The New waterflow housing: 2005 (for the Victoria sub model)

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(for the Victoria Sub Model)

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SUMMARY

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The New Waterproof Housing – 2005

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The New Waterproof Housing – 2005

Document Contents

The New Waterproof Housing – 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.

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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 x 1.5 x 0.25 HSS, 3 aluminum pads).

Other optional components include:

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

The New Waterproof Housing – 2005

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.

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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 in^2, 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 in^2 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.

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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/ft^3 = 0.03611 lbs/in^3
Safety Factor: SF = 1.2
Pressure: P = d * ρ * SF
P = 275.6 inches * 0.03611 lbs/in^3 * 1.2 = 11.94 lbs/in^2 $\approx$ 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 psi
Area: 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 P*A) / [Et^3 (L/l^3 + 2.21/L^2)]
= (0.1422 * 12 psi * 88"^{2}) /
[10.0 * 10^6 psi * 0.1875"^{3} (11"/8"^{3} + 2.21/11"^{2})]
= 0.0573 inches

Safety Factor: 1.2
Stress: σ = (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 - Al 6061-T6

Yield Stress: S_y = 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: $D = (0.0.284\ P*A) / [Et^3 (L/l^3 + 1.056\ l^2/L^2)]$

$= (0.1422 * 12\text{ psi} * 119") /$

$[10.0 * 10^6\text{ psi} * 0.25"^3 (12.5"/9.5"^3 + 1.056\ 9.5"^2/12.5"^4)]$

$= 0.0140$ inches

$D = P*k = 12\text{ psi} * 0.0011667$

$k^{-1} = 857.14$

$0.005 / 857.14 = P_1 = 4.2857$

$P_2 = 12 – 4.286 = 7.714$ psi

Load per inch: $w = 7.714\text{ psi} * 12.5" = 96.429$ lbs/in

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

$v_{max} = -5w L^4 / 384 E I$

$0.005" = (96.429\text{ lbs/in}) * 9.5^4 / [384 * 10 * 10^6 * I]$

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".

Properties of Housing

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:

$I = \Sigma I_x + Ad_y^2$

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

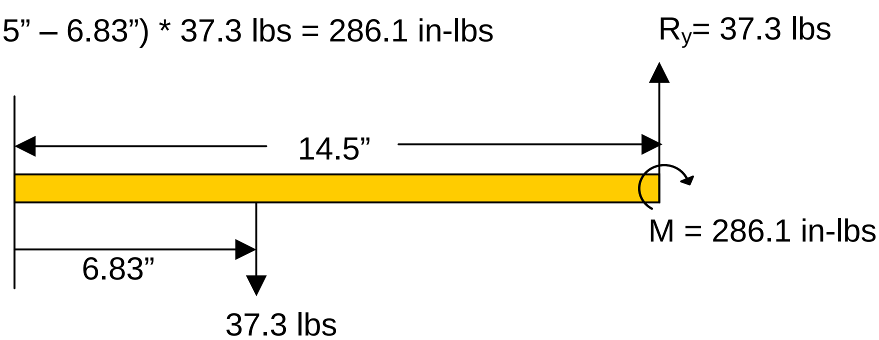
Buoyancy Forces:
F_{bouy} = Volume of water displaced * ρ_{water}

<u>Deflection of Inner Plate</u>
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: $D = (0.1422\, W) / [Et^3 (L/l^3 + 2.21/L^2)]$
$= 0.1422 * 13.3 / [10.0 * 10^6 * 0.375”^3 (12.5/9.5^3 + 2.21/12.5^2)]$
$= 1.24586 * 10^{-4}$ 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: $I = 0.4368$ in^4

Moment: M = (14.5” – 6.83”) * 37.3 lbs = 286.1 in-lbs



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

$EI * d^2v/dx^2 = -\, 286.1\langle x - 0\rangle^0 + 37.3\langle x - 0\rangle^1 - 37.3\langle x - 7.67\rangle^1$
$EI * dv/dx = -\, 286.1x + 37.3/2\, x^2 - 37.3/2\langle x - 7.67\rangle^2 + c_1$
$EI\, v = -286.1/2\, x^2 + 37.3/6\, x^3 - 37.3/6\, \langle x - 7.67\rangle^3 + c_1 x + c_2$
$v(0) = 0$ $\quad dv(0)/dx = 0$ $\quad$ Therefore $c_1 = 0$ and $c_2 = 0$
$EI\, v = -286.1/2\, x^2 + 37.3/6\, x^3 - 37.3/6\, \langle x - 7.67\rangle^3$
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

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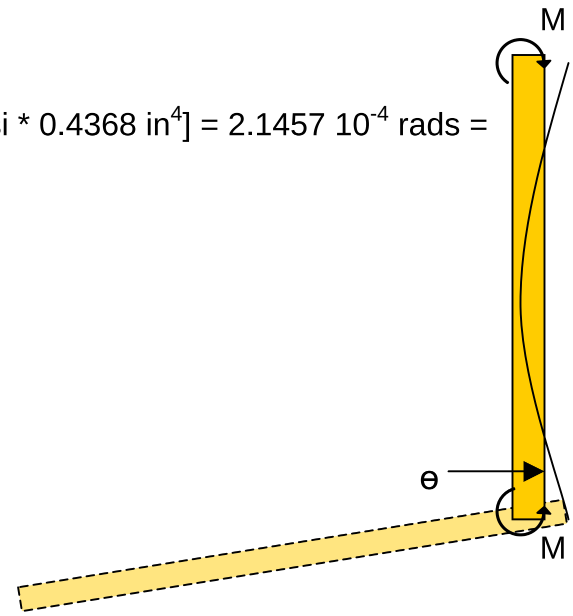

θ_{max} = ML/EI = 286.1 in-lbs * 9.5" / [29 * 10^6 psi * 0.4368 in^4] = 2.1457 10^{-4} rads = 0.0123 degrees
Deflection: 14.5 sin(0.0123) = 0.00311

D_{tot} = 0.00311 + 0.00103 = 0.00414

<u>Frequency of Frame</u>
See algor results

The New Waterproof Housing – 2005

Figures

Figure 1

Figure 3

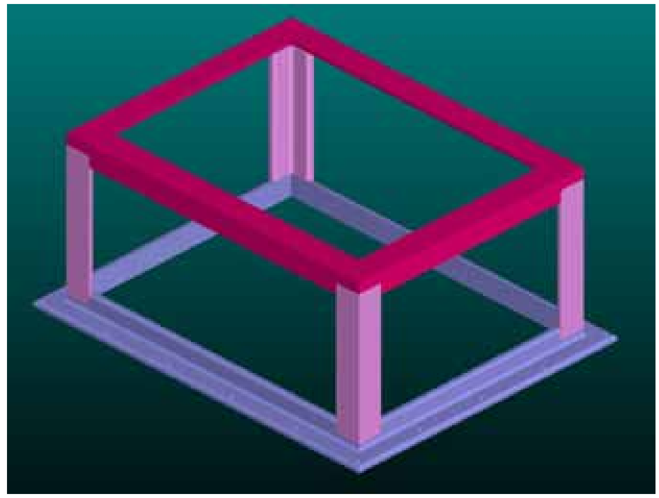

Figure 2

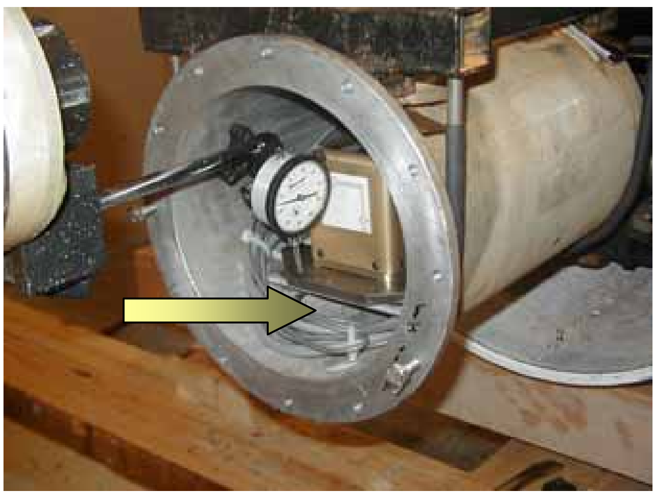

Figure 4

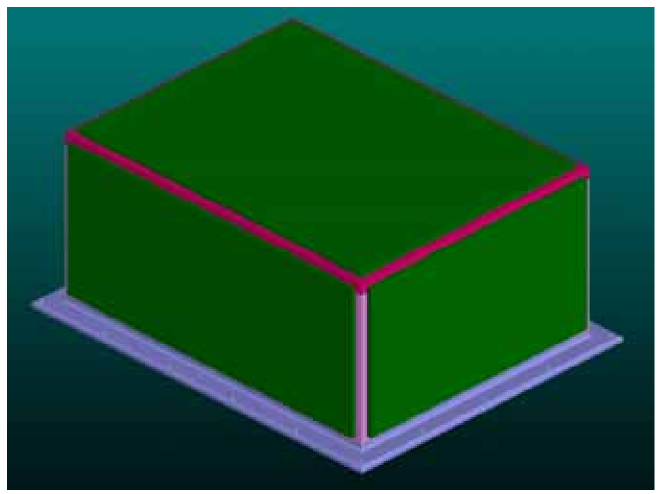

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Figure 5

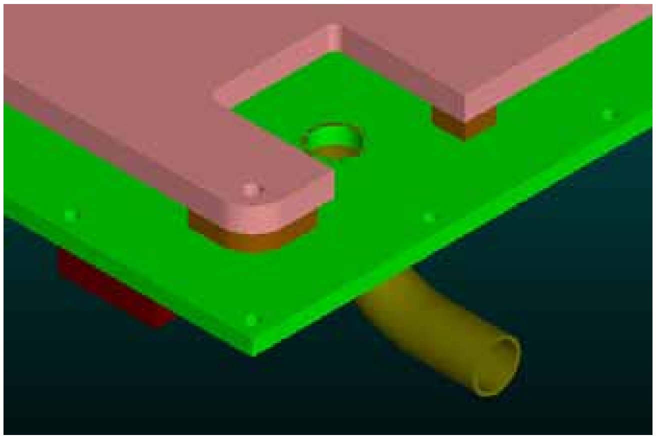


Figure 7

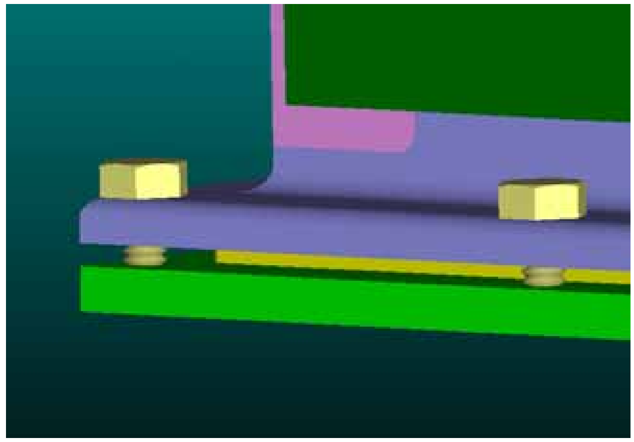


Figure 6

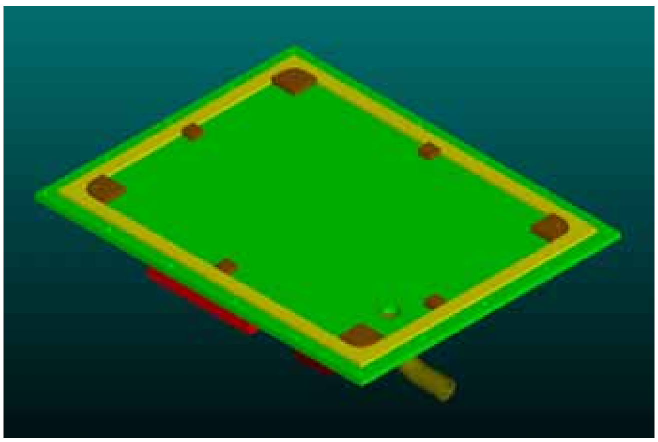
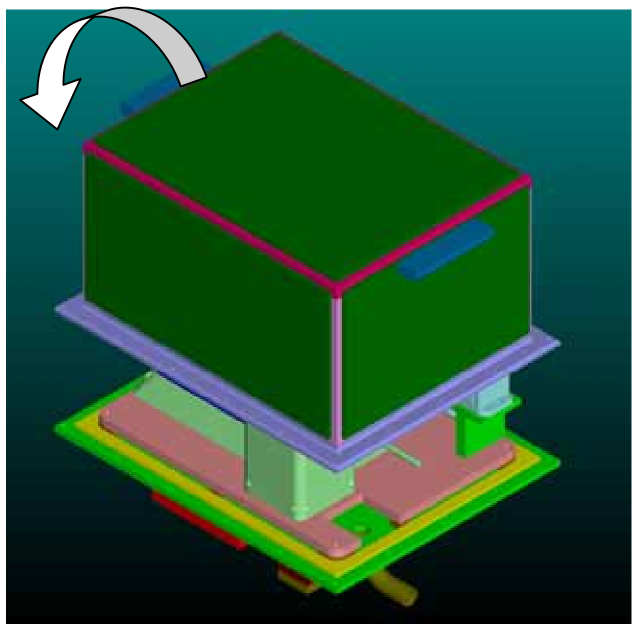


Figure 8



Appendix A

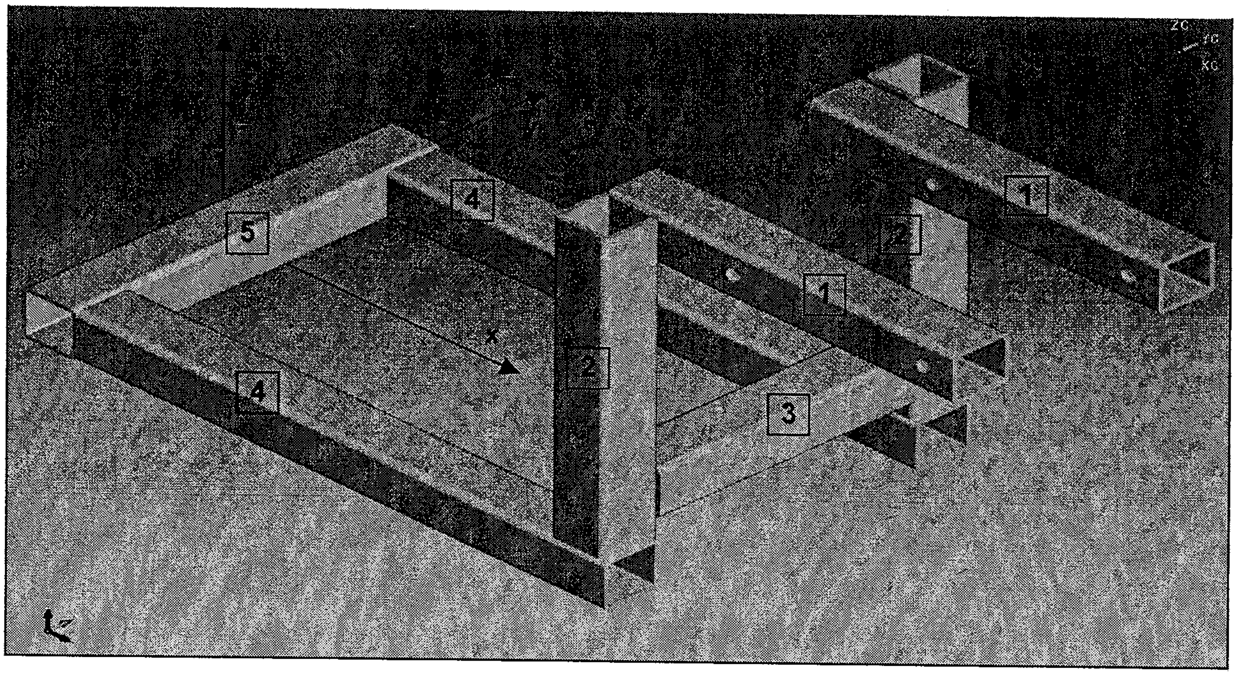
Item	Volume	Specific Weight (Lbs/cu.in)	Weight Per Inch	Length	Weight (Lbs)	Centroid X	Centroid Y	Centroid Z	W*Cx	W*Cy	W*Cz	Material	$/ft or $/ft²	$/in or $/in²	Costs
CANISTER STRUCTURE															
Rear Pads	4.5	0.098			0.441	12.25	0	1.88	5.402	0.000	0.827	0.5" x 1.5" flat bar	$6.09	0.5075	$4.06
Front Pads	1.6875	0.098			0.165	0.75	0	1.88	0.124	0.000	0.310	0.5" x 1.5" flat bar	$6.09	0.5075	$2.79
Base Plate	41.6875	0.098			4.085	7.25	0	2.38	29.619	0.000	9.703	0.25" plate	$10.59	0.0736	$12.27
Base Stiffener	25.875	0.098			2.536	7.25	0	2.00	18.384	0.000	5.072	0.5" plate	$31.85	0.2212	$11.45
Inner Plate	44.53125	0.098			4.364	7.25	0	2.81	31.639	0.000	12.274	3/8" plate	$22.31	0.1549	$18.40
Reinforced Top															
Top Bars	18.375	0.098	0.044	42	1.848	7.25	0	9.66	13.398	0.000	17.854	1" x 1" x 0.25" angle bar	$1.60	0.1333	$5.60
Bottom Bars	21	0.098	0.044	48	2.112	7.25	0	2.84	15.312	0.000	5.996	1" x 1" x 0.25" angle bar	$1.60	0.1333	$6.40
Verticle Bars	9.625	0.098	0.044	22	0.968	7.25	0	6.25	7.018	0.000	6.050	1" x 1" x 0.25" angle bar	$1.60	0.1333	$2.93
Top Side Plates	30.46875	0.098			2.986	7.25	0	6.25	21.648	0.000	18.662	3/16" thick plate	$7.88	0.0547	$4.45
Top Front and Rear Plates	23.15625	0.098			2.269	7.25	0	6.25	16.453	0.000	14.183	3/16" thick plate	$7.88	0.0547	$3.38
Top Roof Plate	22.26563	0.098			2.182	7.25	0	10.13	15.820	0.000	22.093	3/16" thick plate	$7.88	0.0547	$6.50
Hollow Sections															
SUB TOTAL					23.957				174.817	0.000	113.023				$78.22
								CoG	7.297	0.000	4.718				
EQUIPMENT															
PHINS					9.920	4.64	0.1	6.20	46.029	0.992	61.504				
Motion Pak					1.980	9.82	-2.57	4.44	19.444	-5.089	8.791				
Inclinometer (1)					0.708	9.14	2.12	3.66	6.471	1.501	2.591				
Inclinometer (2)					0.708	10.84	3.55	5.66	7.675	2.513	4.007				
SUB TOTAL					13.316				79.618	-0.082	76.894				
								CoG	5.979	-0.006	5.775				
EQUIPMENT AND CANISTER															
					37.273				254.435	-0.082	189.917				
								CoG	6.826	-0.002	5.095				
FRAME															
1			0.184166667	19	3.499	19.25	0	10.25	67.359	0.000	35.866	1.5 x 1.5 x 0.125 HSS	$1.00	0.0833	$1.58
2			0.184166667	19	3.499	15.25	0	6.25	53.362	0.000	21.870	1.5 x 1.5 x 0.125 HSS	$1.00	0.0833	$1.58
3			0.184166667	6	1.105	15.25	0	2.75	16.851	0.000	3.039	1.5 x 1.5 x 0.125 HSS	$1.00	0.0833	$0.50
4			0.184166667	29	5.341	8.75	0	0.75	46.732	0.000	4.006	1.5 x 1.5 x 0.125 HSS	$1.00	0.0833	$2.42
5			0.184166667	10	1.842	0.75	0	0.75	1.381	0.000	1.381	1.5 x 1.5 x 0.125 HSS	$1.00	0.0833	$0.83
SUB TOTAL				83.000	15.286				185.686	0.000	66.162				$6.92
								CoG	12.148	0.000	4.328				
TOTAL					52.559				440.121	-0.082	256.079				$85.14
								CoG	8.374	-0.002	4.872				$110.68

Notes:
Point 0,0,0 is taken to be the most foreward point (x direction) located on the center line of the frame at the lowest point in the z direction.

Specific Weight of Al (6061-T6)	0.098 lbs/cu.in
Specific Weight of Steel (50W CSA - G40.21)	0.284 lbs/cu.in
Volume/in of Al angle bar	0.4375 cu.in/ in length
Weight per inch of Al angle bar	0.042875 lbs/ inch
Weight per inch of Steel Box Frame	0.184167 lbs/ inch or 2.21 Lbs/ft

Boyancy Force on Canister Alone	42.230
Boyancy Force on Frame	2.061
Total Boyancy Force (Lbs)	44.290

Angle Bar (Al)	1 x 1 x 0.25
Frame (Steel)	1.5 x 1.5 x 0.125

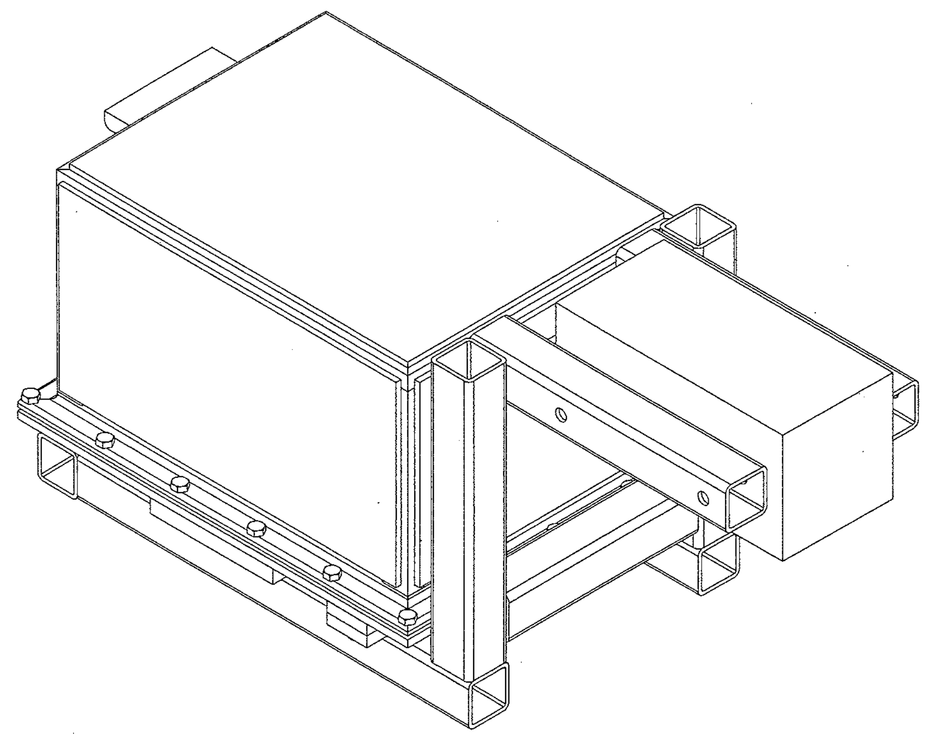


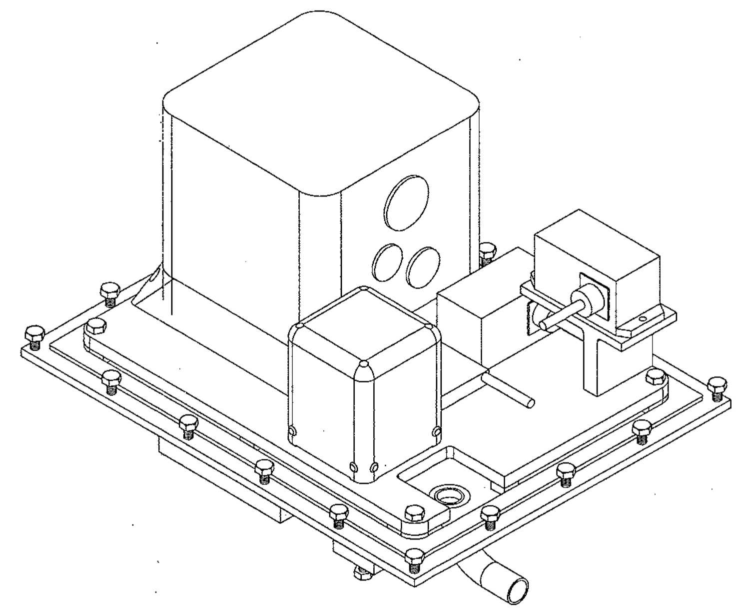
5
4
4
1
1
2
2
3
x

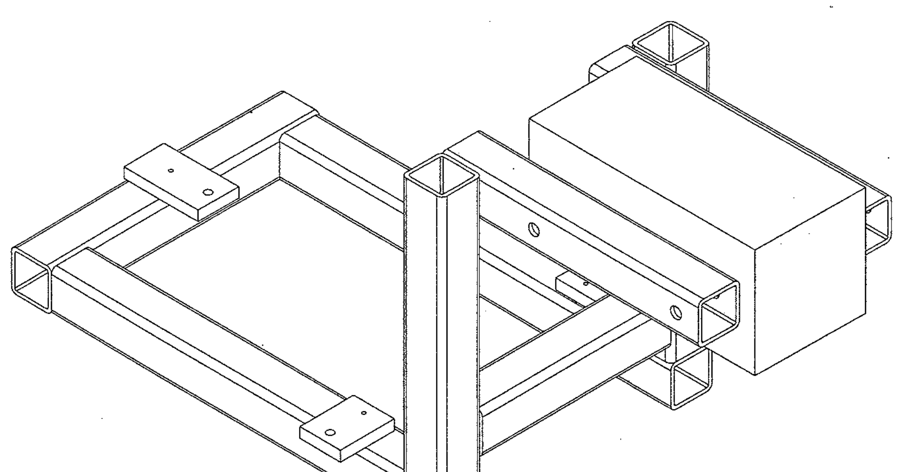
REVISIONS

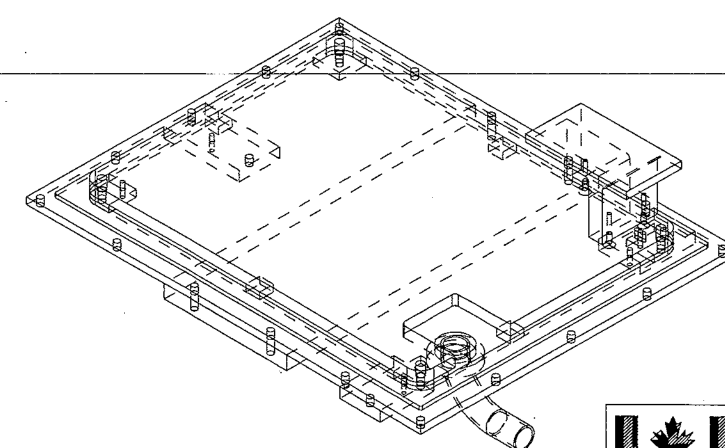
NO.	ZONE	DESCRIPTION	DATE	APPROVED

Notes:





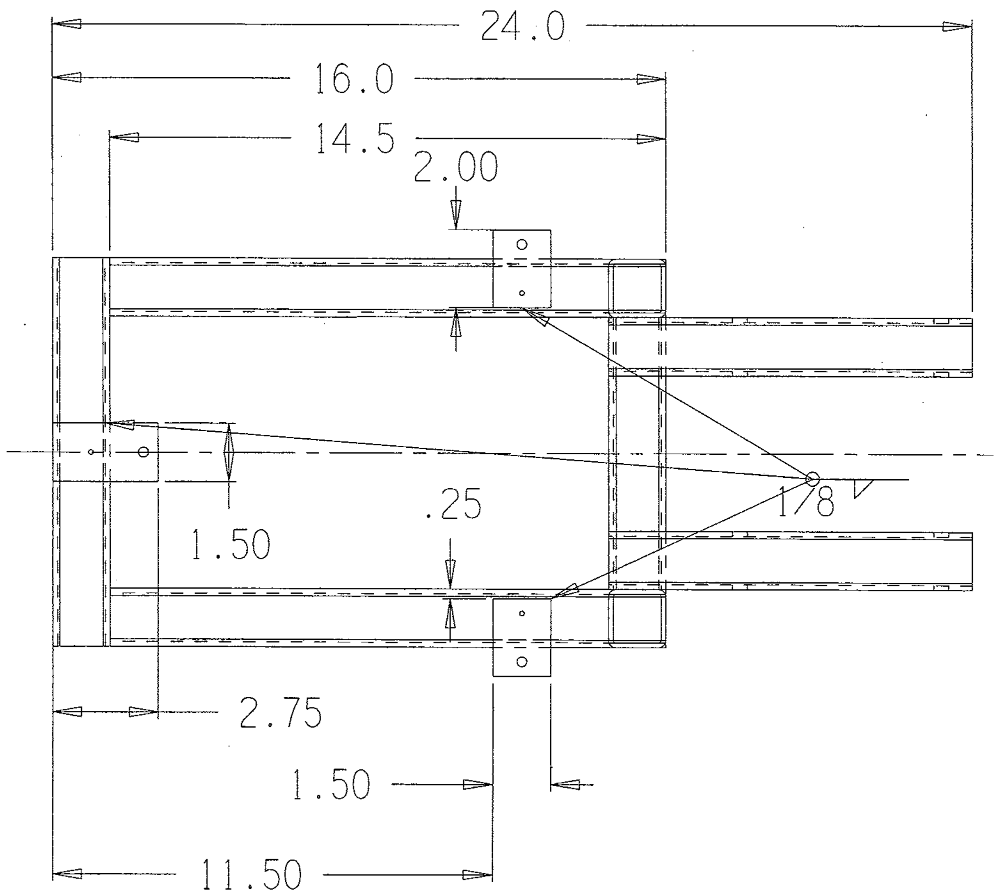


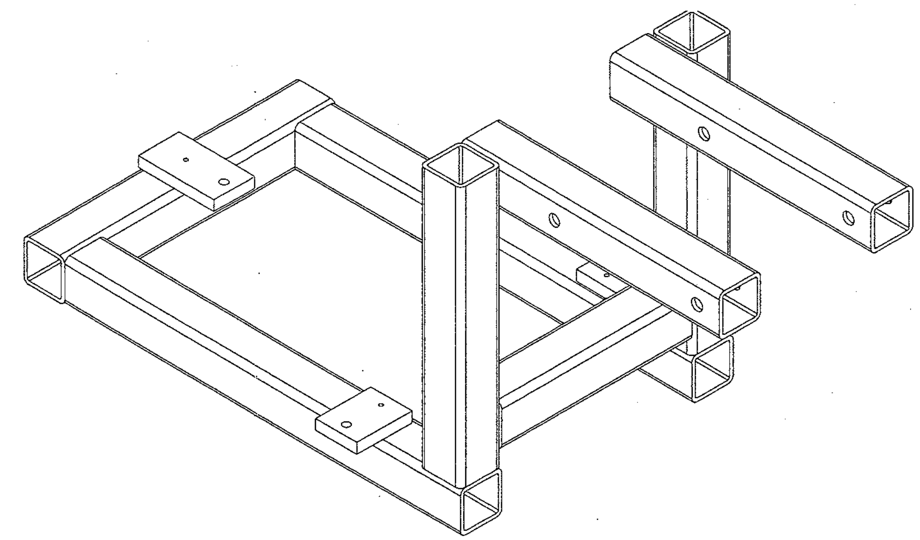


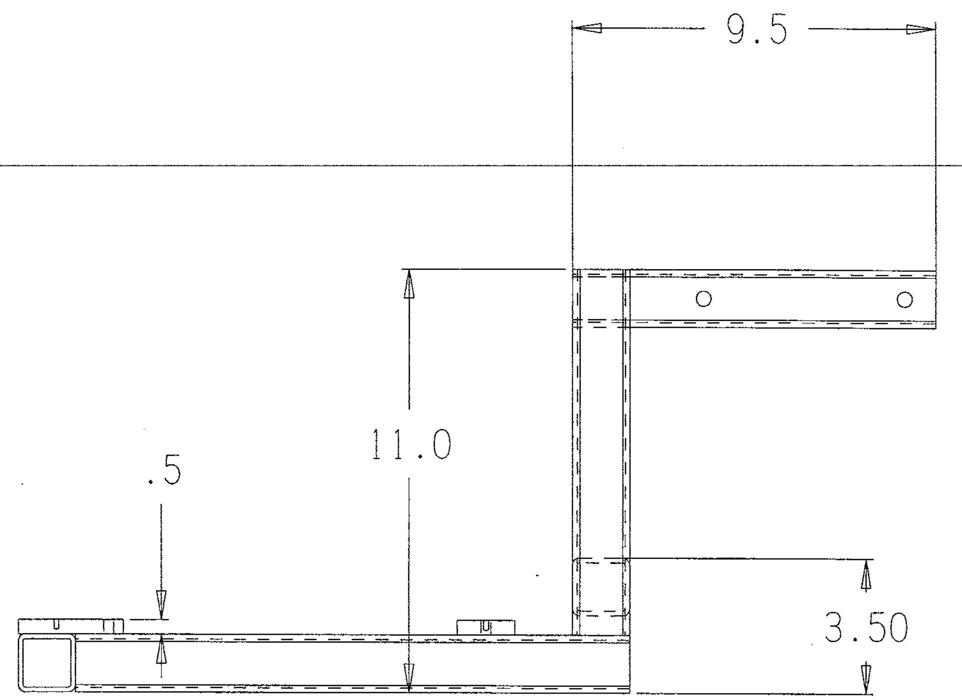
National Research Council Canada / Conseil national de recherches Canada — NRC-CNRC

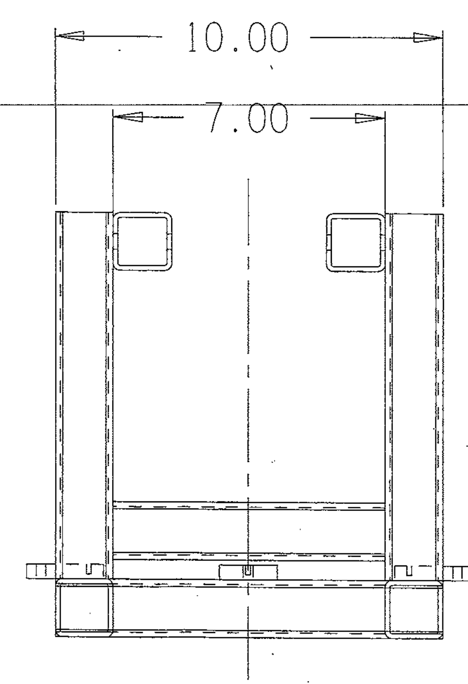
TOLERANCES (unless specified)	Material: Multiple	Institute for Ocean Technology Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5
0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	TRAX 945 DRAWN T.Osmond APPROVED Quantity 1 TITLE Waterproof Housing General Layout A3 NUMBER 945U01 REV SCALE NTS DATE 2005-Aug-16 SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED









Notes:

Deburr - Remove All Sharp Edges

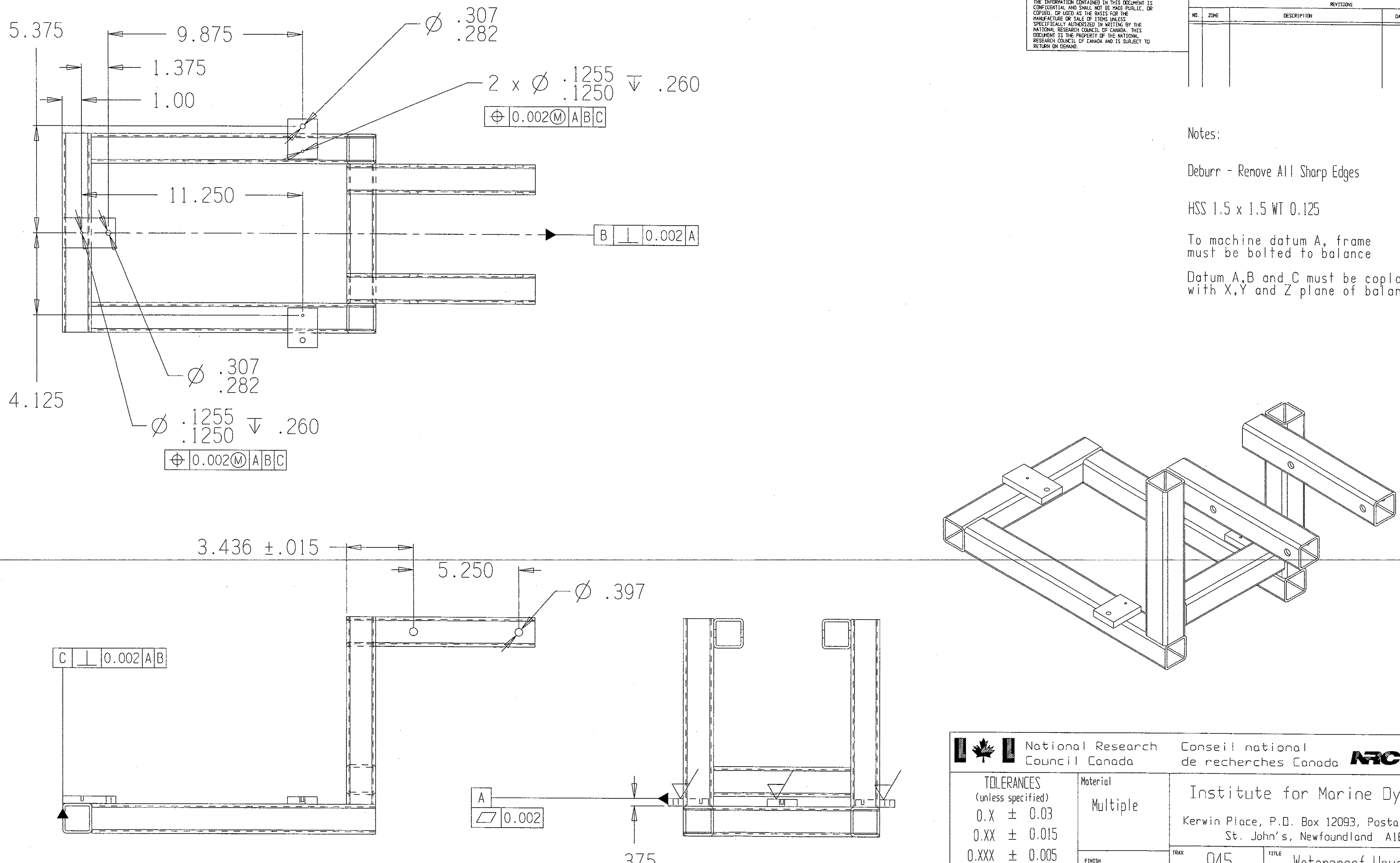
Frame - HSS 1.5 x 1.5 WT 0.125 Steel

Pads - Al 6016-T6

National Research Council Canada | Conseil national de recherches Canada | NRC-CNRC

TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32	Material: See Above FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAX: 945 DRAWN: T. Osmond APPROVED Quantity: 1 TITLE: Waterproof Housing Frame Welding and Fabrication A3 NUMBER: 945U02 REV SCALE: NTS DATE: 2005-July-27 SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED



Notes:

Deburr - Remove All Sharp Edges

HSS 1.5 x 1.5 WT 0.125

To machine datum A, frame must be bolted to balance

Datum A,B and C must be coplanar with X,Y and Z plane of balance

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Conseil national de recherches Canada
NRC-CNRC

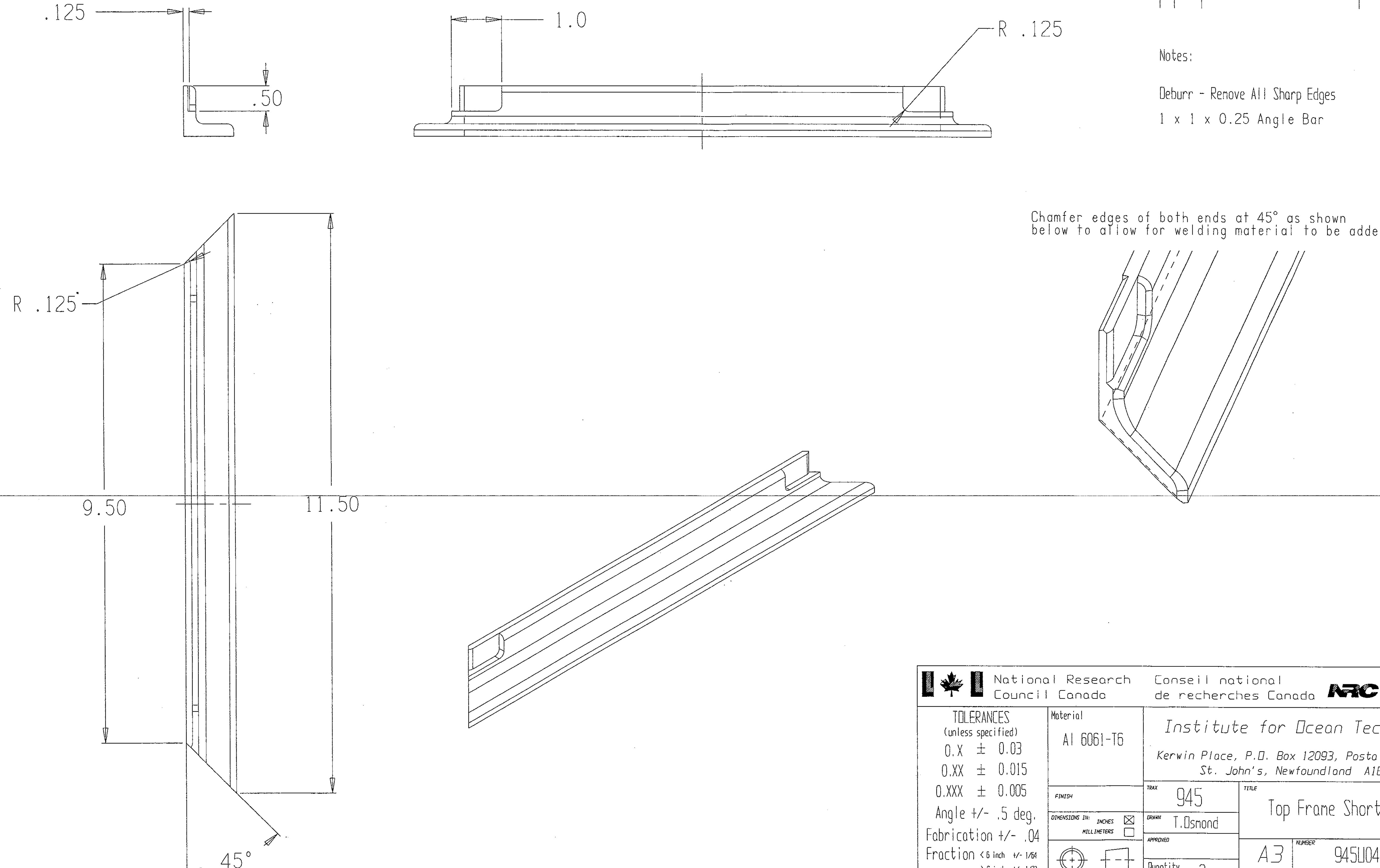
TOLERANCES (unless specified)	Material: Multiple	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5
0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	TRAX 945 DRAWN T. Osmond APPROVED Quantity 1 TITLE Waterproof Housing Frame Machining A3 NUMBER 945U03 REV SCALE NTS DATE 2005-July-27 SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED

Notes:

Deburr - Remove All Sharp Edges

1 x 1 x 0.25 Angle Bar



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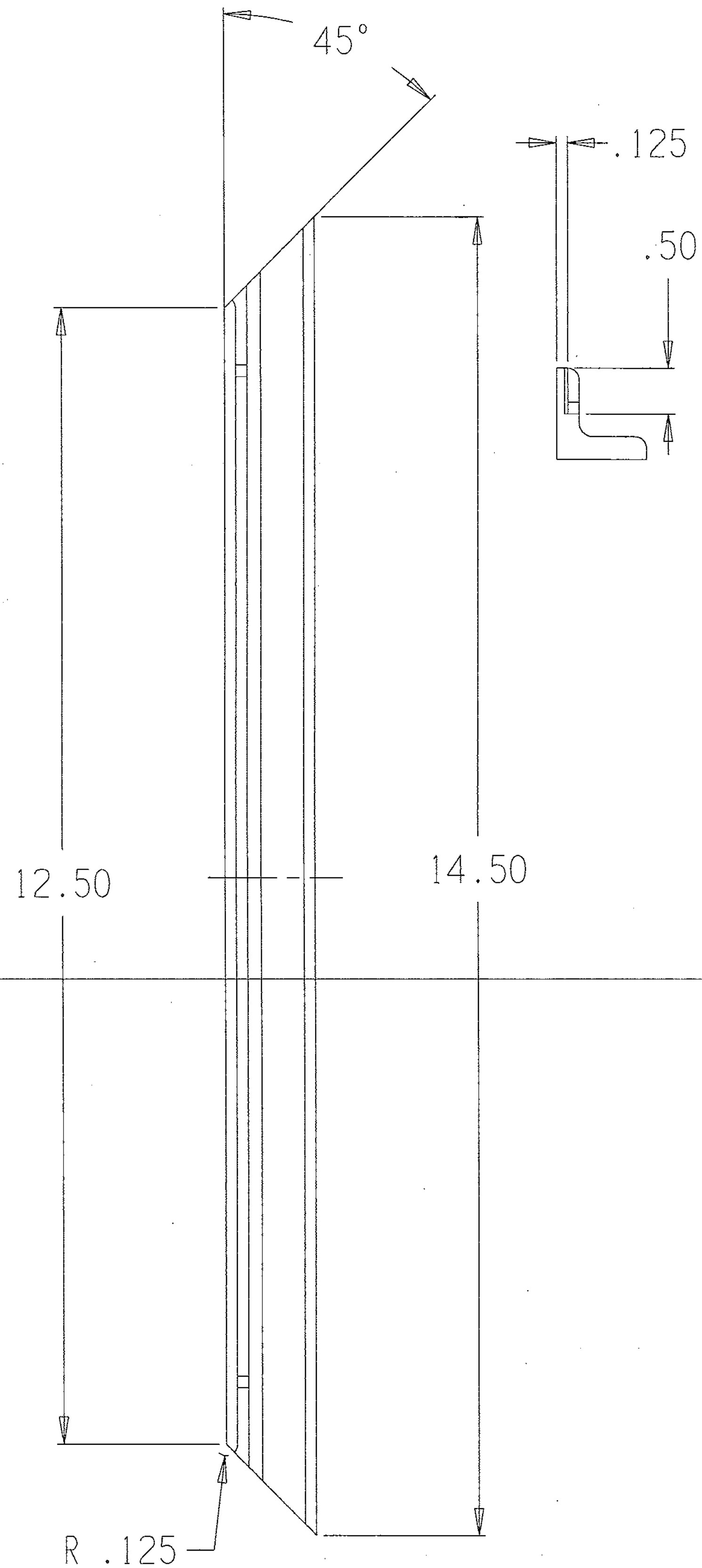
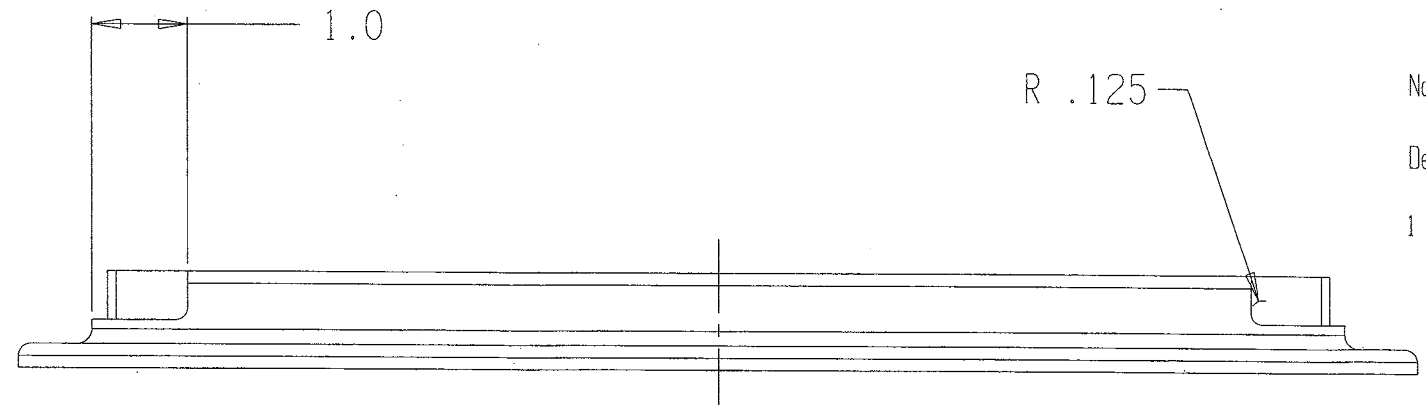
Institute for Ocean Technology
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

TOLERANCES (unless specified)	Material		
0.X ± 0.03	Al 6061-T6		
0.XX ± 0.015			
0.XXX ± 0.005	FINISH	TRAX 945	TITLE Top Frame Short Base Leg
Angle +/- .5 deg.	DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐	DRAWN T.Osmond	
Fabrication +/- .04		APPROVED	A3 — NUMBER 945U04 — REV
Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32	THIRD ANGLE	Quantity 2	SCALE NTS — DATE 2005-June-27 — SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED



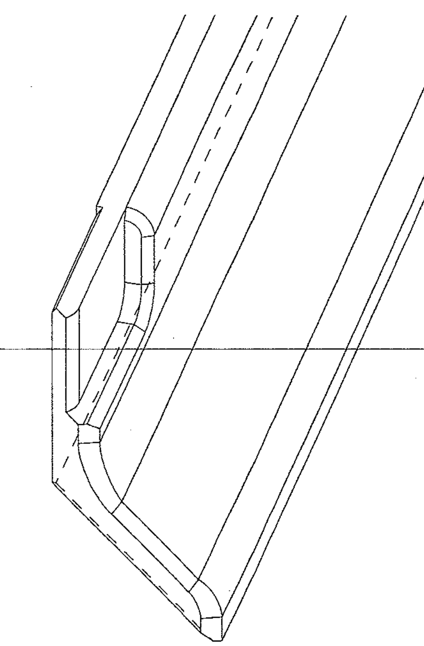


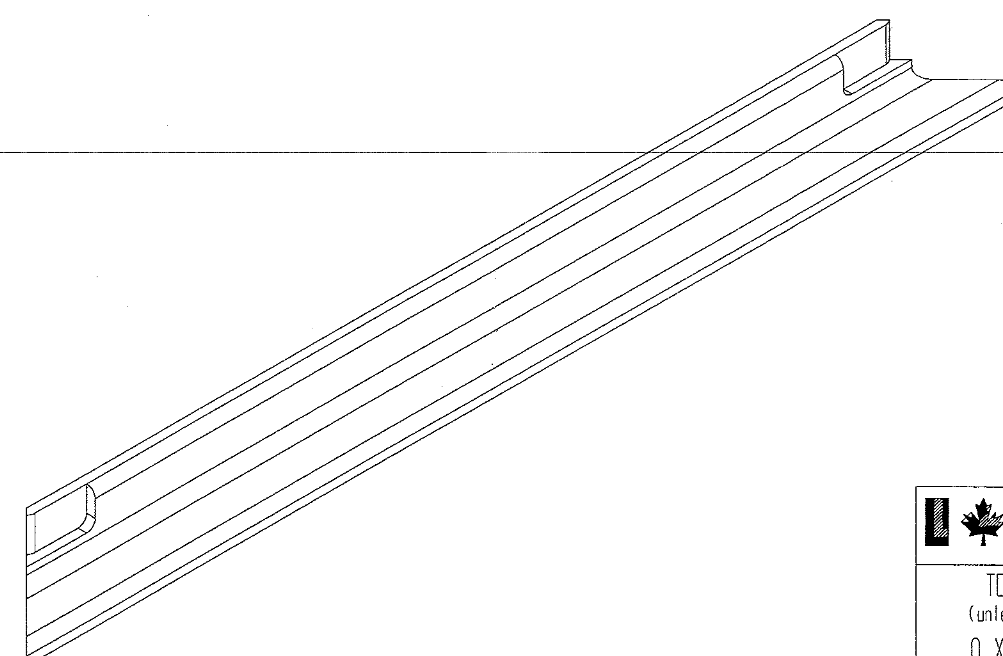
Notes:

Deburr - Remove All Sharp Edges

1 x 1 x 0.25 Angle Bar

Chamfer edges of both ends at 45° as shown below to allow for welding material to be added





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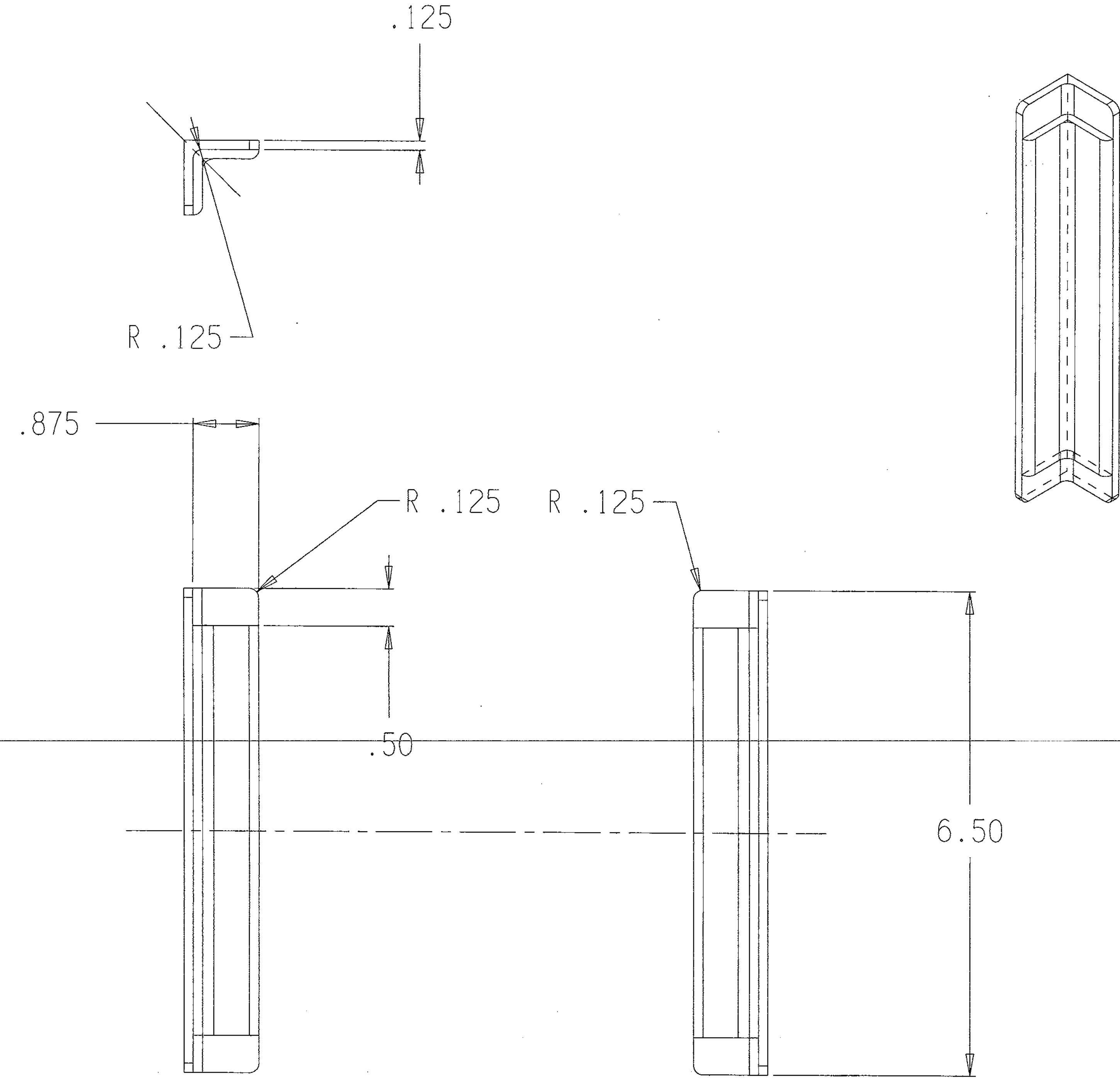
TOLERANCES (unless specified)	Material	Institute for Ocean Technology
0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32	Al 6061-T6	Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5
	FINISH	TRAX 945
	DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐	DRAWN T.Osmond
	THIRD ANGLE	APPROVED
		Quantity 2

TITLE			
Top Frame Long Base Leg			
A3	NUMBER 945U05	REV	
SCALE NTS	DATE 2005-June-27	SHEET 1 OF 1	

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED

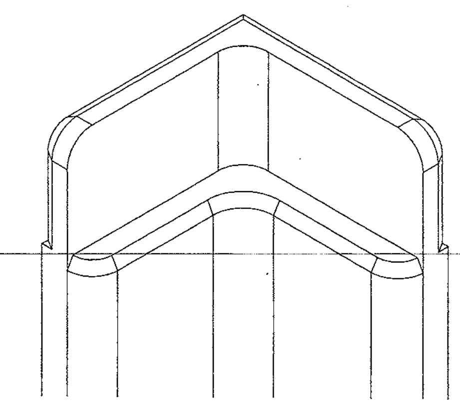


Notes:

Deburr - Remove All Sharp Edges

1 x 1 x 0.25 Angle Bar

Chamfer edges of both ends at 45° as shown below to allow for welding material to be added



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TOLERANCES (unless specified)
0.X ± 0.03
0.XX ± 0.015
0.XXX ± 0.005
Angle +/- .5 deg.
Fabrication +/- .04
Fraction < 6 inch +/- 1/64, > 6 inch +/- 1/32

Material: Al 6061-T6

FINISH

DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐

THIRD ANGLE

Institute for Ocean Technology
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

TRAX: 945
DRAWN: T.Osmond
APPROVED:
Quantity: 4

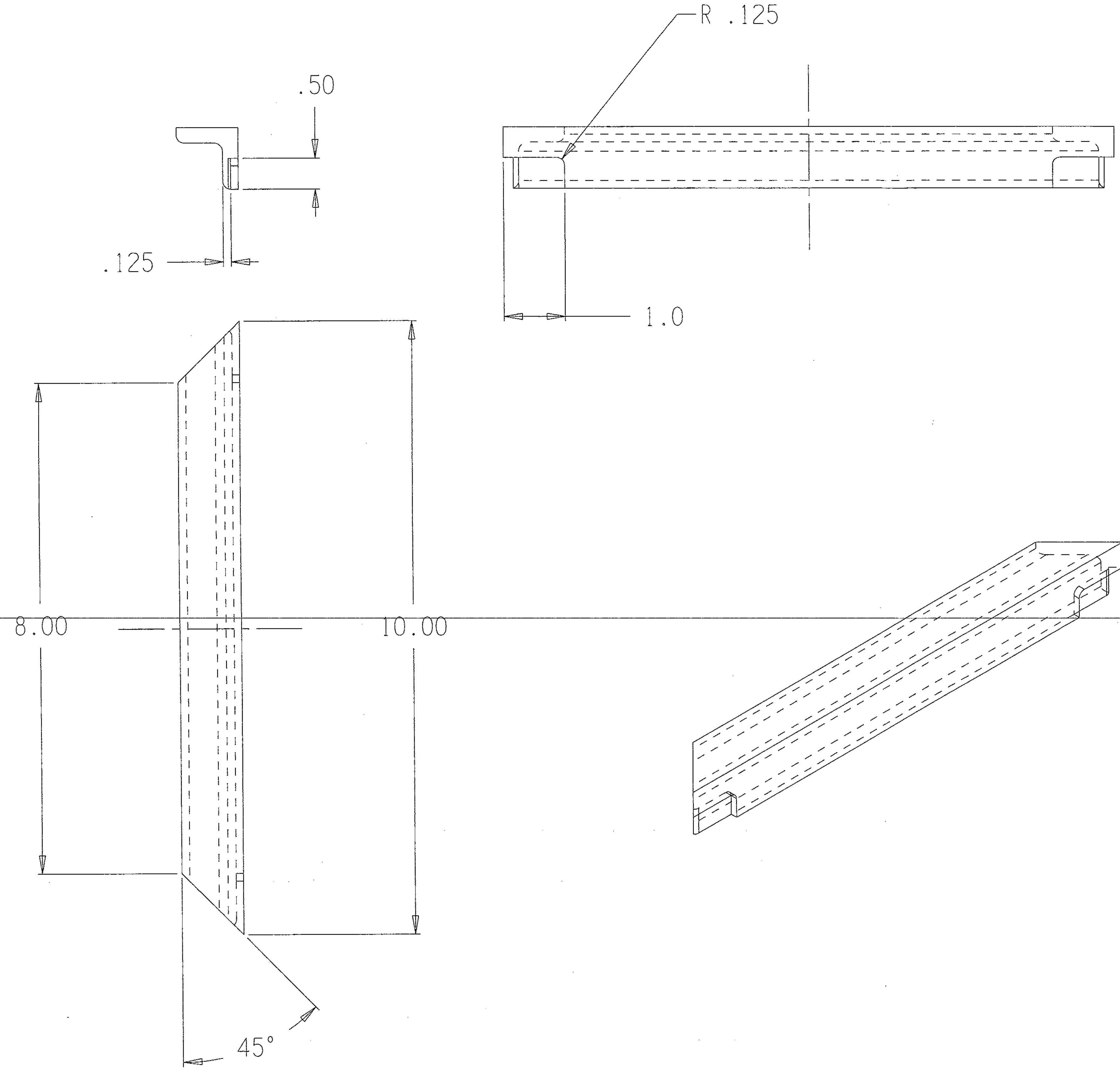
TITLE: Top Frame Side Bar

A3 | NUMBER: 945U06 | REV:

SCALE: NTS | DATE: 2005-July-28 | SHEET 1 OF 1

REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED

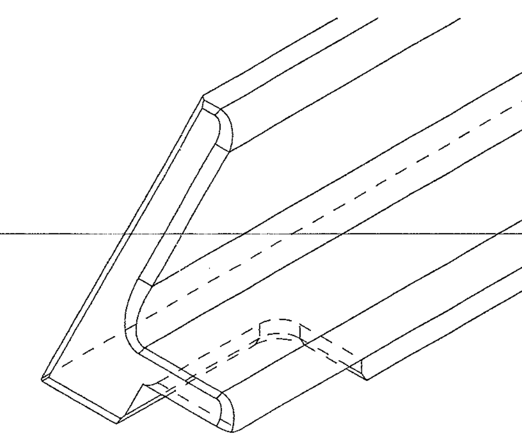


Notes:

Deburr - Remove All Sharp Edges

1 x 1 x 0.25 Angle Bar

Chamfer edges at both ends at 45° as shown below to allow for welding material to be added

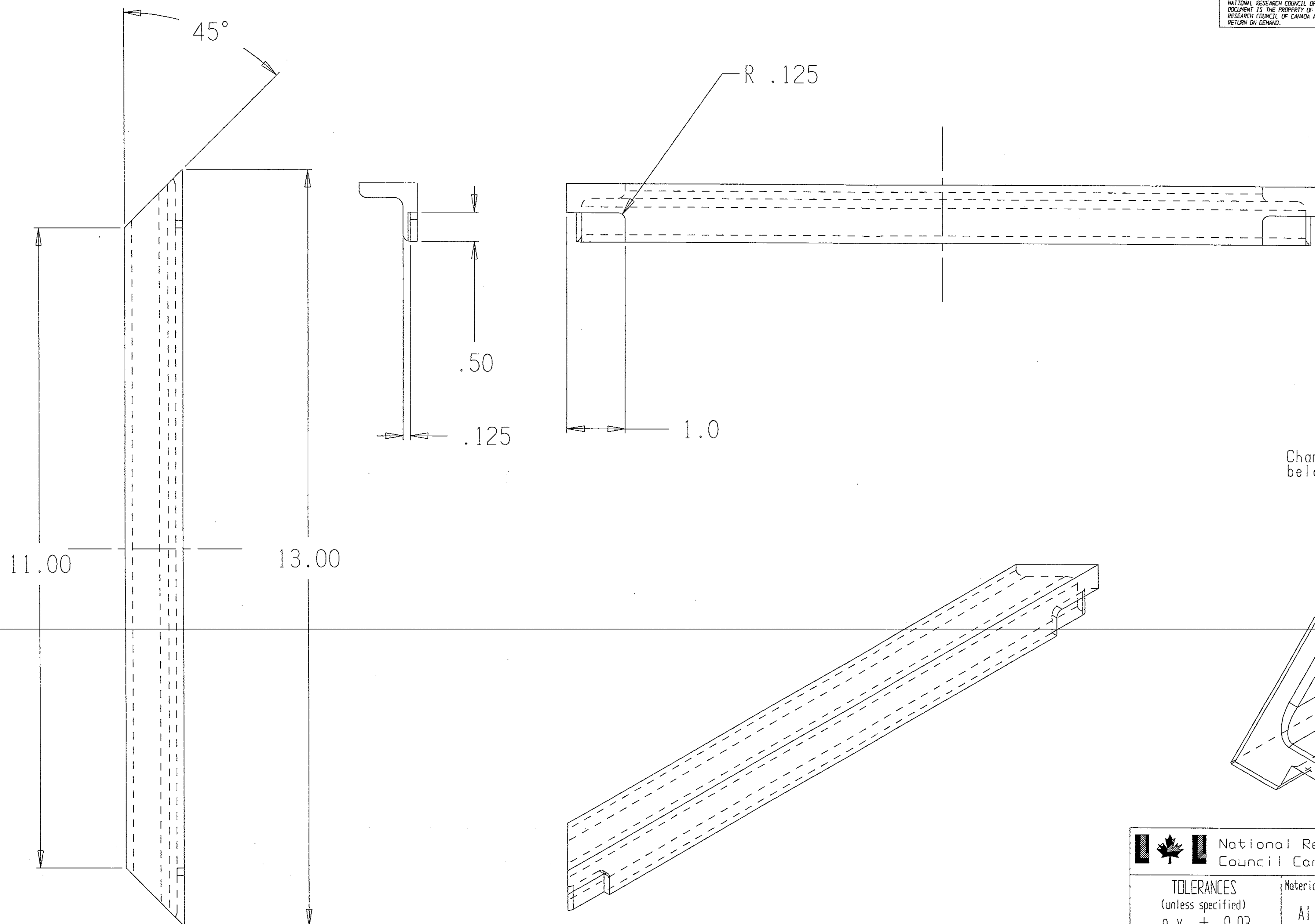


National Research Council Canada / Conseil national de recherches Canada — NRC-CNRC

TOLERANCES (unless specified)	Material	Institute for Ocean Technology
0.X ± 0.03	Al 6061-T6	Kerwin Place, P.O. Box 12093, Postal Station A, St. John's, Newfoundland A1B 3T5
0.XX ± 0.015		
0.XXX ± 0.005	FINISH	TRAX 945 — TITLE Top Frame Short Top Leg
Angle +/- .5 deg.	DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐	DRAWN T.Osmond
Fabrication +/- .04		APPROVED
Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32	THIRD ANGLE	Quantity 2 — A3 — NUMBER 945U07 — REV
		SCALE NTS — DATE 2005-July-27 — SHEET 1 OF 1

REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED

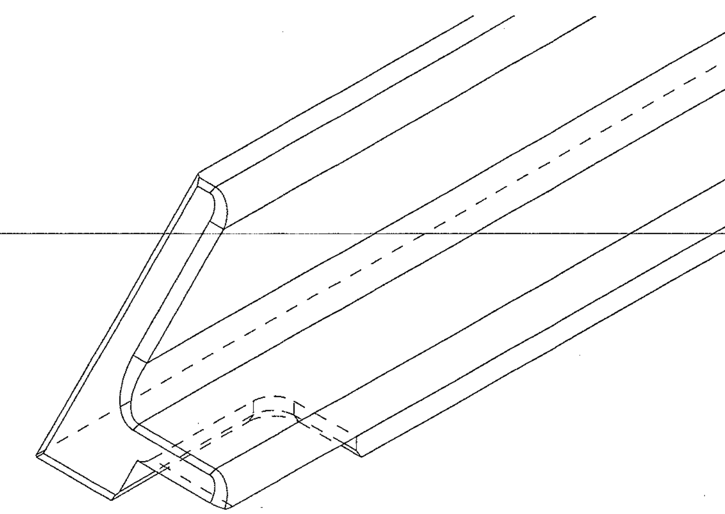


Notes:

Deburr - Remove All Sharp Edges

1 x 1 x 0.25 Angle Bar

Chamfer edges on both sides at 45° as shown below to allow for welding material to be added



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Institute for Ocean Technology

Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

TOLERANCES (unless specified)

0.X ± 0.03
0.XX ± 0.015
0.XXX ± 0.005
Angle +/- .5 deg.
Fabrication +/- .04
Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32

Material	Al 6061-T6
Finish	
Dimensions in	Inches ☒ Millimeters ☐
Third angle	
TRAX	945
Drawn	T.Osmond
Approved	
Quantity	2
Title	Top Frame Long Top Leg
Size	A3
Number	945U08
Rev	
Scale	NTS
Date	2005-July-27
Sheet	1 of 1

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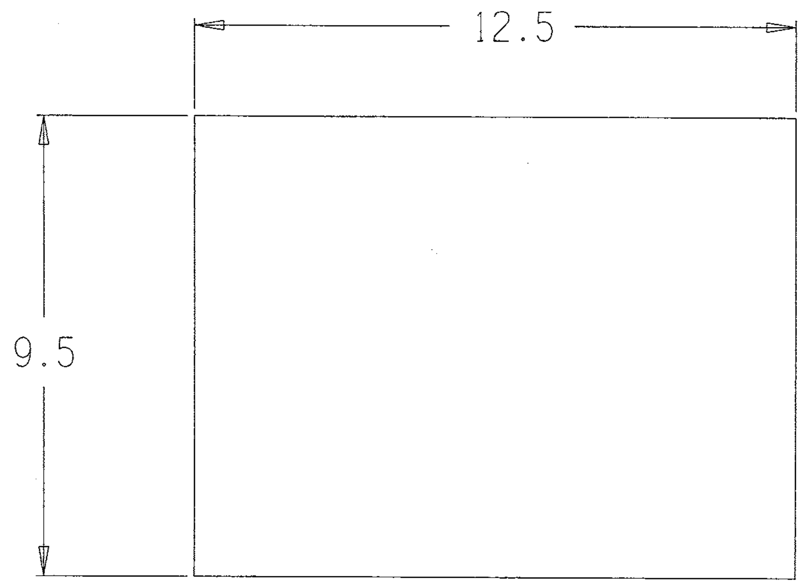
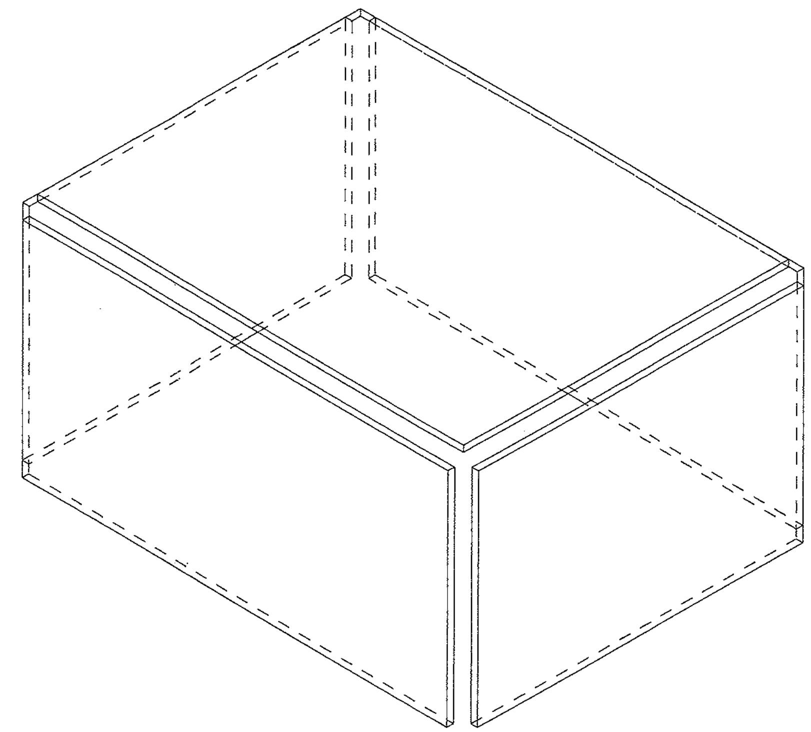
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED

Top Plate x 1





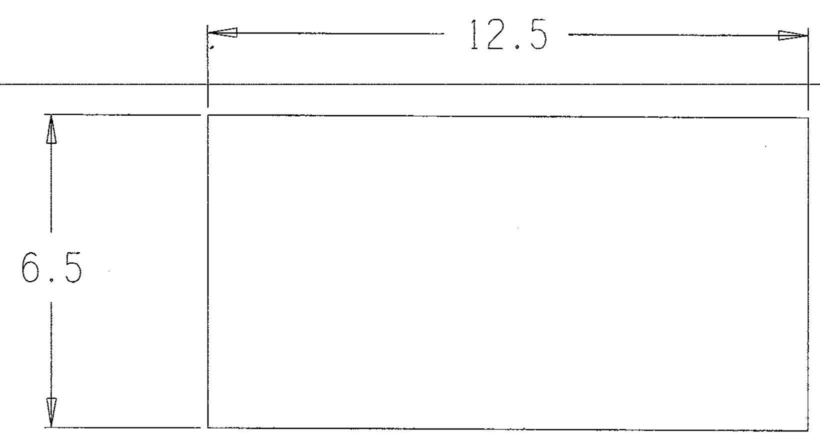
Notes:

Deburr - Remove All Sharp Edges

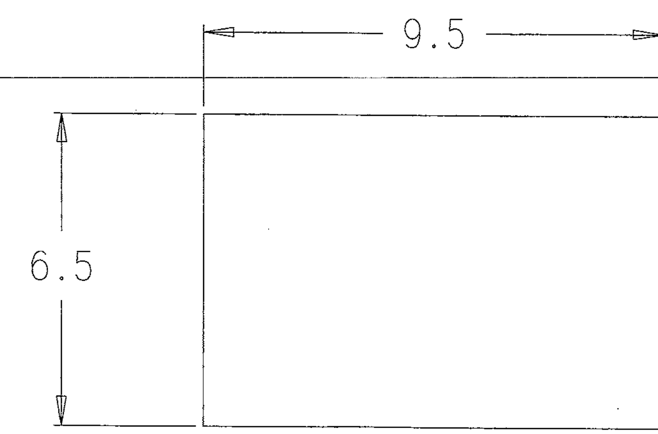
Top Plates

All Plates 0.1875" thick

Side Walls x 2



Front and Rear Plates x 2

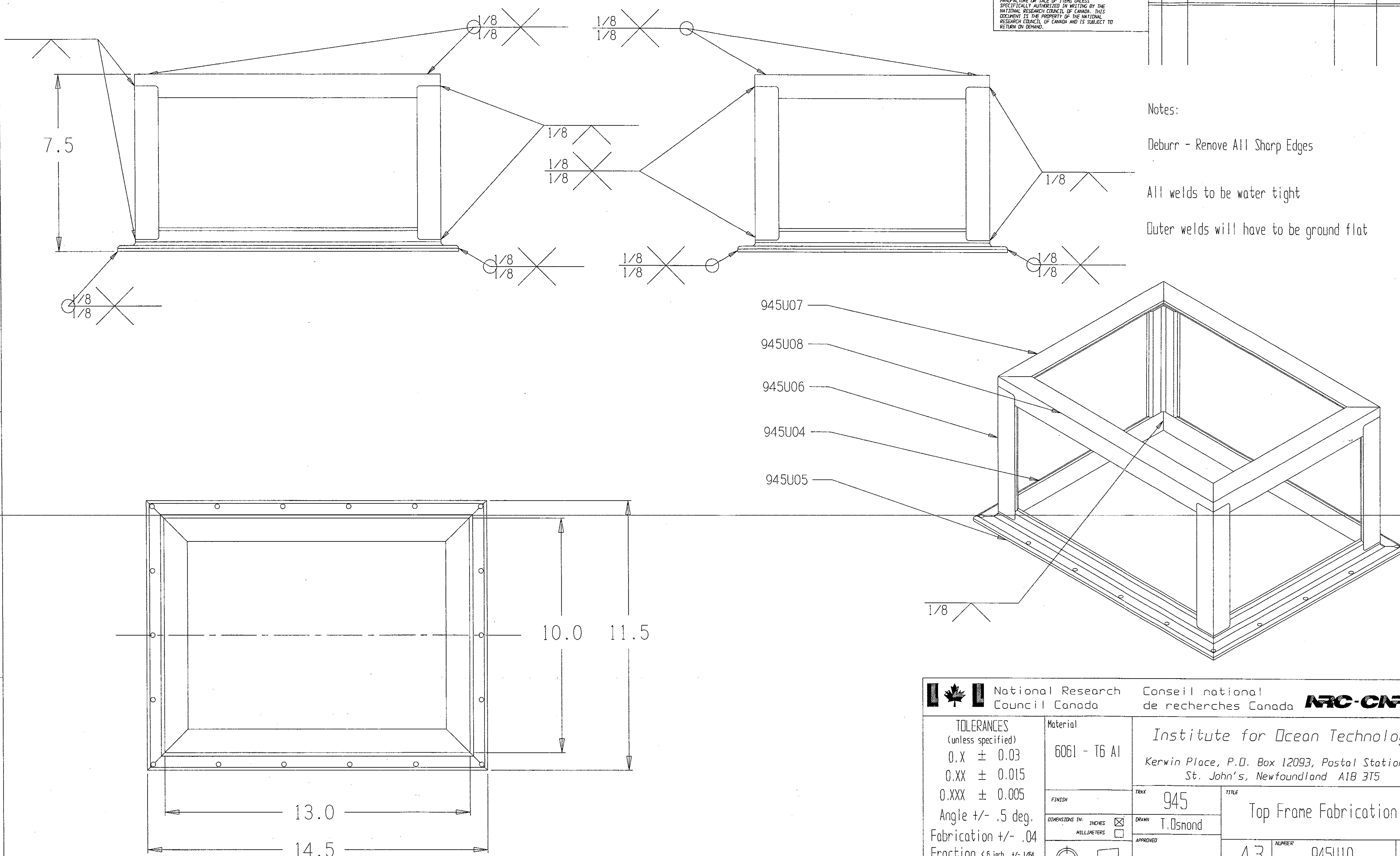


National Research Council Canada — Conseil national de recherches Canada — NRC-CNRC

TOLERANCES (unless specified)	Material: Al 6061-T6	Institute for Ocean Technology
0.X ± 0.03		Kerwin Place, P.O. Box 12093, Postal Station A, St. John's, Newfoundland A1B 3T5
0.XX ± 0.015	FINISH	TRAX: 945 — TITLE: Top Plates
0.XXX ± 0.005	DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐	DRAWN: T.Osmond
Angle +/- .5 deg.		APPROVED
Fabrication +/- .04	THIRD ANGLE	A3 — NUMBER: 945U09 — REV
Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32		Quantity: 1 — SCALE: NTS — DATE: 2005-July-28 — SHEET 1 OF 1

REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED



Notes:

Deburr - Remove All Sharp Edges

All welds to be water tight

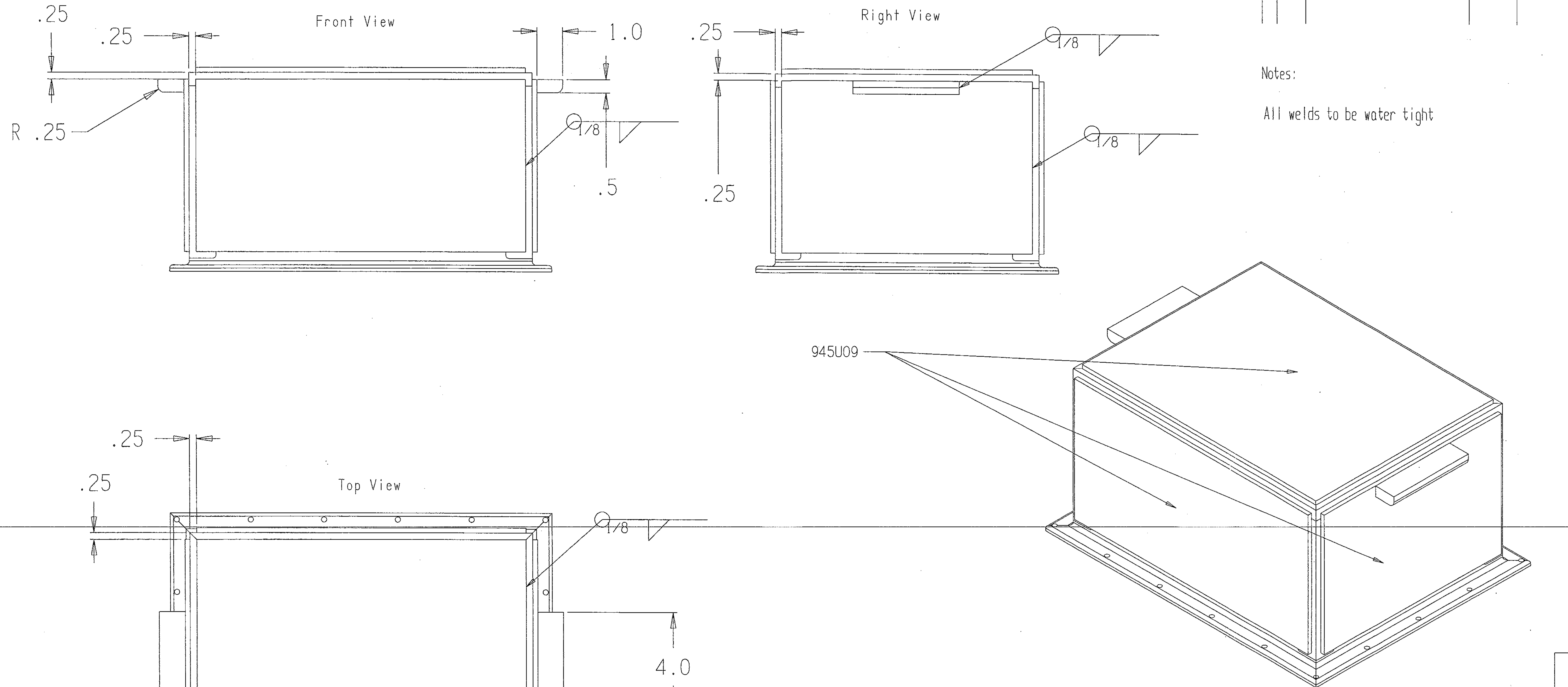
Outer welds will have to be ground flat

National Research Council Canada — Conseil national de recherches Canada — NRC-CNRC

TOLERANCES (unless specified)	0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32
Material	6061 - T6 Al
FINISH	
DIMENSIONS IN:	INCHES ☒ MILLIMETERS ☐
THIRD ANGLE	
TRAX	945
DRAWN	T.Osmond
APPROVED	
Quantity	1
TITLE	Top Frame Fabrication
	A3
NUMBER	945U10
REV	
SCALE	NTS
DATE	2005-June-21
SHEET	1 OF 1

Institute for Ocean Technology
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED



Notes:

All welds to be water tight

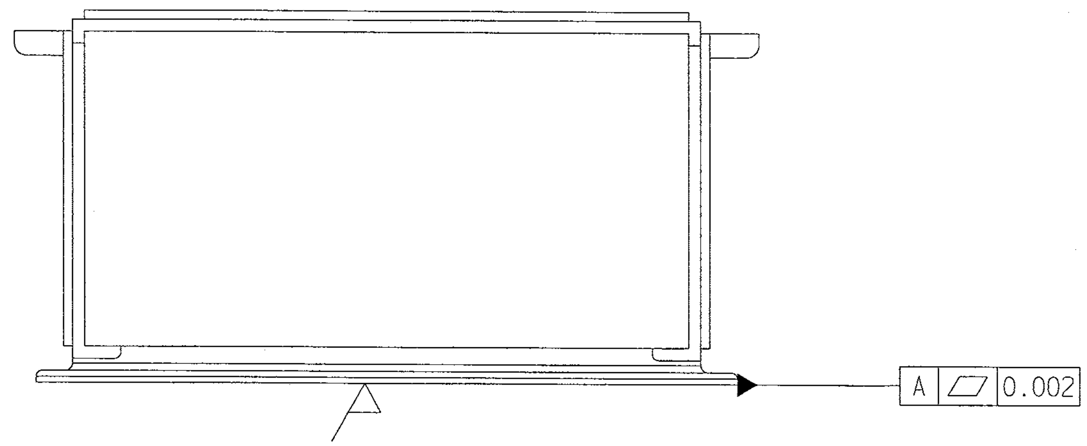
National Research Council Canada
Conseil national de recherches Canada
NRC-CNRC

TOLERANCES (unless specified)	Material	Institute for Ocean Technology
0.X ± 0.03	Al 6061-T6	Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5
0.XX ± 0.015	FINISH	TRAX 945
0.XXX ± 0.005	DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐	DRAWN T.Osmond
Angle +/- .5 deg.		APPROVED
Fabrication +/- .04	THIRD ANGLE	Quantity 1
Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32		

TITLE	Top Frame Full Assembly		
A3	NUMBER 945U11	REV	
SCALE NTS	DATE 2005-July-28	SHEET 1	OF 1

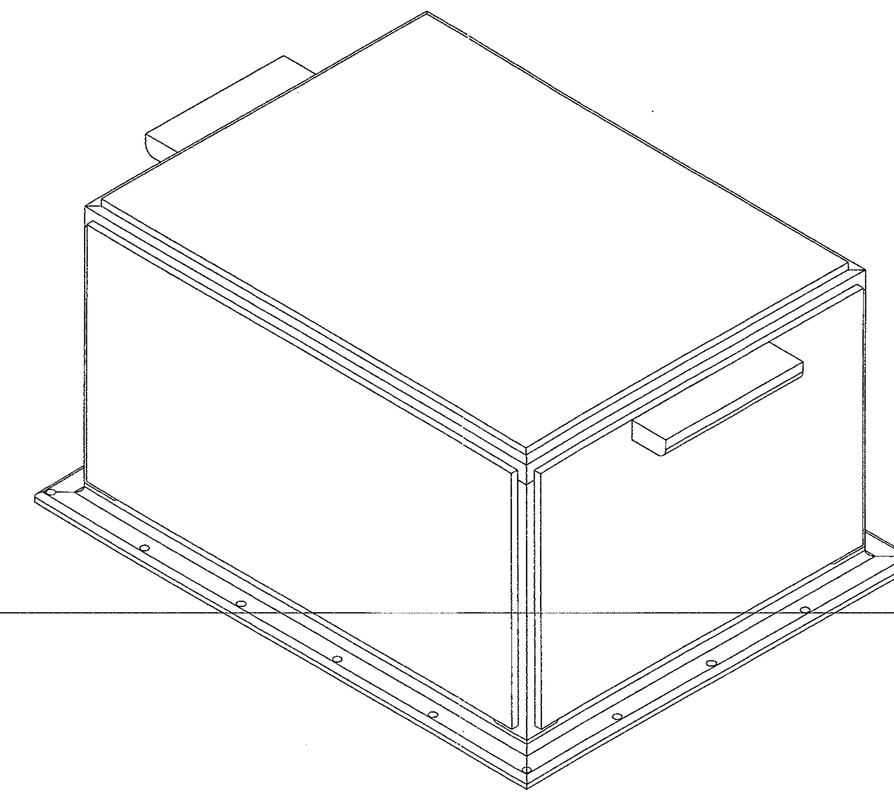
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED

Front View

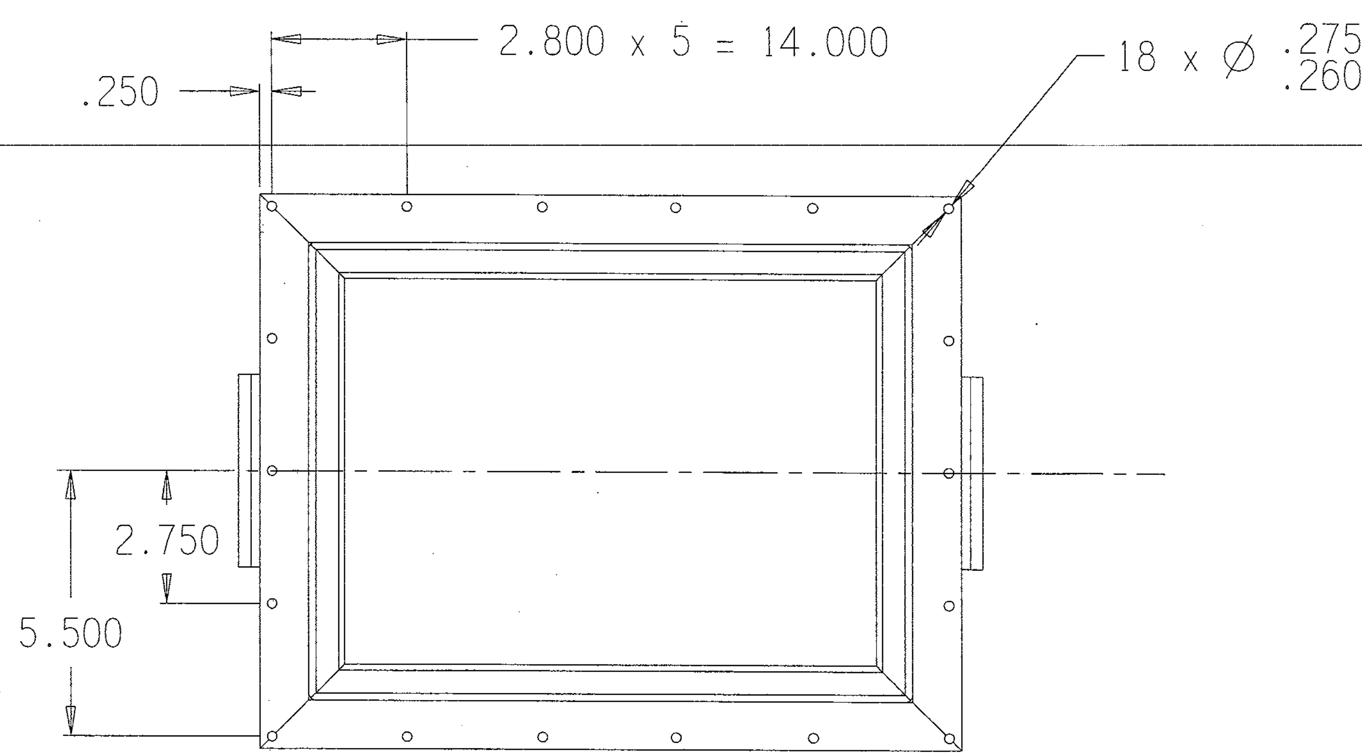


Notes:

Grind external welds flat with surfaces to allow for plates to seal

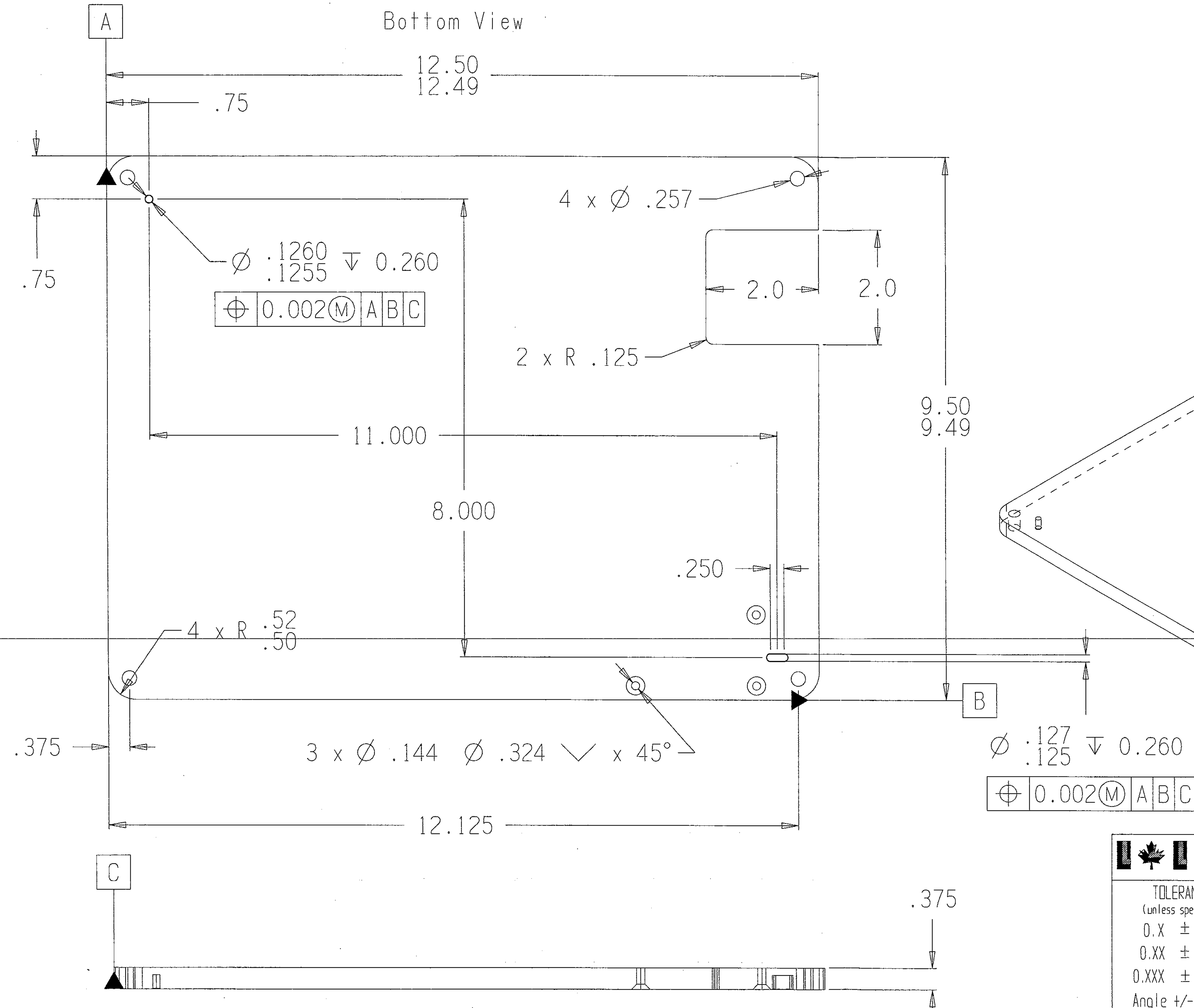


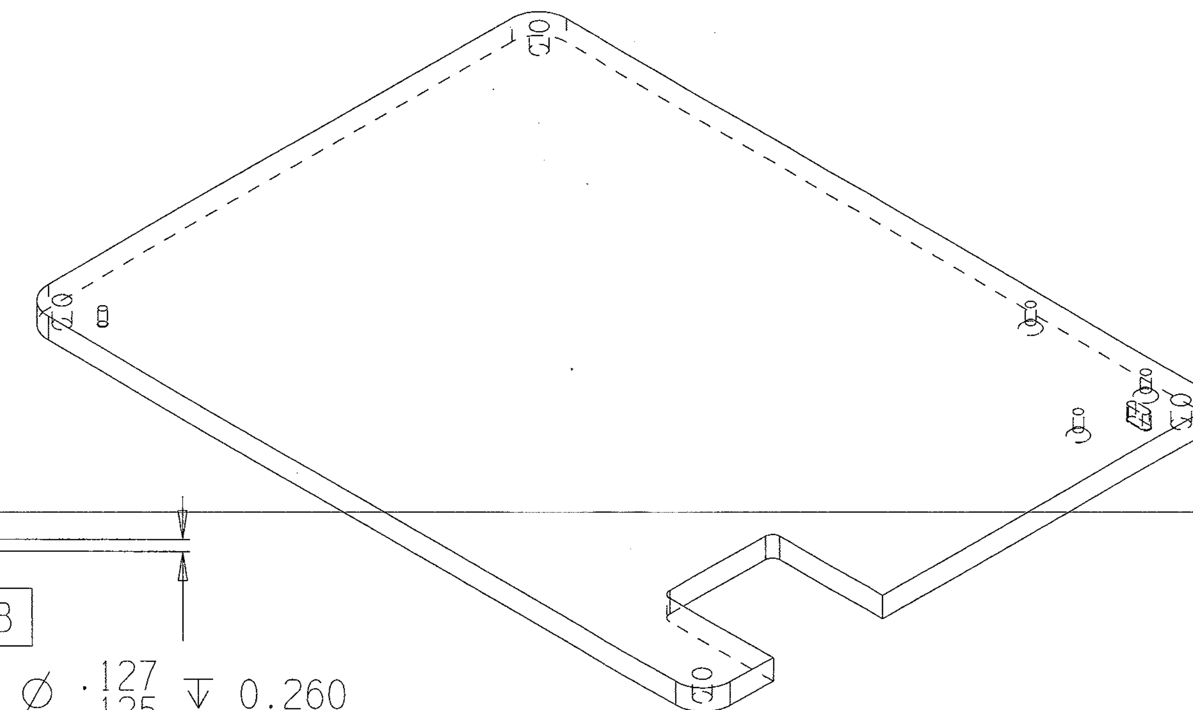
Bottom View



National Research Council Canada
Conseil national de recherches Canada
NRC-CNRC

TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: 6061 - T6 Al FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	*Institute for Ocean Technology* *Kerwin Place, P.O. Box 12093, Postal Station A* *St. John's, Newfoundland A1B 3T5*
	TRAX: 945 DRAWN: T.Osmond APPROVED Quantity: 1	TITLE: Top Frame Machining A3 NUMBER: 945U12 REV SCALE: NTS DATE: 2005-June-21 SHEET 1 OF 1





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NO.	ZONE	DESCRIPTION	DATE	APPROVED

Notes:

Deburr - Remove All Sharp Edges

Pin holes will allow pins better if slightly chanfered

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TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: Al 6061-T6 FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Ocean Technology Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5

TRAX	TITLE		
945	Inner Plate Machining		
DRAWN: T.Osmond			
APPROVED	A3	NUMBER: 945U13	REV
Quantity: 1	SCALE: NTS	DATE: 2005-June-21	SHEET 1 OF 1

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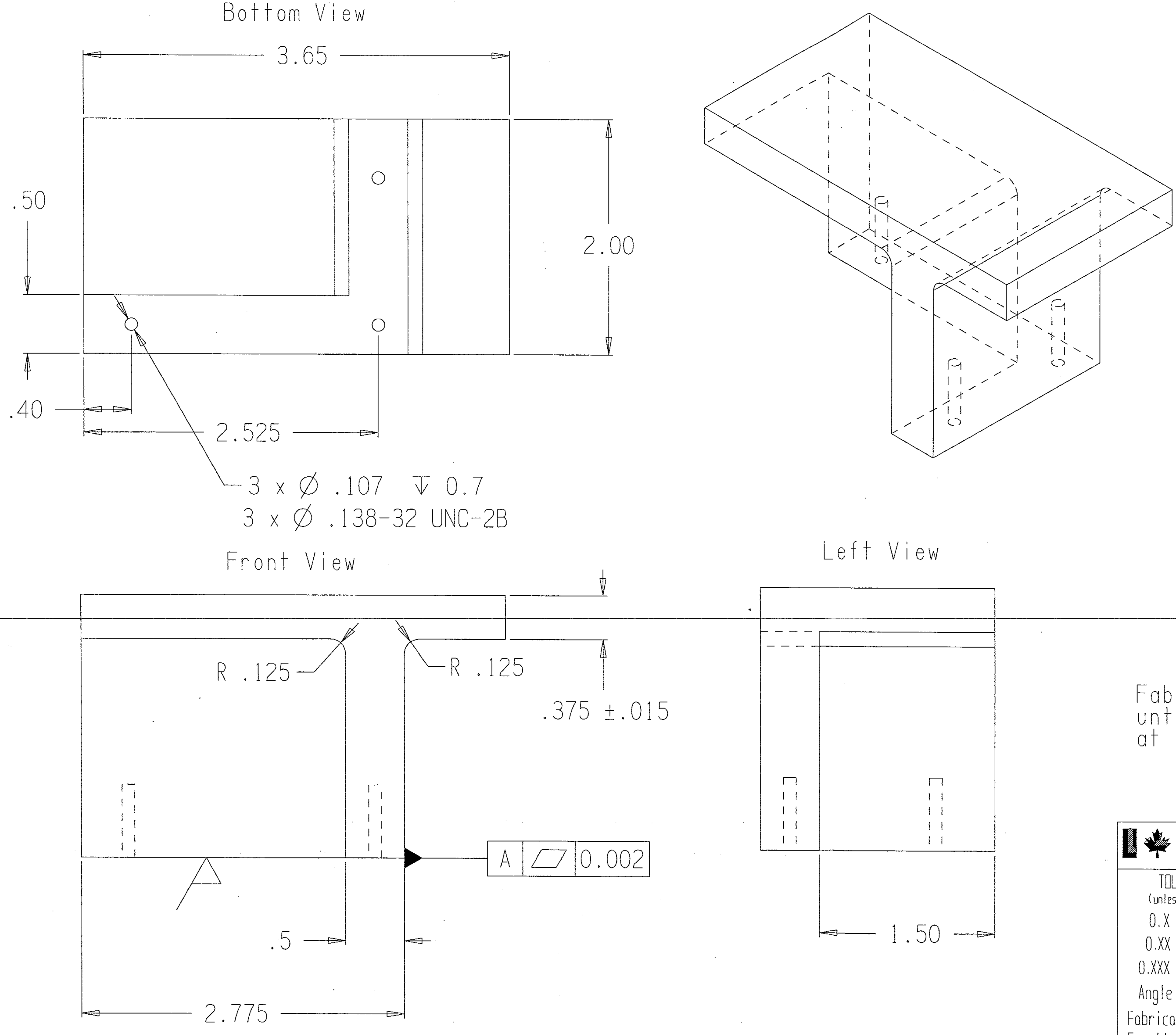

Notes:

Deburr - Remove All Sharp Edges

Fabrication of this piece is not necessary until it is decided to put in all equipment at the same time

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TOLERANCES (unless specified)	Material: Al 6016-T6
0.X ± 0.03	
0.XX ± 0.015	
0.XXX ± 0.005	FINISH
Angle +/- .5 deg.	DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
Fabrication +/- .04	
Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32	THIRD ANGLE

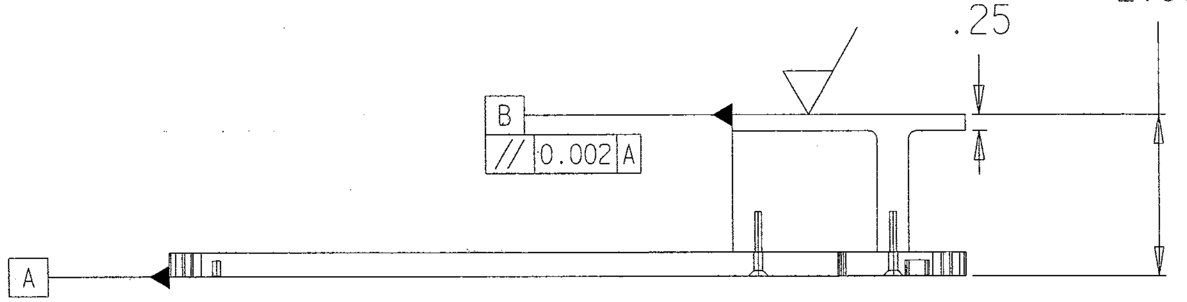
Institute for Ocean Technology

Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5

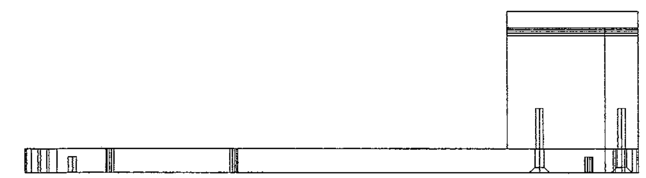
TRAX: 945	TITLE: Inclinometer Platform
DRAWN: T.Osmond	
APPROVED	A3 — NUMBER: 945U14 — REV
Quantity: 1	SCALE: NTS — DATE: 2005-July-28 — SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED

Front View



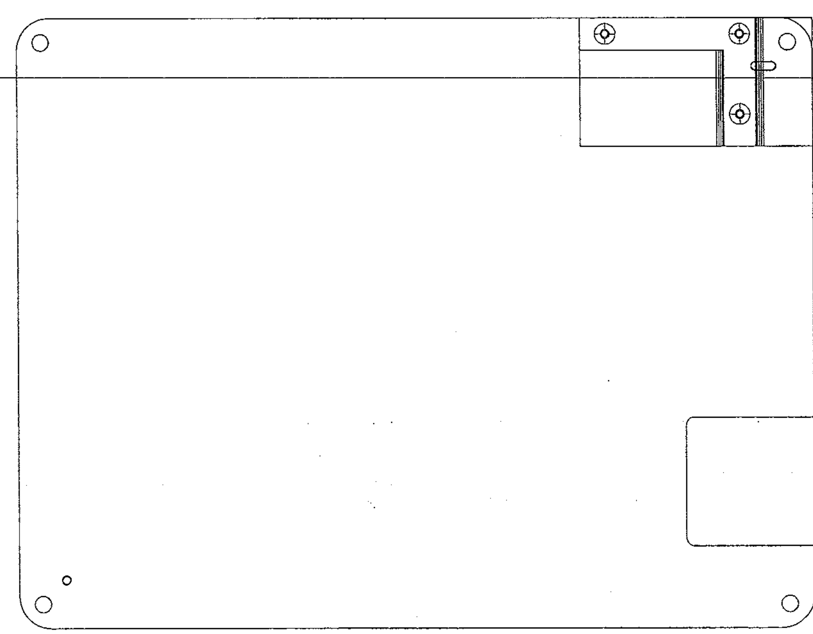
Profile View

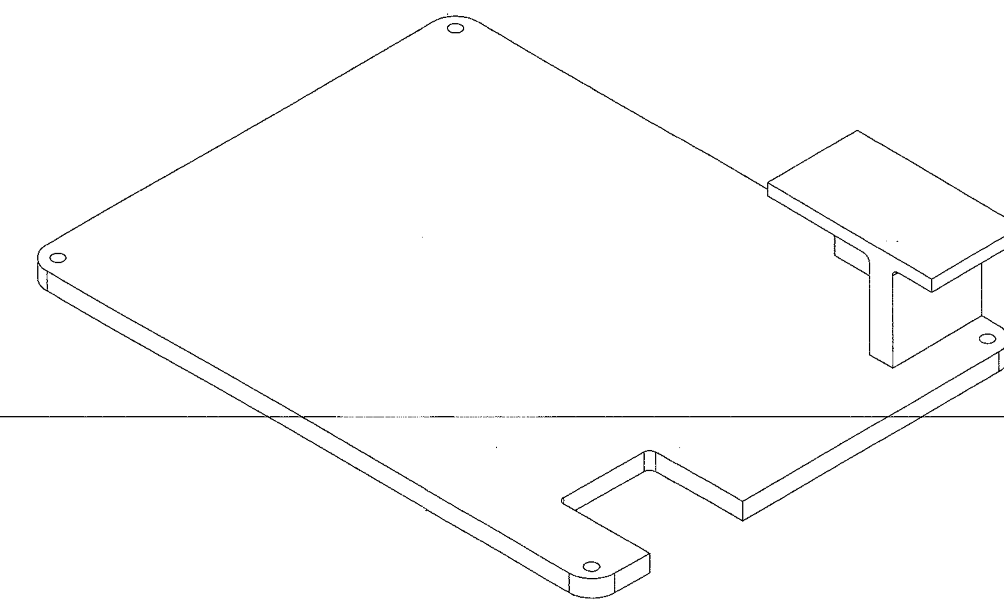


Notes:

Deburr - Remove All Sharp Edges

Top View

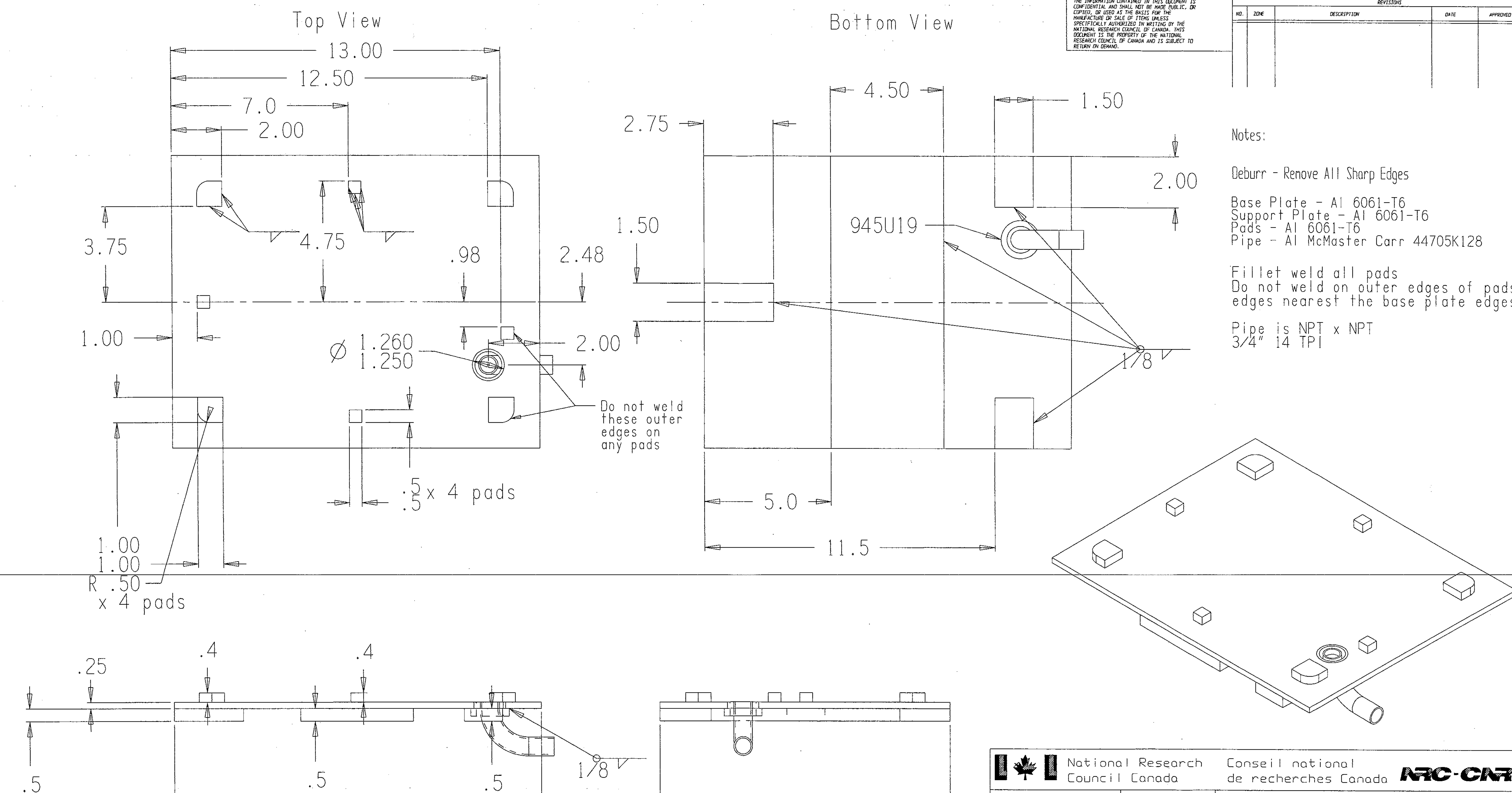




National Research Council Canada / Conseil national de recherches Canada NRC-CNRC

TOLERANCES (unless specified)	Material: Al 6061-T6	Institute for Ocean Technology Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5	
0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005	FINISH	TRAX 945	TITLE Inner Plate Assembly
Angle +/- .5 deg.	DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐	DRAWN T.Osmond	
Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	THIRD ANGLE	APPROVED Quantity 1	A3 NUMBER 945U15 REV SCALE NTS DATE 2005-July-28 SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED



Notes:

Deburr - Remove All Sharp Edges

Base Plate - Al 6061-T6
Support Plate - Al 6061-T6
Pads - Al 6061-T6
Pipe - Al McMaster Carr 44705K128

Fillet weld all pads
Do not weld on outer edges of pads, edges nearest the base plate edges

Pipe is NPT x NPT
3/4" 14 TPI

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TOLERANCES (unless specified)
0.X ± 0.03
0.XX ± 0.015
0.XXX ± 0.005
Angle +/- .5 deg.
Fabrication +/- .04
Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32

Material: Al 6061-T6

FINISH

DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐

THIRD ANGLE

Institute for Ocean Technology
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

TRAX: 945
DRAWN: T.Osmond
APPROVED:
Quantity: 1

TITLE: Base Plate Fabrication

A3 | NUMBER: 945U16 | REV:

SCALE: NTS | DATE: 2005-July-27 | SHEET 1 OF 1

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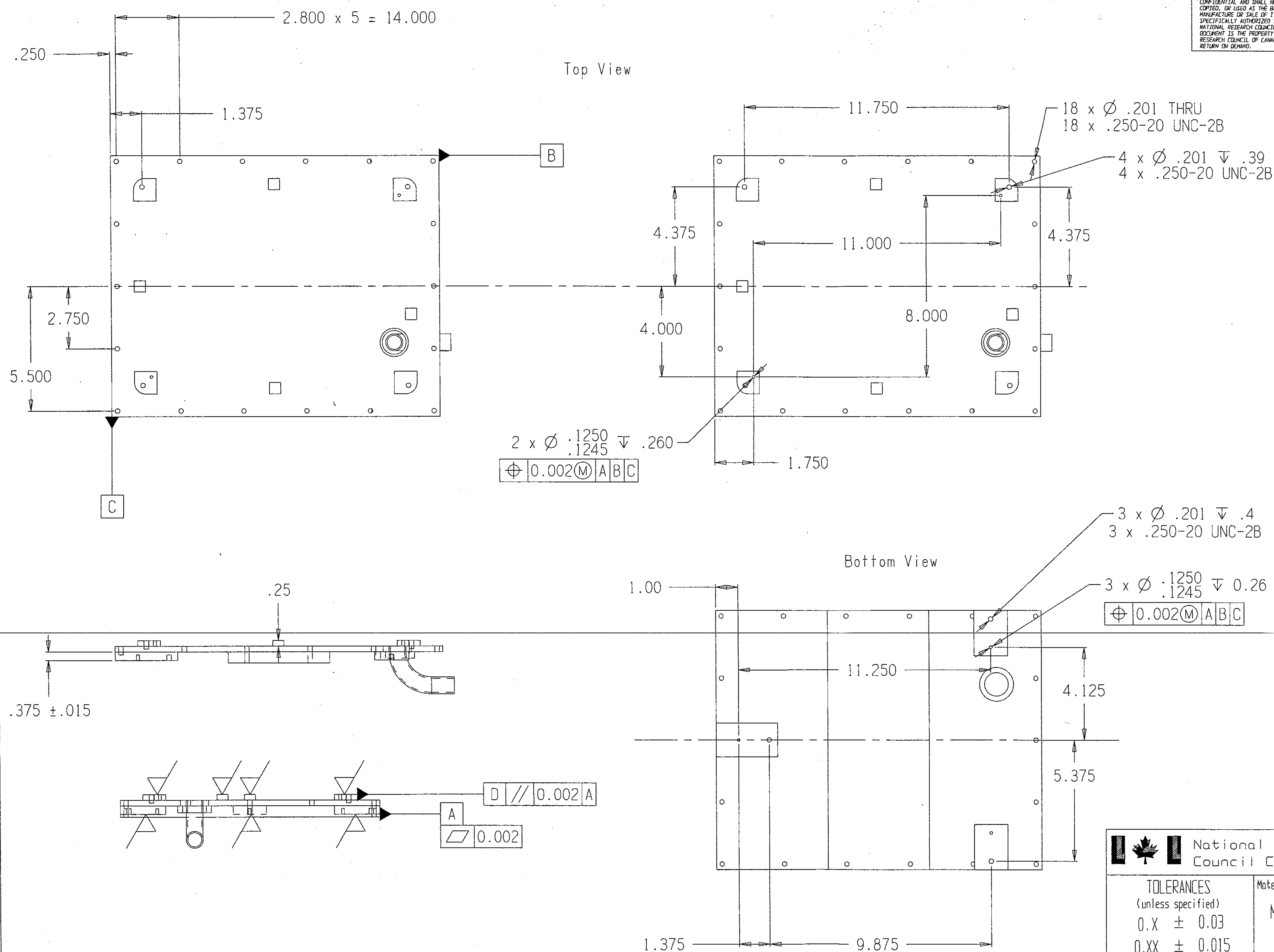
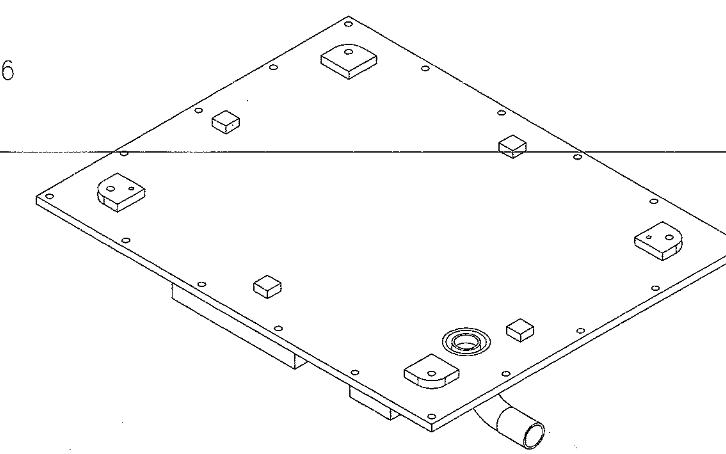
NO.	ZONE	DESCRIPTION	DATE	APPROVED





Notes:

Bolts - F593C Steel 1/4"

Deburr - Remove all sharp edges

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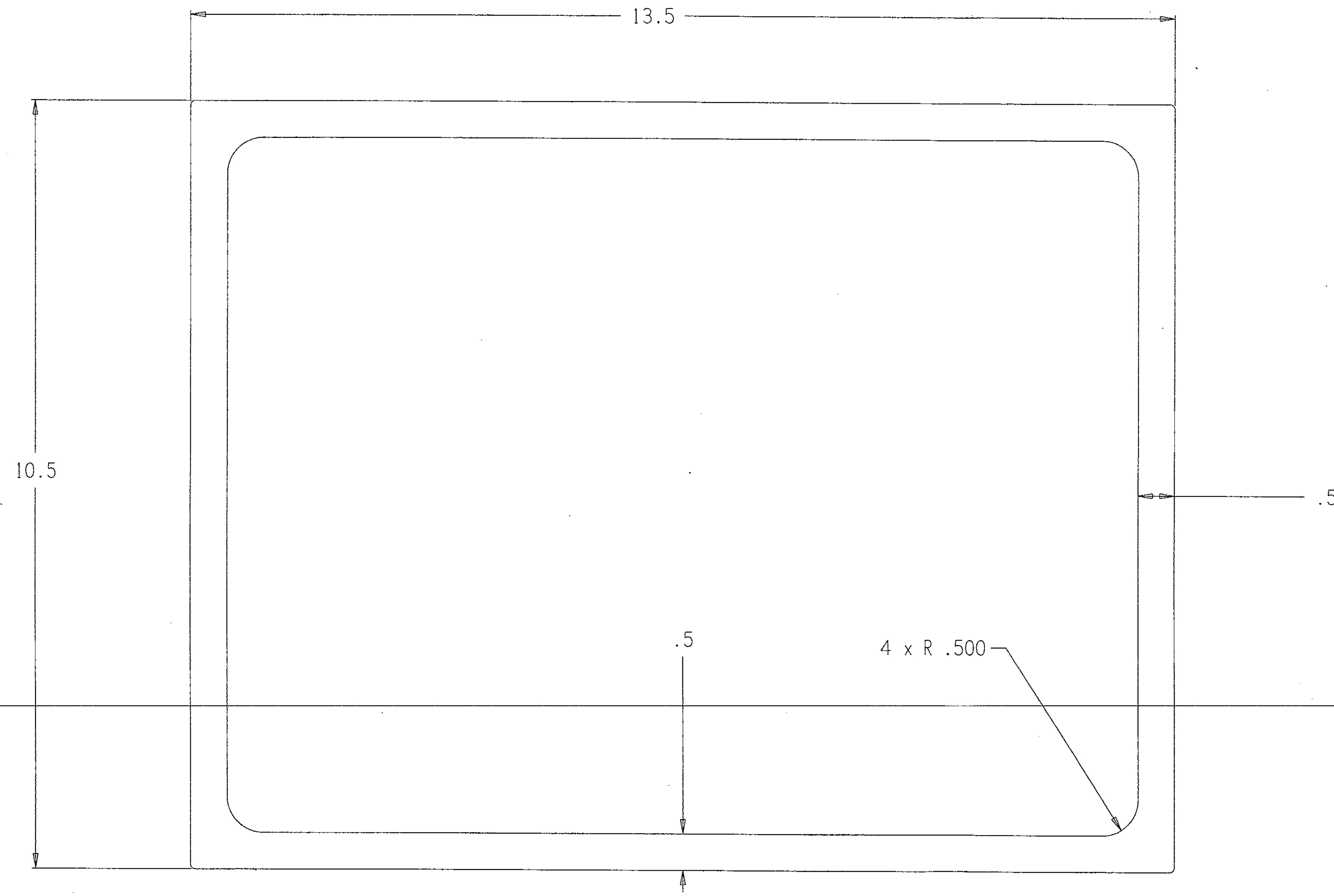
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: Multiple FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Ocean Technology Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5

TRAX: 945	TITLE: Base Plate Machining		
DRAWN: T.Osmond			
APPROVED	A3	NUMBER: 945U17	REV
Quantity: 1	SCALE: NTS	DATE: 2005-Aug-16	SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED



Notes:

Material thickness 0.125" - 0.375"

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TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64; > 6 inch +/- 1/32	Material: TBD FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	*Institute for Ocean Technology* *Kerwin Place, P.O. Box 12093, Postal Station A* *St. John's, Newfoundland A1B 3T5* TRAX: 945 DRAWN: T.Osmond APPROVED: Quantity: 1 TITLE: Gasket A3 NUMBER: 945U18 REV SCALE: NTS DATE: 2005-Aug-5 SHEET 1 OF 1

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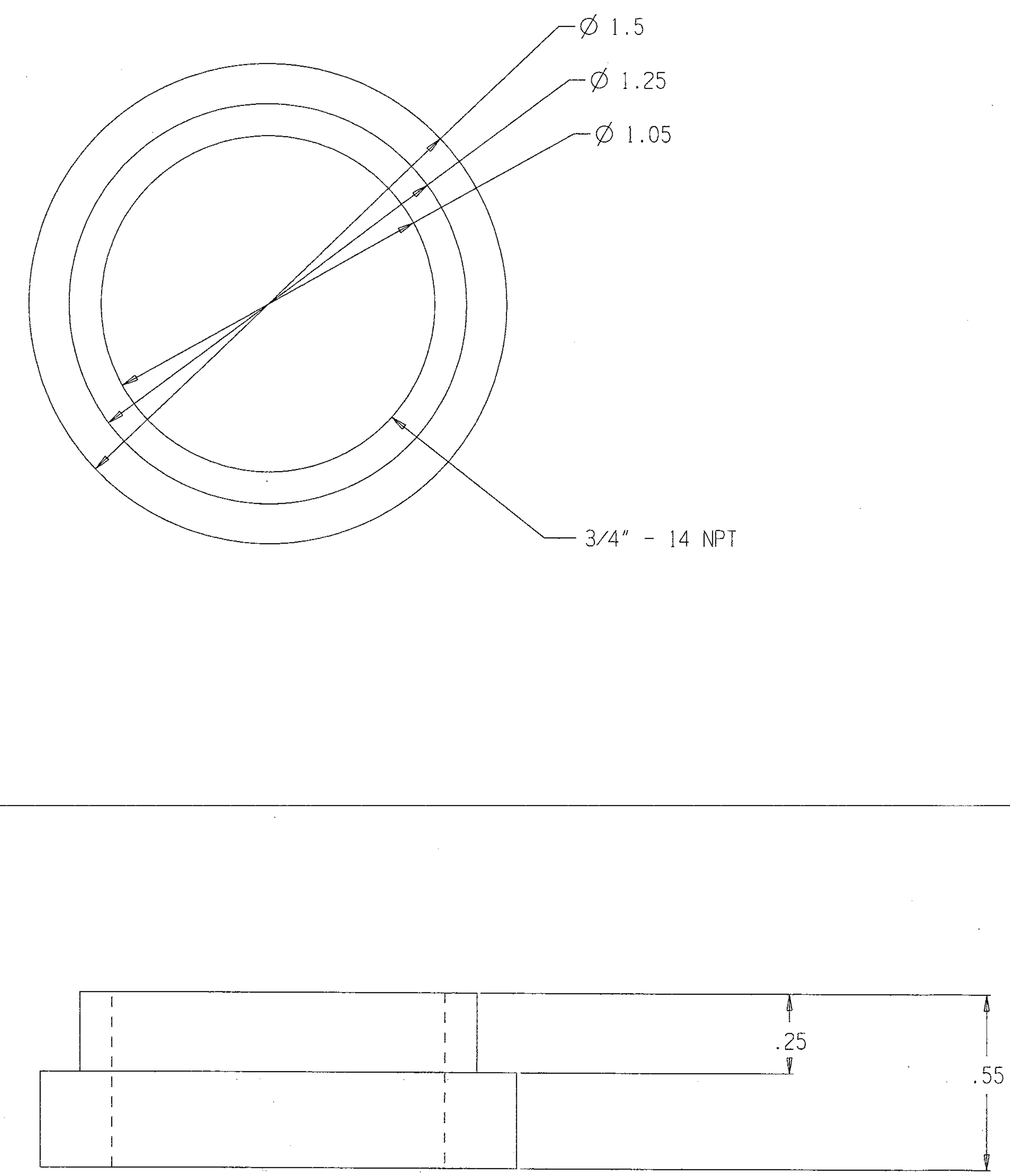
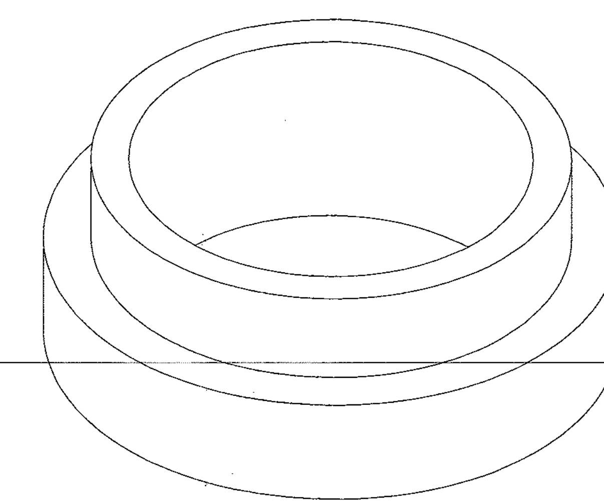
REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED



Notes:



National Research Council Canada
Conseil national de recherches Canada
NRC-CNRC

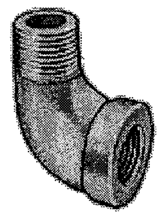
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: Al 6061-T6 FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	*Institute for Ocean Technology* *Kerwin Place, P.O. Box 12093, Postal Station A* *St. John's, Newfoundland A1B 3T5*

TRAX: 945	TITLE: Plug	
DRAWN: T.Osmond		
APPROVED	A3	NUMBER: 945U19	REV
Quantity 1	SCALE: NTS	DATE: 2005-Aug-16	SHEET 1 OF 1

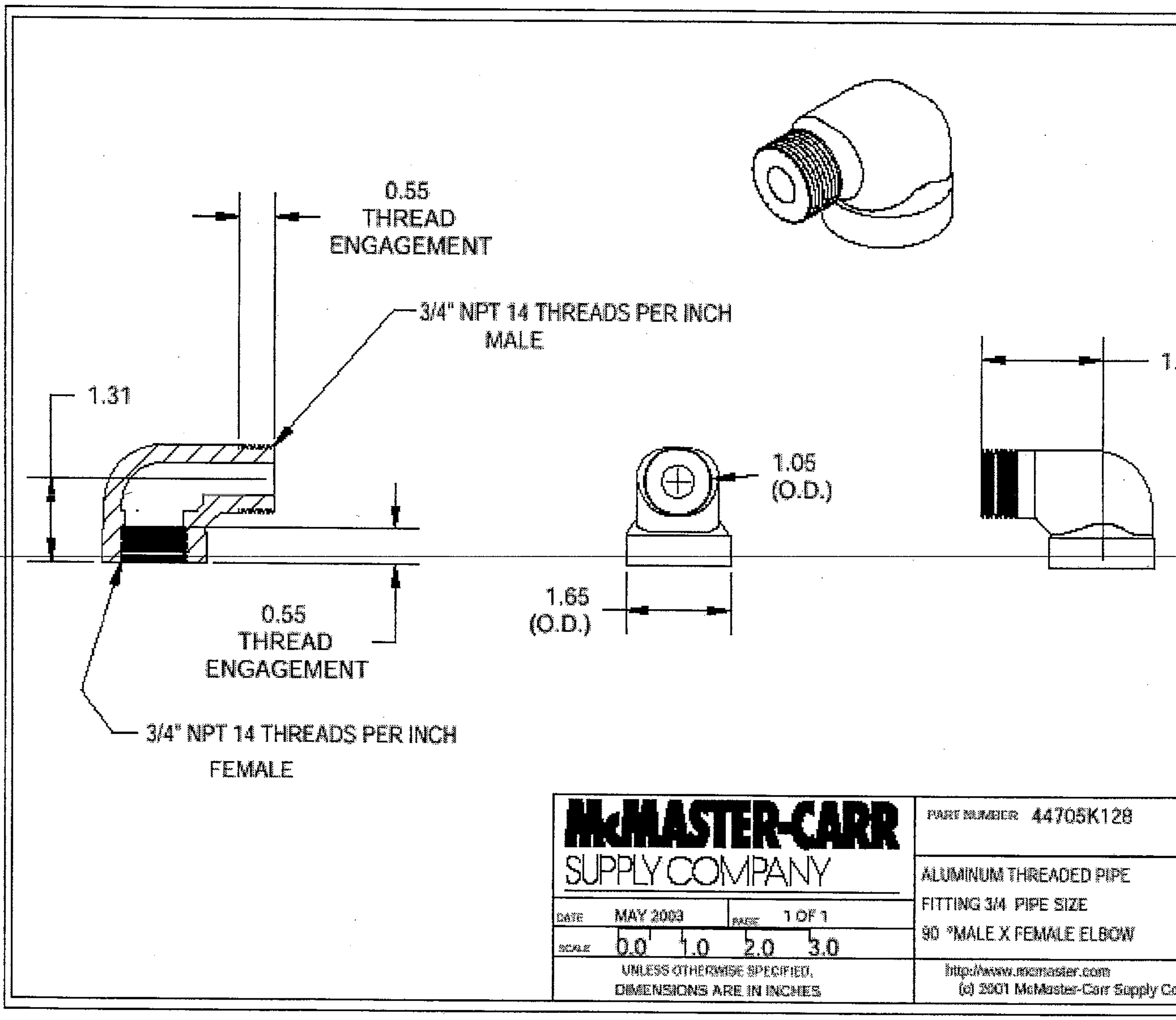
Pipe Fittings > Shape > Elbow Type Pipe to Pipe > Pipe Size

Aluminum Pipe Fittings and Pipe

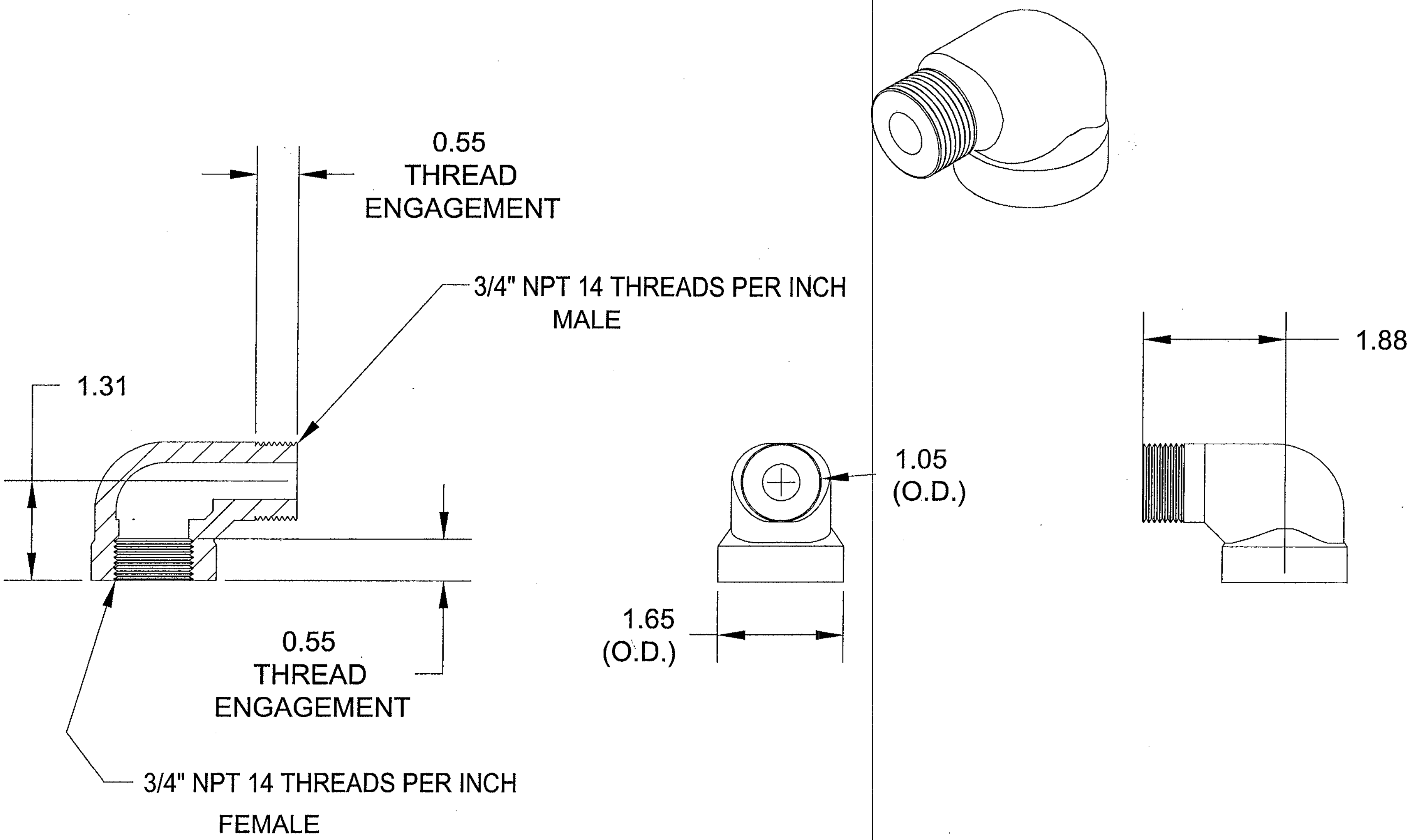
This item matches all of your specifications.



Part Number 44705K128	$
Shape	Elbow
Elbow Type Pipe to Pipe	Male x Female 90° Elbow
Pipe Size	3/4"
Pipe to Pipe Connection	NPT x NPT
Maximum Pressure (psi)	150
Specifications Met	ANSI B1.20.1



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



McMASTER-CARR
SUPPLY COMPANY

PART NUMBER 44705K128

ALUMINUM THREADED PIPE
FITTING 3/4 PIPE SIZE
90 ° MALE X FEMALE ELBOW

DATE MAY 2003
PAGE 1 OF 1
SCALE 0.0 1.0 2.0 3.0

UNLESS OTHERWISE SPECIFIED,
DIMENSIONS ARE IN INCHES

http://www.mcmaster.com

Designation: F 593 – 02$^{\epsilon 2}$

Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs[1]

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.

ϵ^1 NOTE—Table 2 was editorially corrected in February 2004.
ϵ^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	Alloys[A]	Condition[B]
1	304, 305, 384, 304 L, 18-9LW, 302HQ[D]	(CW) cold worked[C]
2	316, 316 L	(CW) cold worked[C]
3	321, 347	(CW) cold worked[C]
4	430[E]	(CW) cold worked[C]
5	410[F]	(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

[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:

Alloy Group	Condition Furnished Unless Otherwise Specified	Optional Conditions (must be specified)
1, 2, 3	CW	AF, A, SH
4	CW	A
5	H	HT
6	H	HT
7	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 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 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 ± 50°F (1038 ± 28°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 ± 50°F (788 ± 28°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 H is specified, the Martensitic Alloys 410, 416, and 416Se shall be hardened and tempered by heating to 1850 ± 50°F (1010 ± 28°C) sufficient for austenitization, held for at least ½ 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 ± 50°F (1010 ± 28°C) sufficient for austenitization, held for at least ½ 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 ± 25°F (1038 ± 14°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 ± 15°F (621 ± 8°C) for 4 h and air cooled to provide the specified properties.

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.

Alloy Group	Alloys
1	304, 304 L, 305, 384, 18-9LW, 302HQ[A]
2	316, 316 L
3	321, 347
4	430[B]
5	410[C]
6	431
7	630

[A] 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 Group	UNS Designation	Alloy	Composition, % maximum except as shown									
			Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Copper	Molybdenum	Others
							Austenitic 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[A]	. . .
1	S30323	303 Se	0.15	2.00	0.20	0.060	1.00	17.0 to 19.0	8.0 to 10.0	. . .	. . .	Se 0.15 min
1	S30400	304	0.08	2.00	0.045	0.030	1.00	18.0 to 20.0	8.0 to 10.5	1.00	. . .	. . .
1	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	. . .	. . .
1	S30500	305	0.12	2.00	0.045	0.030	1.00	17.0 to 19.0	10.5 to 13.0	1.00	. . .	. . .
1	S38400	384	0.08	2.00	0.045	0.030	1.00	15.0 to 17.0	17.0 to 19.0	. . .	0.50 max[A]	. . .
1	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	. . .	. . .
1	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	. . .	. . .
1	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	. . .	. . .
2	S31600	316	0.08	2.00	0.045	0.030	1.00	16.0 to 18.0	10.0 to 14.0	. . .	2.00 to 3.00	. . .
2	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	. . .
3	S32100	321	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	9.0 to 12.0	. . .	. . .	Ti 5× C min
3	S34700	347	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	9.0 to 13.0	. . .	. . .	Cb+Ta 10 × C min
							Ferritic Alloys					
4	S43000	430	0.12	1.00	0.040	0.030	1.00	16.0 to 18.0	. . .	. . .		. . .
4	S43020	430F	0.12	1.25	0.060	0.15 min	1.00	16.0 to 18.0			0.60 max[A]	
							Martensitic Alloys					
5	S41000	410	0.15	1.00	0.040	0.030	1.00	11.5 to 13.5	. . .	. . .		
5	S41600	416	0.15	1.25	0.060	0.15 min	1.00	12.0 to 14.0			0.60 max[A]	
5	S41623	416Se	0.15	1.25	0.060	0.060	1.00	12.0 to 14.0				Se 0.15 min
6	S43100	431	0.20	1.00	0.040	0.030	1.00	15.0 to 17.0	1.25 to 2.50	. . .	. . .	. . .
							Precipitation Hardening Alloy					
7	S17400	630	0.07	1.00	0.040	0.030	1.00	15.0 to 17.5	3.0 to 5.0	3.0 to 5.0	. . .	Cb+Ta 0.15–0.45

[A] At manufacturer's option, determined only when intentionally added.

TABLE 2 Mechanical Property Requirements[A]

Stainless Alloy Group	Condition[B]	Alloy Mechanical Property Marking	Nominal Diameter, in.	Full-Size Tests: Tensile Strength ksi[C]	Full-Size Tests: Yield Strength, ksi[D,C]	Full-Size Tests: Rockwell Hardness	Machined Specimen Tests: Tensile Strength ksi[C]	Machined Specimen Tests: Yield Strength, ksi[D,C]	Machined Specimen Tests: Elongation in 4 D, %
				Austenitic Alloys					
1 (303, 304, 304 L, 305, 384, XM1, 18-9LW, 302HQ, 303Se)	AF	F593A	¼ to 1½ , incl	65 to 85	20	B85 max	60	20	40
	A	F593B	¼ to 1½ , incl	75 to 100	30	B65 to 95	70	30	30
	CW1	F593C	¼ to ⅝ , incl	100 to 150	65	B95 to C32	95	60	20
	CW2	F593D	¾ to 1½ , incl	85 to 140	45	B80 to C32	80	40	25
	SH1	F593A	¼ to ⅝ , incl	120 to 160	95	C24 to C36	115	90	12
	SH2	F593B	¾ to 1, incl	110 to 150	75	C20 to C32	105	70	15
	SH3	F593C	1⅛ to 1¼ , incl	100 to 140	60	B95 to C30	95	55	20
	SH4	F593D	1⅜ to 1½ , incl	95 to 130	45	B90 to C28	90	40	28
2 (316, 316L)	AF	F593E	¼ to 1½ , incl	65 to 85	20	B85 max	60	20	40
	A	F593F	¼ to 1½ , incl	75 to 100	30	B65 to 95	70	30	30
	CW1	F593G	¼ to ⅝ , incl	100 to 150	65	B95 to C32	95	60	20
	CW2	F593H	¾ to 1½ , incl	85 to 140	45	B80 to C32	80	40	25
	SH1	F593E	¼ to ⅝ , incl	120 to 160	95	C24 to C36	115	90	12
	SH2	F593F	¾ to 1, incl	110 to 150	75	C20 to C32	105	70	15
	SH3	F593G	1⅛ to 1¼ , incl	100 to 140	60	B95 to C30	95	55	20
	SH4	F593H	1⅜ to 1½ , incl	95 to 130	45	B90 to C28	90	40	28
3 (321, 347)	AF	F593J	¼ to 1½ , incl	65 to 85	20	B85 max	60	20	40
	A	F593K	¼ to 1½ , incl	75 to 100	30	B65 to 95	70	30	30
	CW1	F593L	¼ to ⅝ , incl	100 to 150	65	B95 to C32	95	60	20
	CW2	F593M	¾ to 1½ , incl	85 to 140	45	B80 to C32	80	40	25
	SH1	F593J	¼ to ⅝ , incl	120 to 160	95	C24 to C36	115	90	12
	SH2	F593K	¾ to 1, incl	110 to 150	75	C20 to C32	105	70	15
	SH3	F593L	1⅛ to 1¼ , incl	100 to 140	60	B95 to C30	95	55	20
	SH4	F593M	1⅜ to 1½ , incl	95 to 130	45	B90 to C28	90	40	28
				Ferritic Alloys					
4 (430, 430F)	AF	F593X	¼ to 1½ , incl	55 to 75	30	B85 max	50	25	. . .
	A	F593N	¼ to 1½ , incl	55 to 75	30	B85 max	50	25	. . .
	CW1	F593V	¼ to ⅝ , incl	60 to 105	40	B75 to 98	55	35	. . .
	CW2	F593W	¾ to 1½ , incl	55 to 100	30	B65 to 95	50	25	. . .
				Martensitic Alloys					
5 (410, 416, 416Se)	H	F593P	¼ to 1½ , incl	110 to 140	90	C20 to 30	110	90	18
	HT	F593R	¼ to 1½ , incl	160 to 190	120	C34 to 45	160	120	12
6 (431)	H	F593S	¼ to 1½ , incl	125 to 150	100	C25 to 32	125	100	15
	HT	F593T	¼ to 1½ , incl	180 to 220	140	C40 to 48	180	140	10
				Precipitation Hardening Alloys					
7 (630)	AH	F593U	¼ to 1½ , 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

TABLE 3 Mechanical Test Requirements for Bolts and Studs[A]

Item	Nominal Length: Diameters ¾ in. and Less	Nominal Length: Diameters Over ¾ in.	Tensile Load, lbf	Full-Size Tests: Wedge Tensile Strength	Full-Size Tests: Axial Tensile Strength	Full-Size Tests: Yield Strength	Rockwell Hardness	Machined Specimen Tests: Tensile Strength	Machined Specimen Tests: Yield Strength	Machined Specimen Tests: Elongation
Square and hex bolts and hex cap screws	less than 2¼ *D*	less than 3*D*	all	Option A	Option B	B	Option C	B	B	B
	2¼ *D* and longer	3*D* and longer	120 000 max	mandatory	B	mandatory	B	B	B	B
			over 120 000	Option A	B	Option A	B	Option B	Option B	Option B
Studs and other bolts	less than 2¼ *D*	less than 3*D*	all	B	Option A	B	Option B	B	B	B
	2¼ *D* and longer	3*D* and longer	120 000 max	B	mandatory	mandatory	B	B	B	B
			over 120 000	B	Option A	Option A	B	Option B	Option B	Option B
Specials[C]	all	all	all	B	B	B	mandatory	B	B	B

[A] 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

Nominal Size, in. (*D*)	Coarse Threads–UNC: Threads/in.	Coarse Threads–UNC: Stress Area[A], in.²	Fine Threads-UNF: Threads/in.	Fine Threads-UNF: Stress Area[A], in.²	Thread Series–8 UN: Threads/in.	Thread Series–8 UN: Stress Area[A], in.²
¼ (0.250)	20	0.0318	28	0.0364	...	...
5⁄16 (0.3125)	18	0.0524	24	0.0580	...	...
3⁄8 (0.375)	16	0.0775	24	0.0878	...	...
7⁄16 (0.4375)	14	0.1063	20	0.1187	...	...
½ (0.500)	13	0.1419	20	0.1599	...	...
9⁄16 (0.5625)	12	0.1820	18	0.2030	...	...
⅝ (0.625)	11	0.2260	18	0.2560	...	...
¾ (0.750)	10	0.3340	16	0.3730	...	...
⅞ (0.875)	9	0.4620	14	0.5090	...	...
1.000	8	0.6060	12	0.6630	...	...
1⅛ (1.125)	7	0.7630	12	0.8560	8	0.790
1¼ (1.250)	7	0.9690	12	1.0730	8	1.000
1⅜ (1.375)	6	1.1550	12	1.3150	8	1.233
1½ (1.500)	6	1.4050	12	1.5810	8	1.492

[A] Tensile stress areas are computed using the following formula:

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

where:

A^s = tensile stress area, in.²,
D = nominal size (basic major diameter), in., and
n = number of threads per inch.

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	Number of Tests	Acceptance Criteria: Acceptance Number	Acceptance Criteria: Rejection Number
2 to 50	2	0	1
51 to 500	3	0	1
501 to 35 000	5	0	1
35 001 to 100 000	8	0	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 ⅜ 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.

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.

NRC · CNRC

From Discovery to Innovation...

The New Waterproof Housing (for the Victoria Sub Model)

Tim Osmond

Design and Fabrication Group

Work Term 4 – Mechanical Engineering

April 25th – August 19th, 2005

National Research Council Canada | Conseil national de recherches Canada

Canadä

Agenda

- Old Waterproof Housing
  - Problems
- New Waterproof Housing
  - Design Criteria
  - Features

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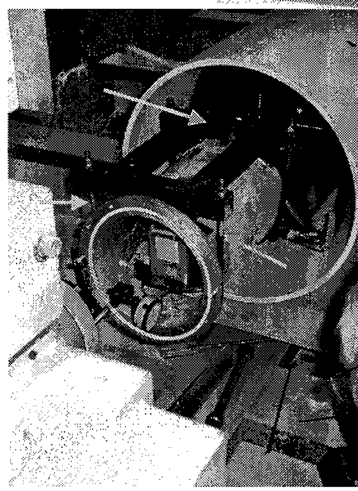
Previously Existing

- Cylindrical shape
- Cantilevered Frame
- Threaded Rods
- Gasket Sealed Front



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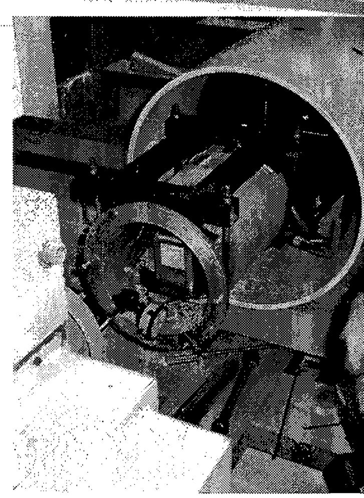
Problems

- Difficult to adjust
- Not Repeatable
- Difficult to access
- Small



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New Design

- Asked to design and fabricate a waterproof housing for:
  - the Victoria Sub Model
  - as piece of general equipment for the Institute

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General Design Criteria

- Completely Waterproof
- More Accessible
- Repeatable
- Larger
- Adjustable
- Versatile

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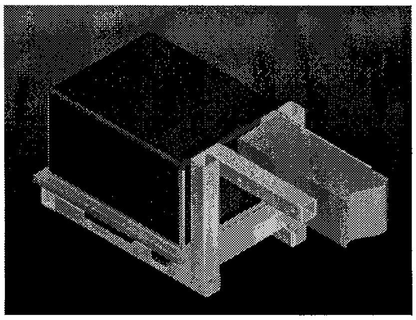
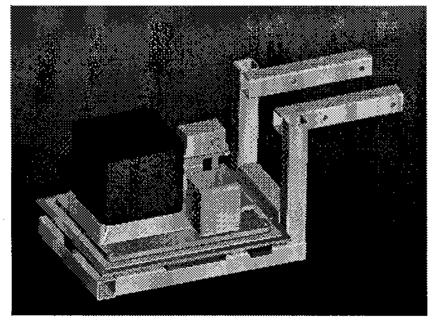
The New Waterproof Housing





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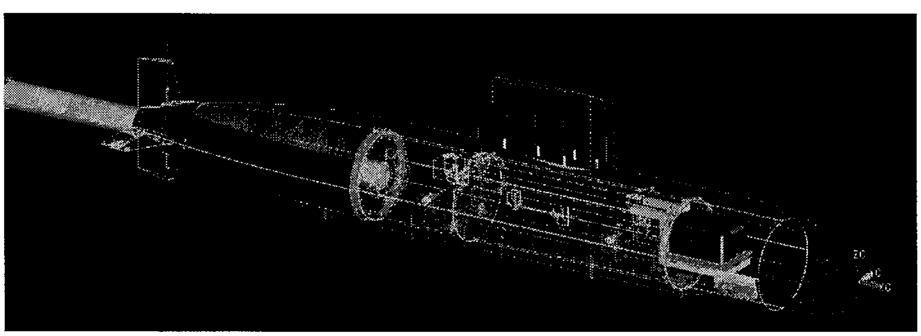
The New Waterproof Housing



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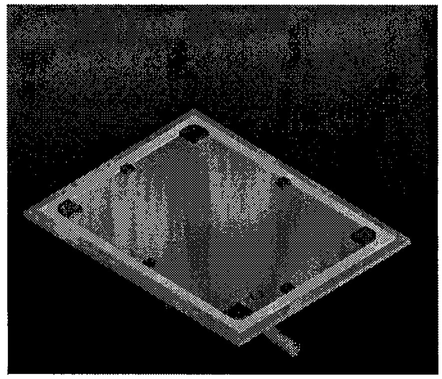
Waterproofing

- Minimized Corner Seams
- Water tight welds
- Neoprene Gasket
- Exit Pipe



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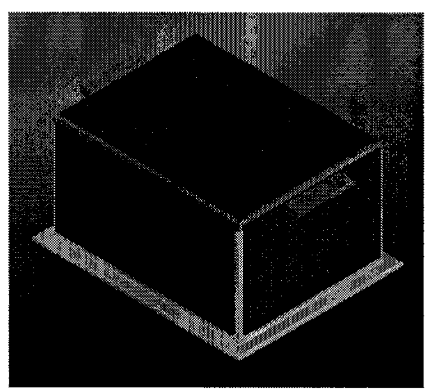
Accessibility

- Open Design
- Top Removal
- Lower Mount Frame
- Handles



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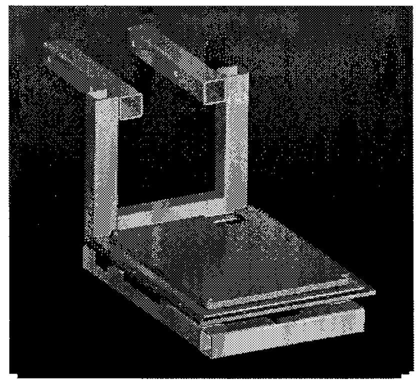
Repeatable

- Machined Surfaces
- Base Plate Pinned and Bolted to Frame
- Inner Plate Pinned and Bolted



NRC·CNRC

Size Accommodation

- Reasonable balance between enough size and low weight
- Fits PHINS, Motion Pak, 2 Inclinometers and a temperature/humidity gauge

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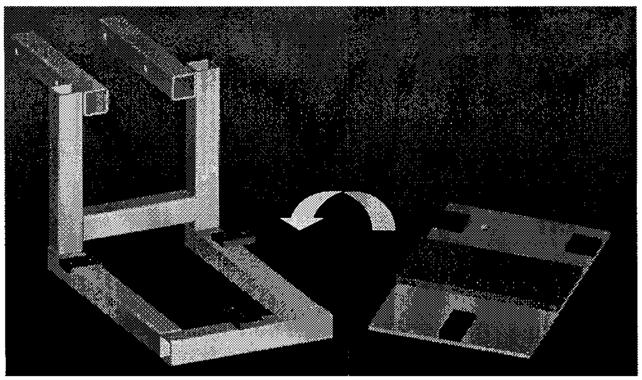
Adjustable

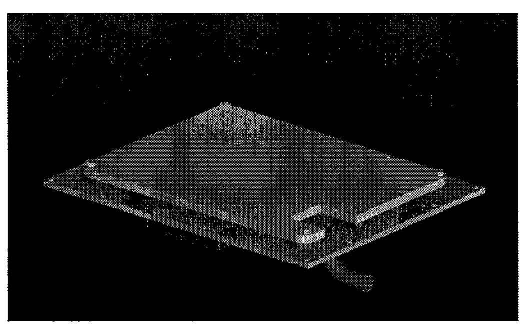
- 3 Pad System



NRC · CNRC

Versatile

- Inner Plate
  - Removable
  - Pinned in location
  - Ample stiffness
  - Offset not to flex



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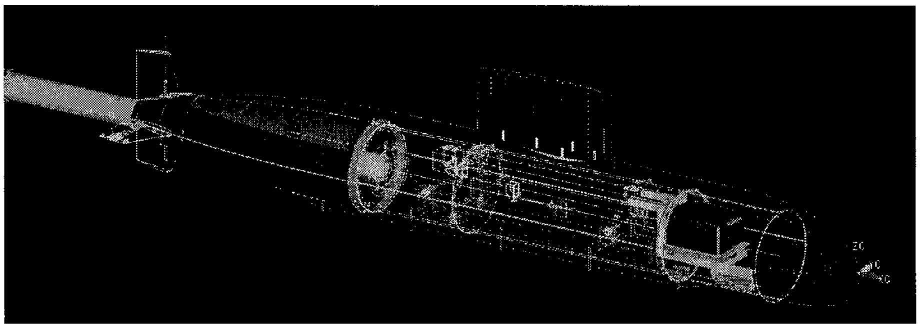
Conclusions

- Improved Design
- Useful Piece of Equipment



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Thank You

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