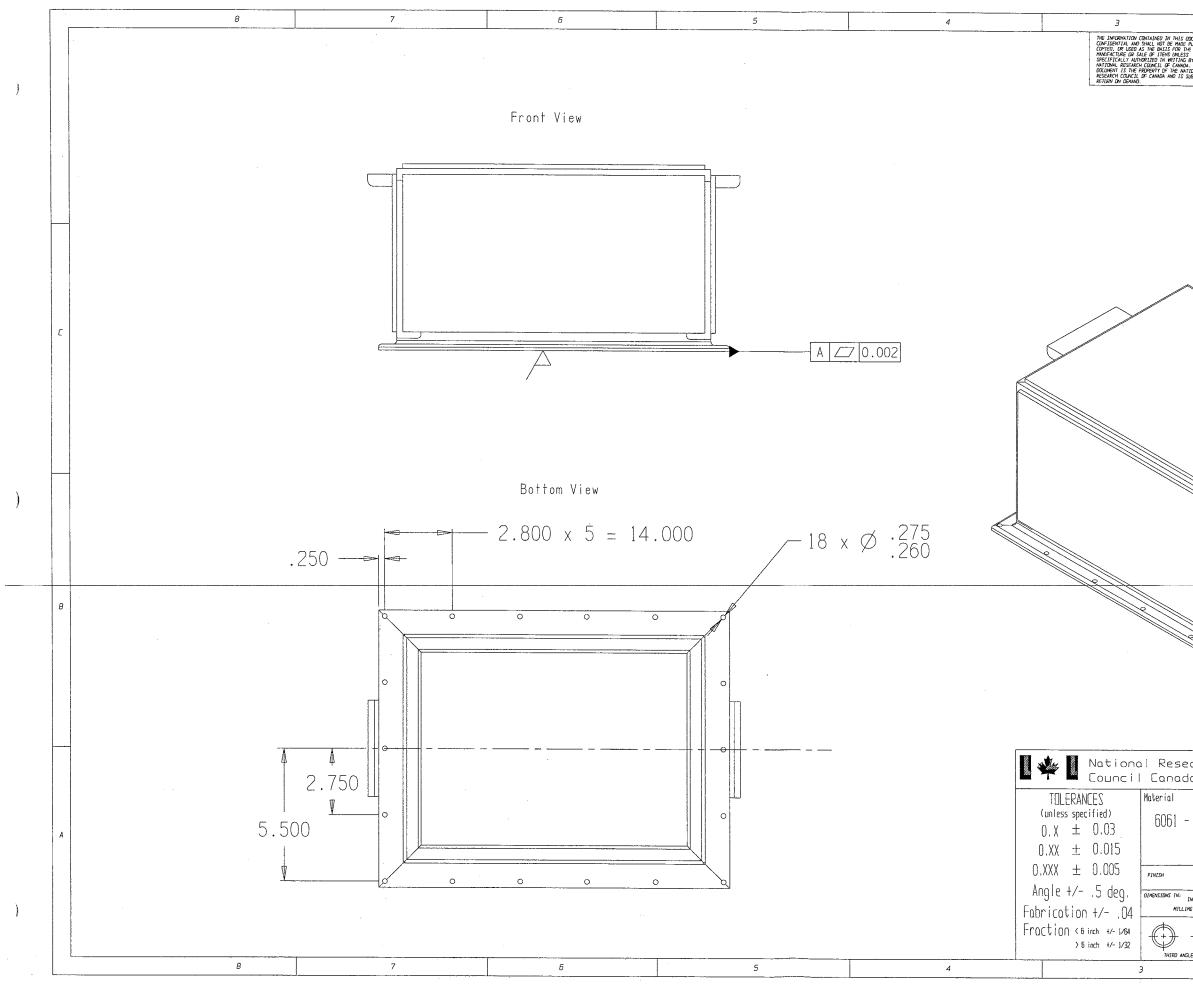


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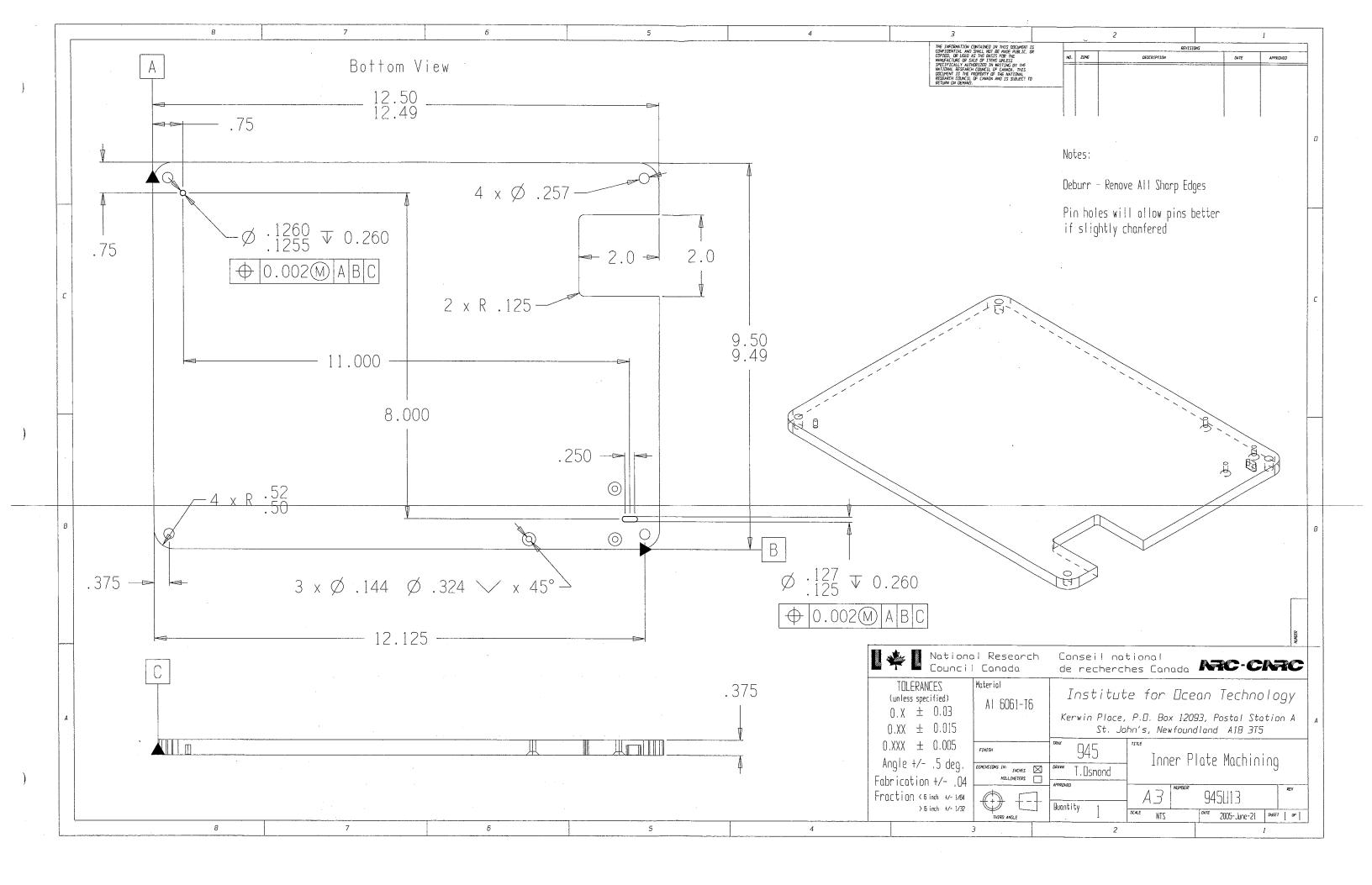


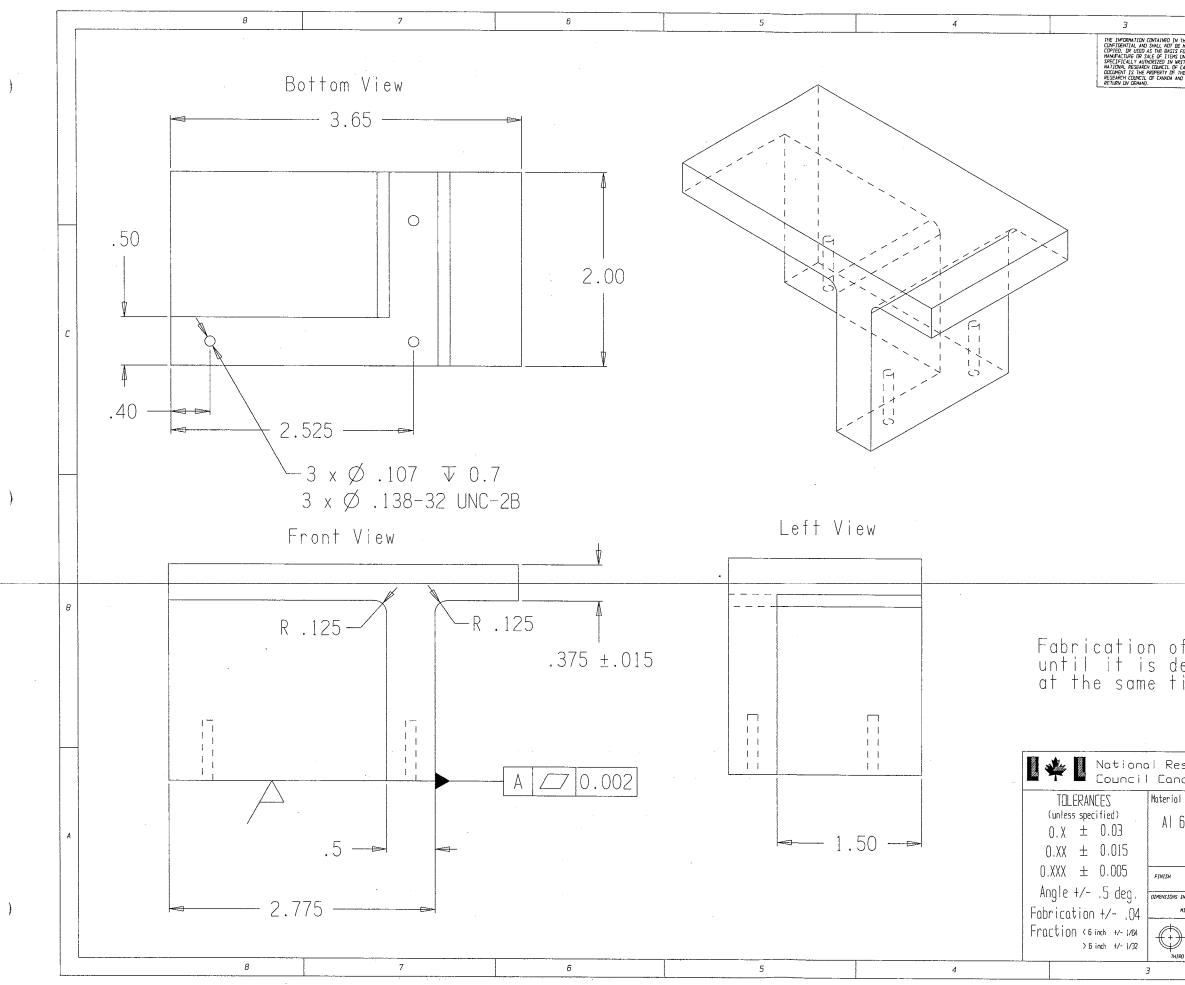


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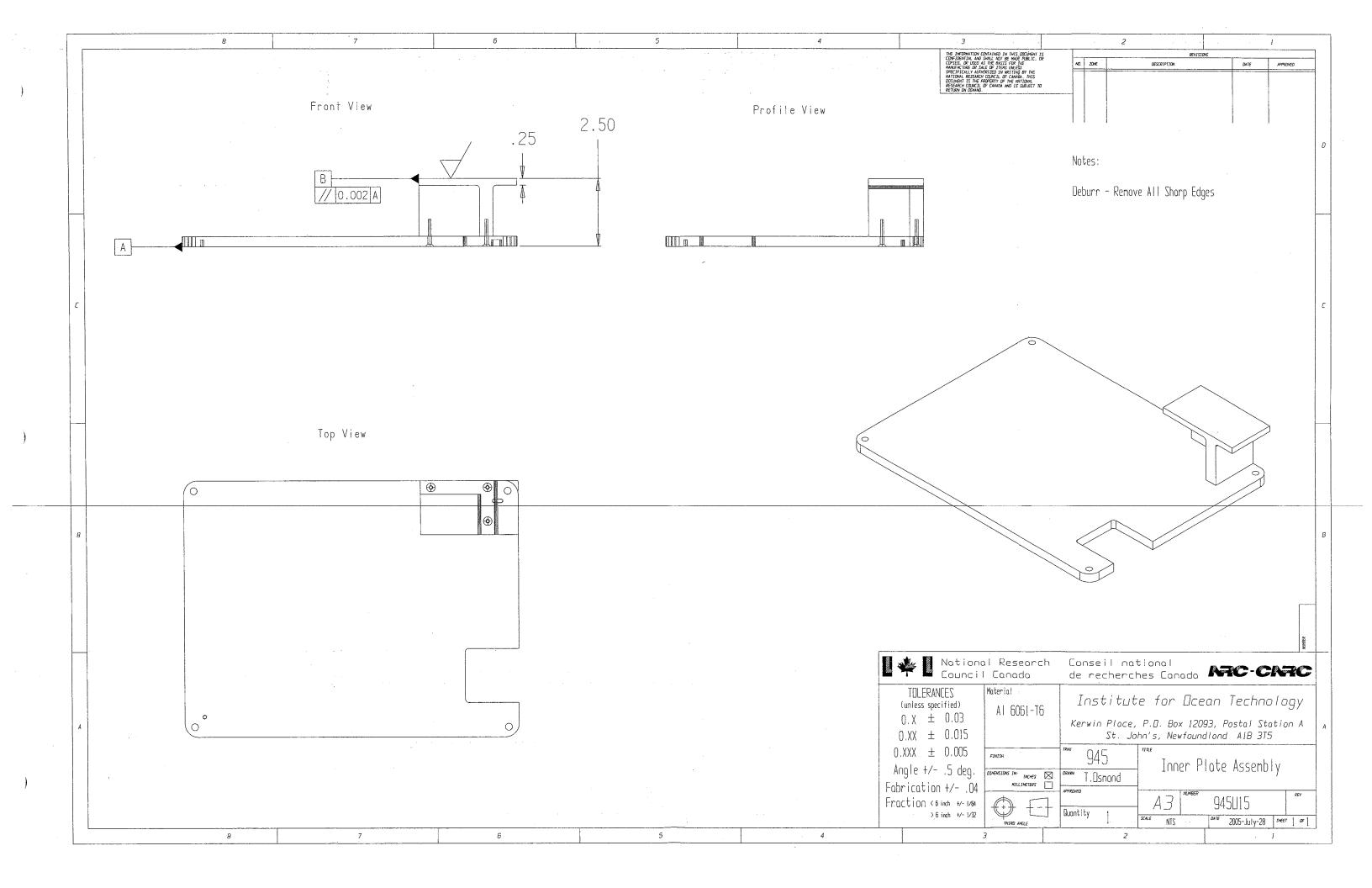


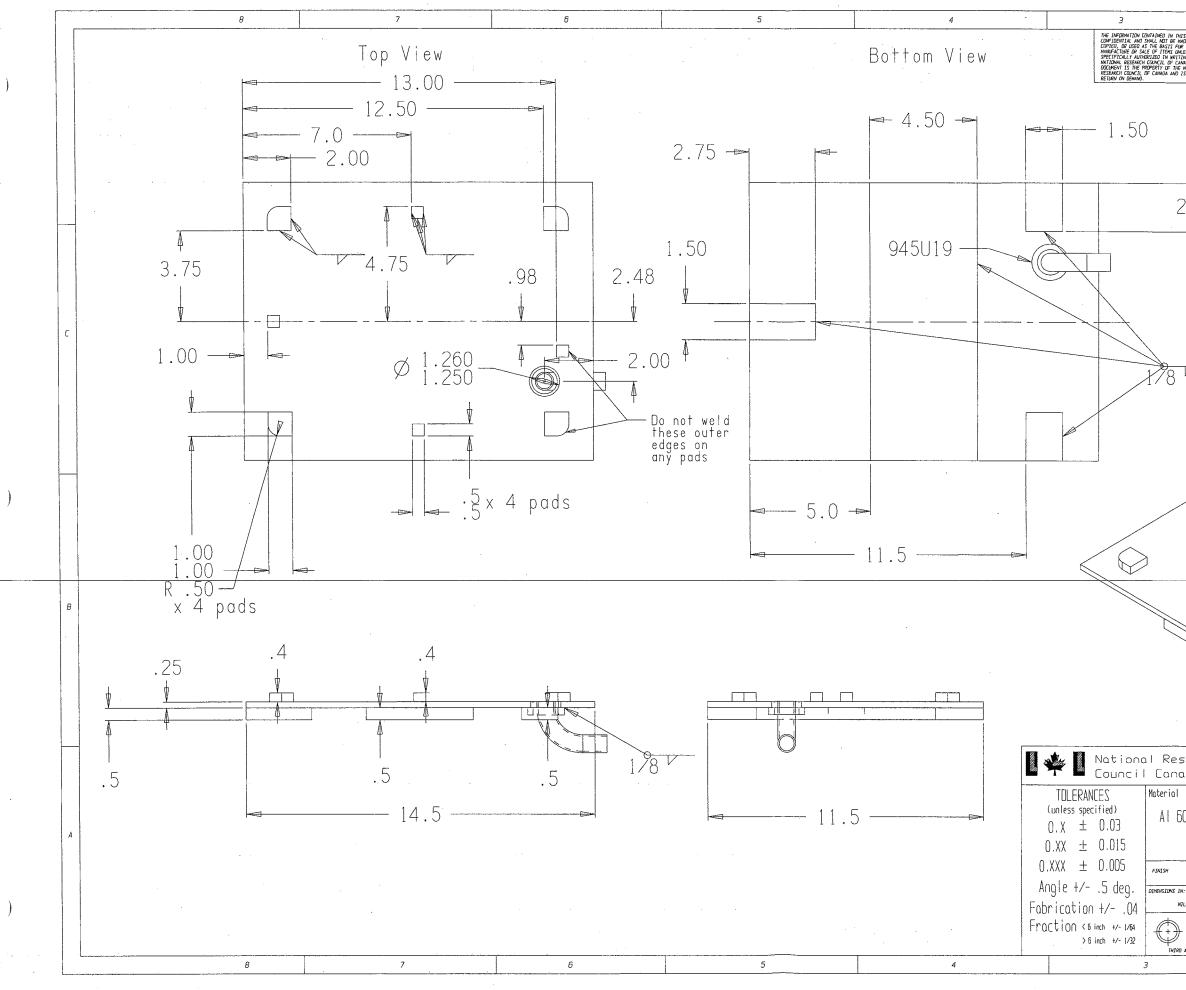
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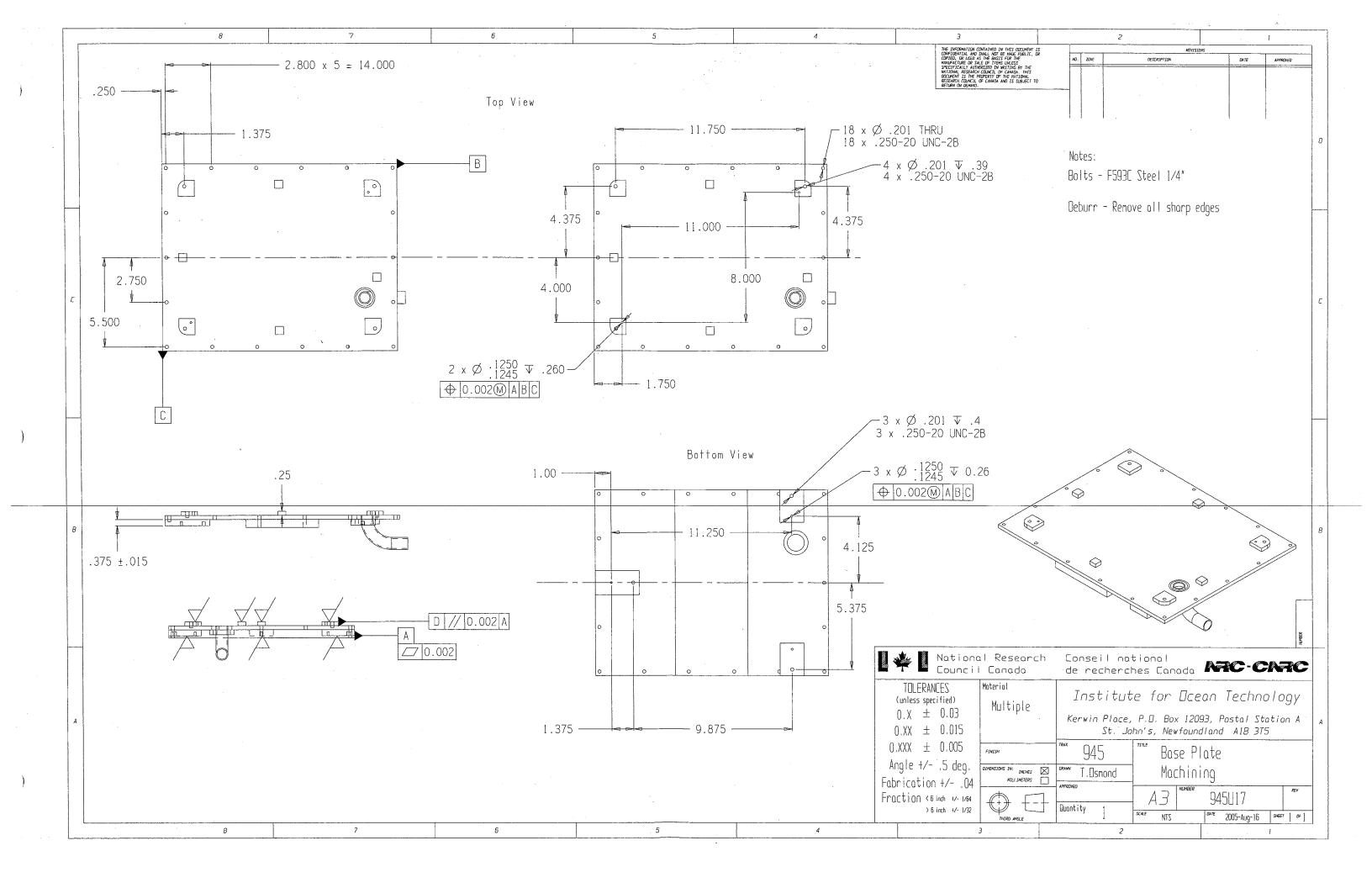


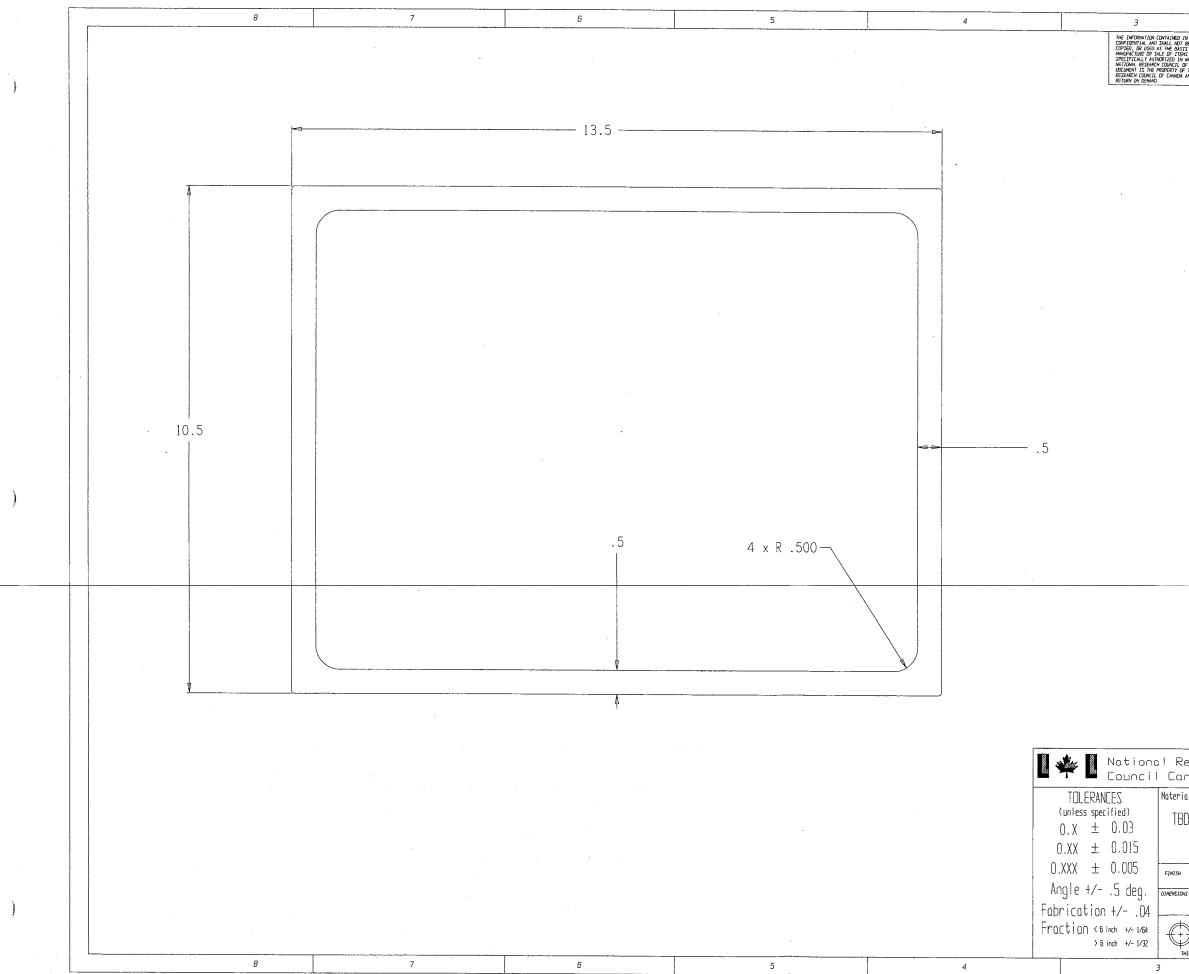
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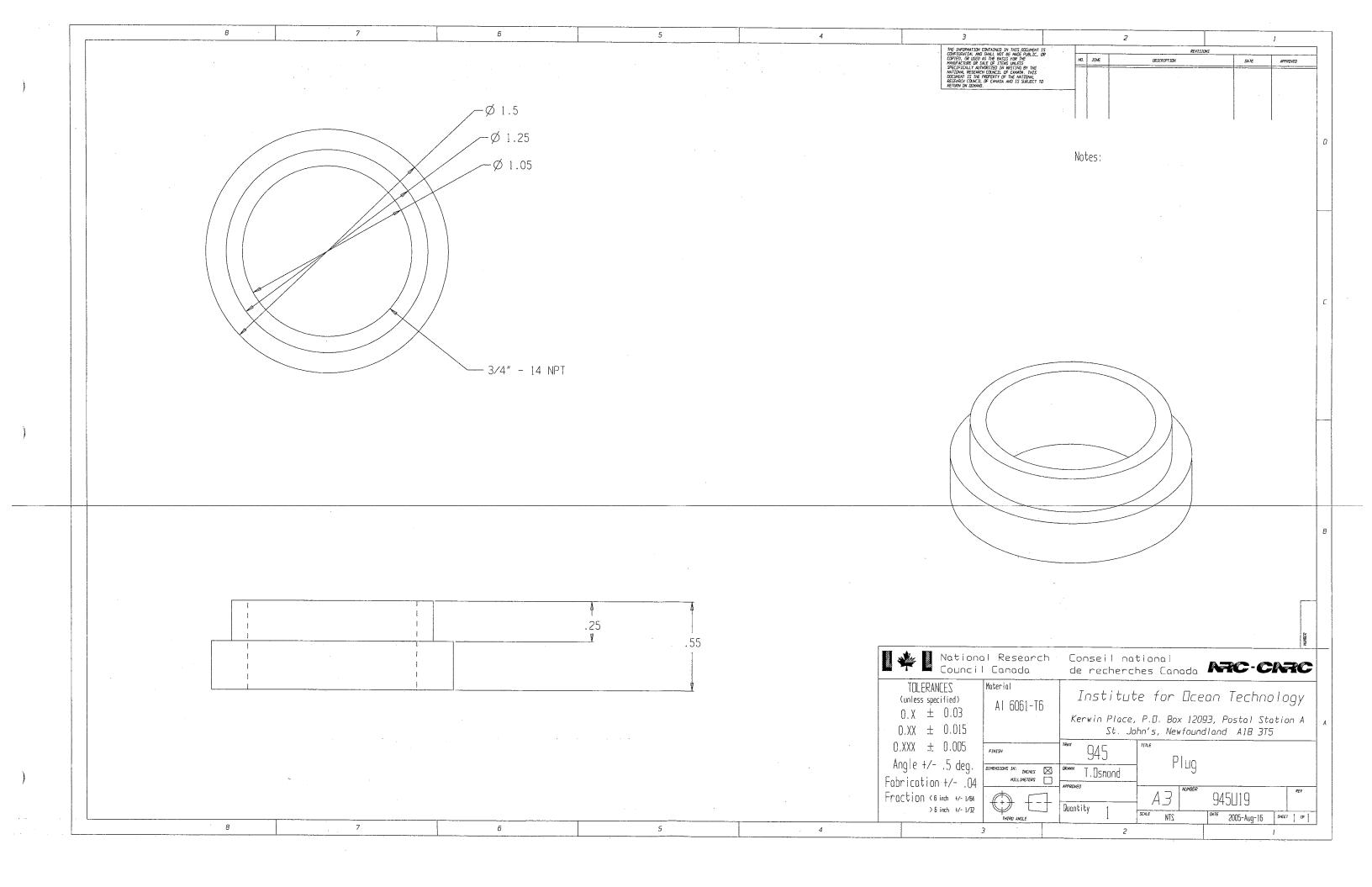


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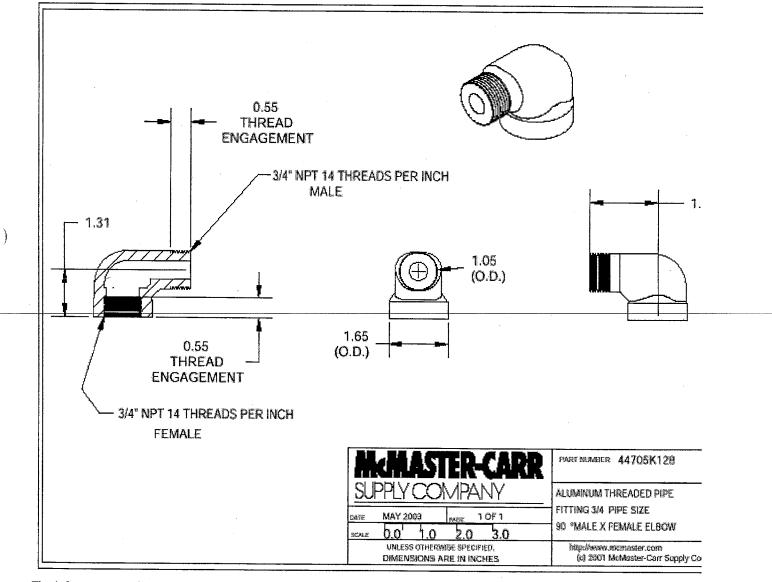
July 27th, 2005 Page 1 of 1

<u>Pipe Fittings</u> > <u>Shape</u> > <u>Elbow Type Pipe to Pipe</u> > <u>Pipe Size</u>

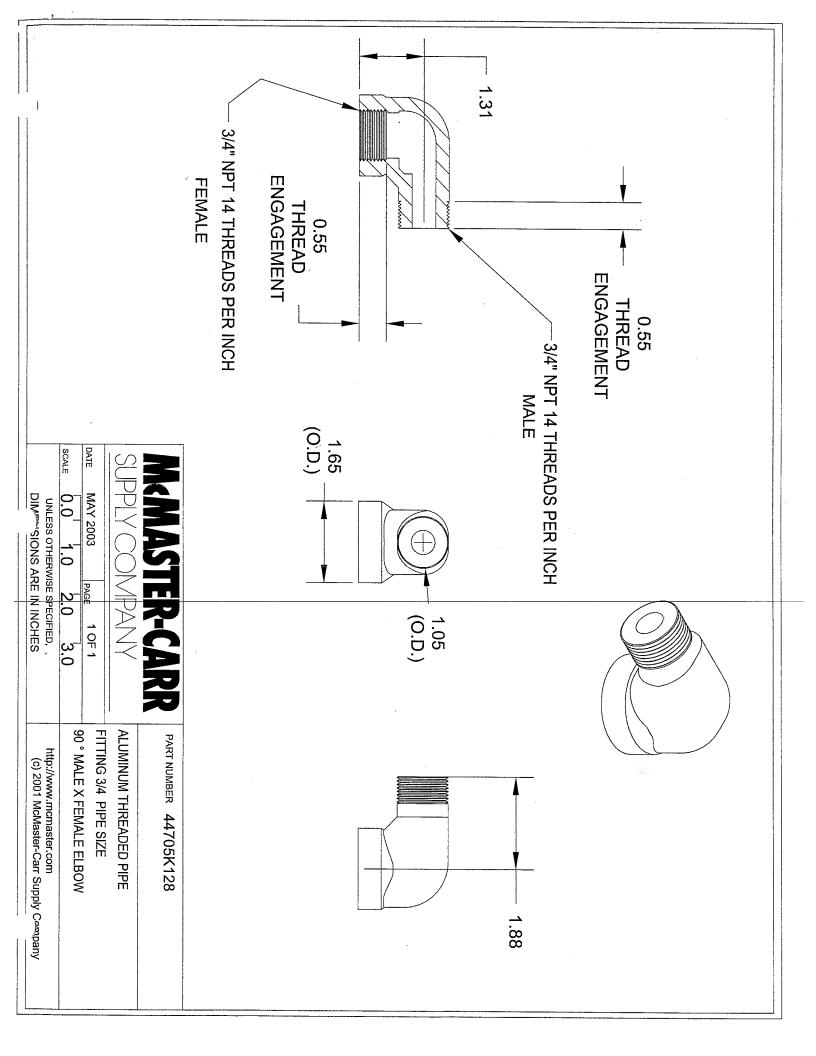
Aluminum Pipe Fittings and Pipe

This item matches all of your specifications.

	Part Number <u>44705K128</u>	\$8
「「」	Shape	Elbow
	Elbow Type Pipe to Pipe	Male x Female 90° Elbow
N Y M	Pipe Size	3/4"
	Pipe to Pipe Connection	NPT × NPT
V	Maximum Pressure (psi)	150
	Specifications Met	ANSI B1.20.1



The information in this technical drawing is provided for reference only. Details





Designation: F 593 – 02^{€2}

Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs¹

This standard is issued under the fixed designation F 593; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

€¹	Note—Table 2 was editorially corrected in February 2004.
€ ²	Note-Section 4.2 was editorially corrected in October 2004.

1. Scope

1.1 This specification covers the requirements for stainless steel bolts, hex cap screws, and studs 0.25 to 1.50 in., inclusive, in nominal diameter in a number of alloys in common use and intended for service applications requiring general corrosion resistance.

1.2 Seven groups of stainless steel alloys are covered, including twelve austenitic, two ferritic, four martensitic, and one precipitation hardening.

Group 1	Alloys ^A 304, 305, 384, 304 L, 18-9LW, 302HQ ^D	Condition [®] (CW) cold worked ^C
2	316, 316 L	(CW) cold worked ^C
3	321, 347	(CW) cold worked ^C
4	430 [∉]	(CW) cold worked ^C
5	410 ^{<i>F</i>}	(H) hardened and tempered
6	431	(H) hardened and tempered
7	630	(AH) age hardened

^A Unless otherwise specified on the inquiry and order, the choice of an alloy from within a group shall be at the discretion of the fastener manufacturer (see 6.1). ^B See 4.2 for options.

^c Sizes 0.75 in. and larger may be hot worked and solution annealed.

 D When approved by the purchaser, Alloys 303, 303Se, or XM1 may be furnished.

^E When approved by the purchaser, Alloy 430F may be furnished.

^F When approved by the purchaser, Alloys 416 or 416Se may be furnished.

1.3 Supplementary requirements of an optional nature are provided, applicable only when agreed upon between the manufacturer and the purchaser at the time of the inquiry and order.

1.4 Suitable nuts for use with bolts, hex cap screws, and studs included in this specification are covered by Specification F 594. Unless otherwise specified, all nuts used on these fasteners shall conform to the requirements of Specification F 594, shall be of the same alloy group, and shall have a specified minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener.

2. Referenced Documents

2.1 ASTM Standards: ²

- A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
- A 276 Specification for Stainless Steel Bars and Shapes
- A 342/A 342M Test Methods for Permeability of Feebly Magnetic Materials
- A 380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
- A 484/A 484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings
- A 493 Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging
- A 555/A 555M Specification for General Requirements for Stainless Steel Wire and Wire Rods
- A 564/A 564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
- A 582/A 582M Specification for Free-Machining Stainless Steel Bars
- A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- A 967 Specification for Chemical Passivation Treatments for Stainless Steel Parts
- D 3951 Practice for Commercial Packaging
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- F 594 Specification for Stainless Steel Nuts
- F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets
- F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
- 2.2 ASME Standards;³
- B1.1 Unified Inch Screw Threads

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¹ This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.04 on Nonferrous Fasteners.

Current edition approved April 10, 2002. Published May 2002. Originally published as F 593 - 78. Last previous edition F 593 - 01.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112.

B18.2.1 Square and Hex Bolts and Screws, Including Hex Cap Screws

3. Ordering Information

3.1 Orders for bolts, hex cap screws, and studs under this specification shall include the following:

3.1.1 Quantity (number of pieces of each item and size),

3.1.2 Name of item (bolt, hex cap screw, stud, etc.),

3.1.3 Size (nominal diameter, threads per inch, length; see Section 9),

3.1.4 Alloy group number (see 6.1), and

3.1.5 Condition (see 4.2).

3.2 Orders for bolts, hex cap screws, and studs under this specification may include the following optional requirements:

3.2.1 Forming (see 4.1.2),

3.2.2 Rolled or cut threads (see 4.1.3),

3.2.3 Composition (see 6.2),

3.2.4 Corrosion Resistance (see 8.1),

3.2.5 Finish (see 10.3),

3.2.6 Rejection (see 16.1), and

3.2.7 Test report (see 17.2).

3.2.8 Supplementary requirements, if any, to be specified on the order (see S1 through S8), and

3.2.9 ASTM specification and year of issue. When year of issue is not specified, fasteners shall be furnished to the latest issue.

NOTE 1—*Example* 10 000 pieces, Hex Cap Screw, 0.250 in. -20×3.00 in., Alloy Group 1, Condition CW, Furnish Test Report, Supplementary Requirement S3.

4. Manufacture

4.1 Manufacture:

4.1.1 Specifications A 276, A 493, A 564/A 564M, and A 582/A 582M are noted for information only as suitable sources of material for the manufacture of bolts, hex cap screws, and studs to this specification.

4.1.2 *Forming*—Unless otherwise specified, the fasteners shall be cold formed, hot formed, or machined from suitable material at the option of the manufacturer.

4.1.3 *Threads*—Unless otherwise specified, the threads shall be rolled or cut at the option of the manufacturer.

4.2 Condition—The fasteners shall be furnished in the following conditions, unless specified to be furnished in one of the optional conditions:

	Condition Furnished Unless	Optional Conditions (must
Alloy Group	Otherwise Specified	be specified)
1, 2, 3	CW	AF, A, SH
4	CW	A
5	н	нт
6	н	нт
/	AH	none

A— Machined from annealed or solution-annealed stock thus retaining the properties of the original material; or hot-formed and solution annealed.
AF— Headed and rolled from annealed stock and then reannealed.

AH— Solution-annealed and age-hardened after forming.

CW-- Headed and rolled from annealed stock thus acquiring a degree of cold

work. Sizes 0.75 in. and larger may be hot-worked and solutionannealed.

H- Hardened and tempered at 1050°F (565°C) minimum.

HT-- Hardened and tempered at 525°F (274°C) minimum.

SH— Machined from strain-hardened stock or cold-worked to develop the specific properties.

5. Heat Treatment

5.1 Alloy Groups 1, 2, and 3 (Austenitic Alloys 303, 303Se, 304, 304 L, 305, 316, 316 L, 321, 347, 384, XM1, 18-9LW, and 302HQ):

5.1.1 Condition A—When Condition A is specified, the austenitic alloys shall be heated to $1900 \pm 50^{\circ}$ F (1038 $\pm 28^{\circ}$ C), at which time the chromium carbide will go into the solution, be held for a sufficient time, and then be cooled at a rate sufficient to prevent precipitation of the carbide and to provide the specified properties.

5.1.2 Condition CW—When Condition CW is specified, the austenitic alloys shall be annealed in accordance with 5.1.1, generally by the raw material manufacturer and then cold worked to develop the specified properties.

5.1.3 Condition AF—When Condition AF is specified, the austenitic alloys shall be annealed in accordance with 5.1.1 after all cold working (including heading and threading) has been completed.

5.2 Alloy Group 4 (Ferritic Alloys 430 and 430F):

5.2.1 Condition A—The ferritic alloys shall be heated to a temperature of $1450 \pm 50^{\circ}$ F (788 $\pm 28^{\circ}$ C), held for an appropriate time, and then air cooled to provide the specified properties.

5.2.2 Condition CW—When Condition CW is specified, the ferritic alloys shall be annealed in accordance with 5.2.1, generally by the raw material manufacturer and then cold worked to develop the specified properties.

5.2.3 Condition AF—When Condition AF is specified, the ferritic alloys shall be annealed in accordance with 5.2.1 after all cold working (including heading and threading) has been completed.

5.3 Alloy Group 5 (Martensitic Alloys 410, 416, and 416Se):

5.3.1 Condition H—When Condition II is specified, the Martensitic Alloys 410, 416, and 416Se shall be hardened and tempered by heating to $1850 \pm 50^{\circ}$ F (1010 $\pm 28^{\circ}$ C) sufficient for austenitization, held for at least $\frac{1}{2}$ h and rapid air- or oil-quenched, and then reheating to 1050° F (565°C) minimum for at least 1 h and air cooled to provide the specified properties.

5.3.2 Condition HT—When Condition HT is specified, the Martensitic Alloys 410, 416, and 416Se shall be hardened and tempered by heating to $1850 \pm 50^{\circ}$ F ($1010 \pm 28^{\circ}$ C) sufficient for austenitization, held for at least $\frac{1}{2}$ h and rapid air- or oil-quenched, and then reheating to 525° F (274° C) minimum for at least 1 h and air cooled to provide the specified properties.

5.4 Alloy Group 6 (Martensitic Alloy 431):

5.4.1 *Conditions H and HT*—Martensitic Alloy 431 shall be hardened and tempered in accordance with 5.3.1 and 5.3.2 as applicable.

5.5 Alloy Group 7 (Precipitation Hardening Alloy 630):

5.5.1 Condition AH—Precipitation Hardening Alloy 630 shall be solution annealed and aged by heating to $1900 \pm 25^{\circ}$ F (1038 $\pm 14^{\circ}$ C) for at least ½ h and rapid air- or oil-quenched to 80°F (27°C) maximum, then reheating to a temperature of $1150 \pm 15^{\circ}$ F (621 $\pm 8^{\circ}$ C) for 4 h and air cooled to provide the specified properties.

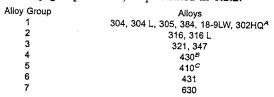
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6. Chemical Composition

6.1 *Alloy Groups*—It is the intent of this specification that fasteners shall be ordered by alloy group numbers, which include alloys considered to be chemically equivalent for general purpose use. The alloy groupings are shown as follows. The purchaser has the option of ordering a specific alloy, in stead of an alloy group number, as permitted in 6.2.2.



⁴ When approved by the purchaser, Alloys 303, 303Se, or XM1 may be furnished.

^B When approved by the purchaser, Alloy 430F may be furnished.

^c When approved by the purchaser, Alloys 416 or 416Se may be furnished. 6.2 *Chemical Composition Limits*:

6.2.1 Ordering by Alloy Group—Unless otherwise specified on the inquiry and order (see Supplementary Requirement S4), the choice of an alloy from within a group shall be at the discretion of the fastener manufacturer as required by his method of fastener fabrication and material availability. The specific alloy used by the fastener manufacturer shall be clearly identified on any certification required by the order and shall have a chemical composition conforming to the requirements of Table 1 for the specific alloy.

6.2.2 Ordering by Specific Alloy—When ordered by a specific alloy number, the fasteners shall conform to the chemical composition limits of Table 1 for the specific alloy.

6.3 Product Analysis:

6.3.1 When performed, product analysis to determine chemical composition shall be performed on at least one fully manufactured finished fastener representing each lot. The chemical composition thus determined shall conform to the requirements of Table 1 for the specified alloy or alloy group as appropriate, subject to the Product Analysis Tolerance in Specifications A 484/A 484M and A 555/A 555M.

6.3.2 In the event of discrepancy, a referee chemical analysis of samples from each lot shall be made in accordance with 14.1.

7. Mechanical Properties

7.1 The finished fasteners shall meet the applicable mechanical property and test requirements of Table 2 and Table 3 as appropriate for the specified alloy group and condition and shall be tested for conformance to the mechanical property requirements as specified herein.

7.2 Fasteners having a nominal thread diameter-length combination as follows:

Thread Diameter, in.	Thread Length, in.
0.75 or less	2.25 D or longer
Over 0.75	3 D or longer

and a breaking load of 120 000 lbf (535 kN) or less shall be tested full size and shall meet the full-size tensile (minimum and maximum) and yield strength requirements in Table 2 for the specified alloy.

7.3 Fasteners having a nominal thread diameter-length combination in accordance with 7.2 and a breaking load exceeding 120 000 lbf (535 kN) shall be tested full-size and shall meet the full size tensile (minimum and maximum) and yield strength properties in Table 2. When equipment of sufficient capacity for such tests is not available, or if excessive length of the fasteners makes full-size testing impractical, use of standard or

TABLE 1 Chemical Requirements

Alloy	UNS Designa-	Alloy	•				Comp	osition, % max	kimum except as	shown		
	tion		Carbon	Manga- nese	Phos- phorus	Sulfur	Silicon	Chromium	Nickel	Copper	Molybdenum	Others
·							Auste	nitic Alloys				
1	S30300	303	0.15	2.00	0.20	0.15 min	1.00	17.0 to 19.0	8.0 to 10.0		0.60 max ⁴	
1	S30323	303 Se		2.00	0.20	0.060	1.00	17.0 to 19.0	8.0 to 10.0			Se 0.15 min
	S30400	304	0.08	2.00	0.045	0.030	1.00	18.0 to 20.0	8.0 to 10.5	1.00	•••	
	S30403	304 L	0.03	2.00	0.045	0.030	1.00	18.0 to 20.0	8.0 to 12.0	1.00	•••	
	S30500	305	0.12	2.00	0.045	0.030	1.00	17.0 to 19.0	10.5 to 13.0	1.00	•••	•••
	S38400	384	0.08	2.00	0.045	0.030	1.00	15.0 to 17.0	17.0 to 19.0		0.50A	• • •
	S20300	XM1	0.08	5.0 to 6.5	0.040	0.18 to 0.35	1.00	16.0 to 18.0	5.0 to 6.5	1.75 to 2.25	0.50 max ^A	•••
	S30430	18–9LW	0.10	2.00	0.045	0.030	1.00	17.0 to 19.0	8.0 to 10.0	3.0 to 4.0	• • •	
	S30433	302HQ	0.03	2.00	0.045	0.030	1.00	17.0 to 19.0	8.0 to 10.0	3.0 to 4.0		• • •
	S31600	316	0.08	2.00	0.045	0.030	1.00	16.0 to 18.0	10.0 to 14.0			•••
	S31603	316 L	0.03	2.00	0.045	0.030	1.00	16.0 to 18.0	10.0 to 14.0	•••	2.00 to 3.00	•••
	S32100	321	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	9.0 to 12.0	•••	2.00 to 3.00	•••
	S34700	347	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	9.0 to 12.0	•••	• • •	Ti 5×Cmin Cb+Ta 10×Cmir
						· ·	Ferri	ic Alloys		•••	•••	
	S43000	430	0.12	1.00	0.040	0.030		······				· ·····
	S43020	430F	0.12	1.25	0.060	0.030 0.15 min	1.00 1.00	16.0 to 18.0 16.0 to 18.0	• • • •	•••	0.60 max ^A	、 ···
							Marten	sitic Alloys	·			
	S41000	410	0.15	1.00	0.040	0.030	1.00	11.5 to 13.5			· · · · · · · · · · · · · · · · · · ·	
	S41600	416	0.15	1.25	0.060	0.15 min	1.00	12.0 to 14.0	• • •	• • •		
	S41623	416Se	0.15	1.25	0.060	0.060	1.00	12.0 to 14.0			0.60 max ^A	
	S43100	431	0.20	1.00	0.040	0.030	1.00	15.0 to 17.0	1.25 to 2.50			Se 0.15 min
								Hardening Allo				
	S17400	630	0.07	1.00	0.040	0.030		15.0 to 17.5	3.0 to 5.0	3.0 to 5.0	····	Cb+Ta 0.15-0.45

At manufacturer's option, determined only when intentionally added

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TABLE 2 Mechanical Property Reguir	irements ^A
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			TADLE 2 Meet	nanical Property						
Stain-		Alloy Mechanical	Nominal		Full-Size Te	SIS	Machined Specimen Tests			
less Al- loy Group	Condition ^B	Property Marking	Diameter, in.	Ten <u>sile</u> Strength ksi ^C	Yield Strength, ksi ^{D,C}	Rockwell Hardness	Tensile Strength ksi ^C	Yield Strength, ksi ^{D,C}	Elon- gation in 4 <i>D</i> , %	
				Austenitic Alloys			· · · · · · ·	· · · · ·		
	AF	F593A	1/4 to 11/2, incl	65 to 85	20	B85 max	60	20	40	
1 .		F593B	1/4 to 11/2, incl	75 to 100	30	B65 to 95	- 70	30	30	
(303, 304,	CW1	_ F593C	1⁄4 to 5∕8 , incl	100 to 150	65	B95 to C32	95	60	20,	
304 L, 305,	CW2	F593D	3/4 to 11/2, incl	85 to 140	45	B80 to C32	80	40	25	
384,	SH1	<u>F593A</u>	1/4 to 5/8, incl	120 to 160	95	C24 to C36	115	90	12	
XM1, 18-9LW,	SH2	F593B	3/4 to 1, incl	110 to 150	75	C20 to C32	105	70	15	
302HQ, 303Se) -	SH3	<u>F593C</u>	11/8 to 11/4 , incl	100 to 140	60	B95 to C30	95	55	20	
,	SH4	F593D	1¾ to 1½ , incl	95 to 130	45	B90 to C28	90	40	28	
	AF	F593E	1/4 to 11/2, incl	65 to 85	20	B85 max	60	20	40	
	A	F593F	1/4 to 11/2, incl	75 to 100	30	B65 to 95	70	30	30	
	CW1	F593G	. ¼ to 5⁄8, incl	100 to 150	65	B95 to C32	95	60	20	
2 .	CW2	F593H	3/4 to 11/2, incl	85 to 140	45	B80 to C32	- 80	40	25	
(316,	SH1	<u>F593E</u>	1/4 to 5/8, incl	120 to 160	95	C24 to C36	115	90	12	
316L) -	J SH2	F593F	3/4 to 1, incl	110 to 150	75	C20 to C32	105	70	15	
	SH3	<u>F593G</u>	11/a to 11/4, incl	100 to 140	60	B95 to C30	95	55	20	
	SH4	<u>F593H</u>	13/8 to 11/2 , incl	95 to 130	45	B90 to C28	90	40	28	
	AF	F593J	1/4 to 11/2, incl	65 to 85	20	B85 max	60	20	40	
	A	F593K	1⁄4 to 11⁄2 , incl	75 to 100	30	B65 to 95	70	30	30	
3	CW1	F593L	1⁄4 to 5∕8, incl	100 to 150	65	B95 to C32	95	60	20	
(321, 347)	CW2	F593M	3/4 to 11/2, incl	85 to 140	45	B80 to C32	80	40	25	
	SH1	<u>F593J</u>	¼ to % , incl	120 to 160	95	C24 to C36	115	90	12	
	SH2	F593K	34 to 1, incl	110 to 150	75	C20 to C32	105	70	15	
	SH3	F593L	11/8 to 11/4, incl	100 to 140	60	B95 to C30	95	55	20	
	SH4	<u>F593M</u>	13% to 11/2, incl	95 to 130	45	B90 to C28	90	40	28	
				Ferritic Alloys						
4	AF	F593X	1/4 to 11/2, incl	55 to 75	30	B85 max	50	25		
430, 430F)	A	F593N	1/4 to 11/2, incl	55 to 75	30	B85 max	50	25		
	CW1	F593V	1/4 to 5/8, incl	60 to 105	40	B75 to 98	55	35	· · · · · · · · · · · · · · · · · · ·	
·	CW2	F593W	3/4 to 11/2, incl	55 to 100	30	B65 to 95	50	25	•••	
				Martensitic Alloys						
	H	F593P	1/4 to 11/2 , incl	110 to 140	90	C20 to 30	110	90	18	
(410, 416, 416Se)	HT	F593R	1/4 to 11/2, incl	160 to 190	120	C34 to 45	160	120	12	
6	H	F593S	1/4 to 11/2, incl	125 to 150	100	C25 to 32	125	100	15	
(431)	HT	F593T	1/4 to 11/2 , incl	180 to 220	140	C40 to 48	180	140	10	
7	AL2	F 50211		pitation Hardening A						
(630)	AH	F593U	1/4 to 11/2, incl	135 to 170	105	C28 to 38	135	105	16	

^A Minimum values except where shown as maximum or as a range.

^B Legend of conditions:

A---Machined from annealed or solution-annealed stock thus retaining the properties of the original material, or hot-formed and solution-annealed.

AF-Headed and rolled from annealed stock and then reannealed.

AH-Solution annealed and age-hardened after forming.

CW-Headed and rolled from annealed stock thus acquiring a degree of cold work; sizes 0.75 in. and larger may be hot worked and solution-annealed.

H-Hardened and tempered at 1050°F (565°C) minimum.

HT-Hardened and tempered at 525°F (274°C) minimum.

SH-Machined from strain hardened stock or cold-worked to develop the specified properties.

^C The yield and tensile strength values for full-size products shall be computed by dividing the yield and maximum tensile load values by the stress area for the product size and thread series determined in accordance with Test Methods F 606 (see Table 4). ^D Yield strength is the stress at which an offset of 0.2 % gage length occurs.

round specimens that meet the "machined specimen test tensile properties" in Table 2 is permitted. In the event of discrepancy or dispute between test results obtained from full-size finished fasteners and standard or round specimens, the referee method shall be tests performed on full-size finished fasteners.

7.4 Fasteners that are too short (lengths less than that specified in 7.2 (see Test Methods F 606 and Table 4); have insufficient threads for tension; or have drilled or undersized heads, drilled or reduced bodies, and so forth, that are weaker than the thread section, shall not be subject to tension tests but

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TABLE 3 Mechanical Test Requirements for Bolts and Studs^A

Item	Nominal Length		Tensile Load, Ibf		Full-Si	Machined Specimen Tests				
	Diameters ¾ in. and Less	Diameters Over ¾ in.	-	Wedge Tensile Strength	Axial Tensile Strength	Yield Strength	Rockwell Hardness	Tensile Strength	Yield Strength	Elongation
Square and hex bolts and hex cap screws	less than 2¼ <i>D</i> 2¼ <i>D</i> and longer	less than 3D 3D and longer	all 120 000 max over 120 000	Option A mandatory Option A	Option B 8 8	в mandatory Option A	Option C B B	в в Option B	в В Option B	в Оption B
Studs and other bolts	iess than 2¼ D 2¼ D and longer	less than 3 <i>D</i> 3 <i>D</i> and longer	ali 120 000 max over 120 000	B B B	Option A mandatory Option A	в mandatory Option A	Option B B B	в в Option B	в в Option B	в в Option B
Specials ^C	ali	all	all	B	₿	в	mandatory	В	B	В

Where options are given, all the tests under an option shall be performed. Option A, Option B, and Option C indicates manufacturer may perform all Option A (full-size), all Option B (machined specimen), or all Option C tests whichever is preferred. Option A tests should be made whenever feasible. ^B Tests that are not mandatory.

^C Special fasteners are those fasteners with special configurations including drilled heads, reduced body, etc., that are weaker than the threaded section. Special fasteners having full-size heads shall be tested as specified for studs and other bolts.

TABLE 4	Tensile	Stress	Areas	and	Threads	per	Inch
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Nominal Size, in. (D)	Coarse Threads-UNC		Fine	Threads-UNF	Thread Series-8 UN		
	Threads/in.	Stress Area ⁴ , in. ²	Threads/in.	Stress Area ^A , in. ²	Threads/in.	Stress Area ^A in. ²	
1⁄4 (0.250)	20	0.0318	28	0.0364			
⁵ ⁄16 (0.3125)	18	0.0524	24	0.0580	•••	• • •	
3⁄18 (0.375)	16	0.0775	24	0.0878	•••		
7/16 (0.4375)	14	0.1063	20	0.1187	•••	• • •	
1⁄2 (0.500)	13	0.1419	20	0.1599	• • •	•••	
⁹ ⁄16 (0.56 25)	12	0.1820	18	0.2030	•	-	
⁵ ∕8 (0.625)	11	0.2260	18	0.2560	•••	•••	
34 (0.750)	10	0.3340	16	0.3730	•••		
7⁄a (0.875)	9	0.4620	14	0.5090		· • • •	
1.000	8	0.6060	12	0.6630	• • •	••••	
11⁄8 (1.125)	7	0.7630	12	0.8560	0		
1¼ (1.250)	7	0.9690	12	1.0730	8	0.790	
1¾ (1.375)	6	1.1550	12		ō	1.000	
11⁄2 (1.500)	6	1.4050	12	1.3150 1.5810	8 8	1.233 1.492	

Tensile stress areas are computed using the following formula:

$$A^{s} = 0.7854 \left[D - \frac{0.9743}{n} \right]^{2}$$

where:

As tensile stress area, in.²

D = nominal size (basic major diameter), in., and

number of threads per inch. n =

shall conform to the hardness (minimum and maximum) requirements of Table 2.

8. Corrosion Resistance

8.1 Carbide Precipitation:

8.1.1 Rod, bar, and wire in the austenitic Alloy Groups 1, 2, and 3, except the free-machining grades, 303 and 303Se, used to make fasteners in accordance with this specification shall be capable of passing the test for susceptibility to intergranular corrosion as specified in Practice E of Practices A 262.

8.1.2 As stated in Practice A 262, samples may be subjected to the faster and more severe screening test in accordance with Practice A. Failing Practice A, specimens shall be tested in accordance with Practice E and be considered satisfactory if passing Practice E.

9. Dimensions

9.1 Bolts and Hex Cap Screws:

9.1.1 Unless otherwise specified, the dimensions shall be in accordance with the requirements of ASME B18.2.1 for hex cap screws (finished hex bolts).

9.1.2 When specified, the dimensions of bolts shall be in accordance with the requirements of ASME B18.2.1 (type as specified), or such other dimensions shall be specified.

9.2 Studs-Dimensions of studs including double-end clamping and double-end interference shall be as specified by the purchaser.

9.3 Threads-Unless otherwise specified, the bolts, cap screws, and studs shall have Class 2A threads in accordance with ASME B1.1.

9.4 *Points*—Unless otherwise specified, the points shall be flat and chamfered or rounded, at the option of the manufacturer.

10. Workmanship and Finish

10.1 *Workmanship*—The fasteners shall have a workmanlike finish, free of injurious burrs, seams, laps, irregular surfaces, and other defects affecting serviceability.

10.2 Cleaning and Descaling—The fasteners shall be descaled or cleaned, or both, in accordance with Specification A 380.

10.3 *Protective Finishes*—Unless otherwise specified, the fasteners shall be furnished without an additive chemical or metallic finish.

11. Sampling

11.1 A lot, for the purposes of selecting test specimens, shall consist of not more than 100 000 pieces offered for inspection at one time having the following common characteristics:

11.1.1 One type of item (that is, bolts, hex cap screws, studs, etc.),

11.1.2 Same alloy and condition,

11.1.3 One nominal diameter and thread series,

11.1.4 One nominal length,

11.1.5 Produced from one heat of material, and

11.1.6 Heat treated under the same conditions as to time and temperature.

12. Number of Tests and Retests

12.1 Number of Tests:

12.1.1 Mechanical Tests—The mechanical requirements of this specification shall be met in continuous mass production for stock. The manufacturer shall make sample inspections as specified below to ensure that the product conforms to the specified requirements. When tests of individual shipments are required, Supplementary Requirement S1 must be specified in the inquiry and order.

Number of Pieces in Lot	Acceptance Criteria		
	Number of	Acceptance	Rejection
	Tests	Number	Number
2 to 50	2	0	1
51 to 500	3	0	1
501 to 35 000	5	õ	1
35 001 to 100 000	8	ō	1

12.1.2 Corrosion Resistance Tests:

)

12.1.2.1 Unless otherwise specified, inspection for corrosion resistance shall be in accordance with the manufacturer's standard quality control practices. No specific method of inspection is required, but the fasteners shall be produced from suitable raw material and manufactured by properly controlled practices to maintain resistance to corrosion. When corrosion tests are required, Supplementary Requirement S7 must be specified in the inquiry and order, except as noted in 12.1.2.2.

12.1.2.2 Products that have been hot worked shall be solution annealed and tested to determine freedom from precipitated carbides. Not less than one corrosion test shall be made from each lot. Corrosion tests shall be performed in accordance with Practice A 262, Practices A or E as applicable. 12.2 *Retests*: 12.2.1 When tested in accordance with the required sampling plan, a lot shall be subject to rejection if any of the test specimens fail to meet the applicable test requirements.

12.2.2 If the failure of a test specimen is due to improper preparation of the specimen or to incorrect testing technique, the specimen shall be discarded and another specimen substituted.

13. Significance of Numerical Limits

13.1 For the purposes of determining compliance with the specified limits for properties listed in this specification, an observed value or calculated value shall be rounded in accordance with Practice E 29.

14. Test Specimens

14.1 *Chemical Tests*—When required, samples for chemical analysis shall be taken by drilling, sawing, milling, turning, clipping, or other such methods capable of producing representative samples.

14.2 Mechanical Tests:

14.2.1 Specimens shall be full size or machined in accordance with 7.2 through 7.4. Machined specimens, when required, shall be machined from the fastener in accordance with Test Methods F 606.

14.2.2 The hardness shall be determined on the finished fastener in accordance with Test Methods F 606.

14.3 Corrosion Resistance—Test specimens shall be prepared in accordance with Practices A 262.

15. Test Methods

15.1 *Chemical Analysis*—The chemical composition shall be determined in accordance with Test Methods A 751.

15.1.1 The fastener manufacturer may accept the chemical analysis of each heat of raw material purchased and reported on the raw material certification furnished by the raw material producer. The fastener manufacturer is not required to do any further chemical analysis testing provided that precise heat lot traceability has been maintained throughout the manufacturing process on each lot of fasteners produced and delivered

15.2 Mechanical Tests:

15.2.1 When full-size tests are to be performed, the yield strength and wedge tensile strength or axial tensile strength, as required by Section 7, shall be determined on each sample in accordance with the appropriate methods of Test Methods F 606.

15.2.2 Full-size bolts and hex cap screws subject to tension tests shall be tested using a wedge under the head. The wedge shall be 10° for bolts 0.750-in. nominal diameter and less and 6° for bolts over 0.750-in. diameter.

15.2.3 When machined specimen tests are necessary (see Section 7), the yield strength, tensile strength, and elongation shall be determined on each sample in accordance with Test Methods F 606.

15.2.4 The hardness shall be determined in accordance with Test Methods F 606. A minimum of two readings shall be made on each sample, each of which shall conform to the specified requirements.

15.3 Corrosion Resistance-When specified on the purchase order or inquiry, corrosion tests to determine freedom from precipitated carbides shall be performed in accordance with Practice A 262, Practice A or E as applicable.

16. Rejection and Rehearing

16.1 Unless otherwise specified, any rejection based on tests specified herein and made by the purchaser shall be reported to the manufacturer within 30 working days from the receipt of the product by the purchaser.

17. Certification and Test Reports

17.1 Certificate of Compliance—Unless otherwise specified in the purchase order, the manufacturer shall furnish certification that the product was manufactured and tested in accordance with this specification and the customer's order and conforms to all specified requirements.

17.2 Test Reports—When specified on the order, the manufacturer shall furnish a test report showing the chemical analysis of the fasteners and the results of the last completed set of mechanical tests for each lot of fasteners in the shipment.

17.3 All certification shall indicate the purchase order number and the applicable requirements of Section 3.

18. Product Marking

18.1 Individual Products—All products except studs 3/8 in. in diameter and smaller shall be marked with a symbol identifying the manufacturer. In addition, they shall be marked with the alloy/mechanical property-marking in accordance with Table 2. The manufacturer may at his option add the specific stainless alloy designation from Table 1. However, marking of the stainless alloy designation does not signify compliance with this specification. The marking shall be raised or depressed at the option of the manufacturer.

19. Packaging and Package Marking

19.1 Packaging:

19.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D 3951.

19.1.2 When special packaging requirements are required by the purchaser, they shall be defined at the time of inquiry and order.

19.2 *Package Marking*—Each shipping unit shall include or be plainly marked with the following:

19.2.1 ASTM specification,

19.2.2 Alloy number,

19.2.3 Alloy/mechanical property marking,

19.2.4 Size,

19.2.5 Name and brand or trademark of manufacturer,

19.2.6 Number of pieces,

19.2.7 Country of origin,

19.2.8 Date of manufacture,

19.2.9 Purchase order number, and

19.2.10 Lot number, if applicable.

20. Keywords

20.1 bolts; general use; hex cap screws; stainless; studs

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified by the purchaser in the inquiry and order (see Section 3). Supplementary requirements shall in no way negate any requirement of the specification itself.

S1. Shipment Lot Testing

S1.1 When Supplementary Requirement S1 is specified on the order, the manufacturer shall make sample tests on the individual lots for shipment to ensure that the product conforms to the specified requirements.

S1.2 The manufacturer shall make an analysis of a randomly selected finished fastener from each lot of product to be shipped. Heat or lot control shall be maintained. The analysis of the starting material from which the fasteners have been manufactured may be reported in place of the product analysis.

S1.3 The manufacturer shall perform mechanical property tests in accordance with this specification and Guide F 1470 on the individual lots for shipment.

S1.4 The manufacturer shall furnish a test report for each lot in the shipment showing the actual results of the chemical analysis and mechanical property tests performed in accordance with Supplementary Requirement S1.

S2. Additional Tests

S2.1 When additional tests of mechanical properties are desired by the purchaser, the test(s) shall be made as agreed upon between the manufacturer and the purchaser at the time of the inquiry or order.

S3. Source Inspection

S3.1 When Supplementary Requirement S3 is specified on the inquiry and order, the product shall be subject to inspection by the purchaser at the place of manufacture prior to shipment. The manufacturer shall afford the inspector all reasonable facilities to satisfy that the product is being furnished in. accordance with this specification. All inspections and tests shall be so conducted so as not to interfere unnecessarily with the operations of the manufacturer.

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S4. Alloy Control

S4.1 When Supplementary Requirement S4 is specified on the inquiry and order, the manufacturer shall supply that alloy specified by the customer on his order with no group substitutions permitted without the written permission of the purchaser.

S5. Heat Control

S5.1 When Supplementary Requirement S5 is specified on the inquiry or order, the manufacturer shall control the product by heat analysis and identify the finished product in each shipment by the actual heat number.

S5.2 When Supplementary Requirement S5 is specified on the inquiry and order, Supplementary Requirements S1 and S4 shall be considered automatically invoked with the addition that the heat analysis shall be reported to the purchaser on the test reports.

S6. Permeability

S6.1 When Supplementary Requirement S6 is specified on the inquiry and order, the permeability of bolts, hex cap screws, and studs of Alloy Groups 1, 2, and 3 in Conditions A or AF shall not exceed 1.5 at 100 oersteds when determined in accordance with Test Methods A 342.

S7. Corrosion Resistance Tests

S7.1 When Supplementary Requirement S7 is specified on the inquiry and order, corrosion test(s) shall be performed as agreed upon between the manufacturer and the purchaser at the time of the inquiry or order.

S8. Passivation

S8.1 When Supplementary Requirement S8 is specified on the inquiry or order, the finished product shall be passivated in accordance with Practice A 380 or Specification A 967 at the option of the manufacturer.

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