Net drag apparatus

Slade, T.

Laboratory Memorandum (National Research Council of Canada. Institute for Ocean Technology); no. LM-2005-11, 2006

National Research Council Canada
Conseil national de recherches Canada
Institute for Ocean Technology
Institut des technologies océaniques

Laboratory Memorandum

LM-2005-11

Net Drag Apparatus

T. Slade

May 2006

Canada

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2070	

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SUMMARY

Apparatus designed to measure the drag force on a 1m^2 piece of full-scale fishing net.

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NET DRAG APPARATUS

LM-2005-11

Trent Slade

May 2006

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PROJECT DESCRIPTION

To quantify the unit loading and current attenuation on samples of netting, this netting is to be used as containment for fish farms for deep water applications.

To develop a measuring apparatus that can be used either at IOT, (OEB, Tow Tank) or MUN, (Towing Tank, Flume Tank), and construct the apparatus. This will be done by measuring the hydrodynamic drag on samples of netting either by towing them or by subjecting the samples to a uniform current.

DESIGN CRITERIA

The apparatus will have a measurement system to measure the load on the netting only. The attachment points for the netting are not to be measured. The attachment points are to be wrapped in a foil shape that will be independent of the net drag. The apparatus will be adapted to be able to adjust angles of attack in 5deg increments up to 45deg. The foil shapes will have to stay aligned with the direction of travel or flow. The scale of the netting is 1:1 or 1 m^2, thus eliminating the potential errors in scaling but may cause errors due to edge effects of relatively small samples of full scale netting. The speed range is 0.1m/s to 3m/s, estimated loads on the net can be broken into three ranges Low 0-100N, Medium 100-500, High 500-2000N.

The 1m^2 of netting is to be submerged below the surface of the water by 0.5m. This gives an unsupported vertical leg length of 1.65m. Several designs

were investigated taking into account mostly the extreme moment that would be seen at the top of the vertical post. This moment was due to the initial tension in the net and the added load of the water going past the net. It was decided to go with a THK Linear Rail (SHS55+780L) and Block (SHS55 LCSSC1). These were chosen for the high end of the speed range; unfortunately the first test of the apparatus was at the slowest speed range, the current in the OEB. There was clearly too much seal friction in the SHS Blocks because of the Caged Ball Design.

A redesign was required, this time a Flat link design was conceived and analyzed using Algor. This design is only intended to measure loads in one direction.

DESIGN ANALYSIS AND RESULTS

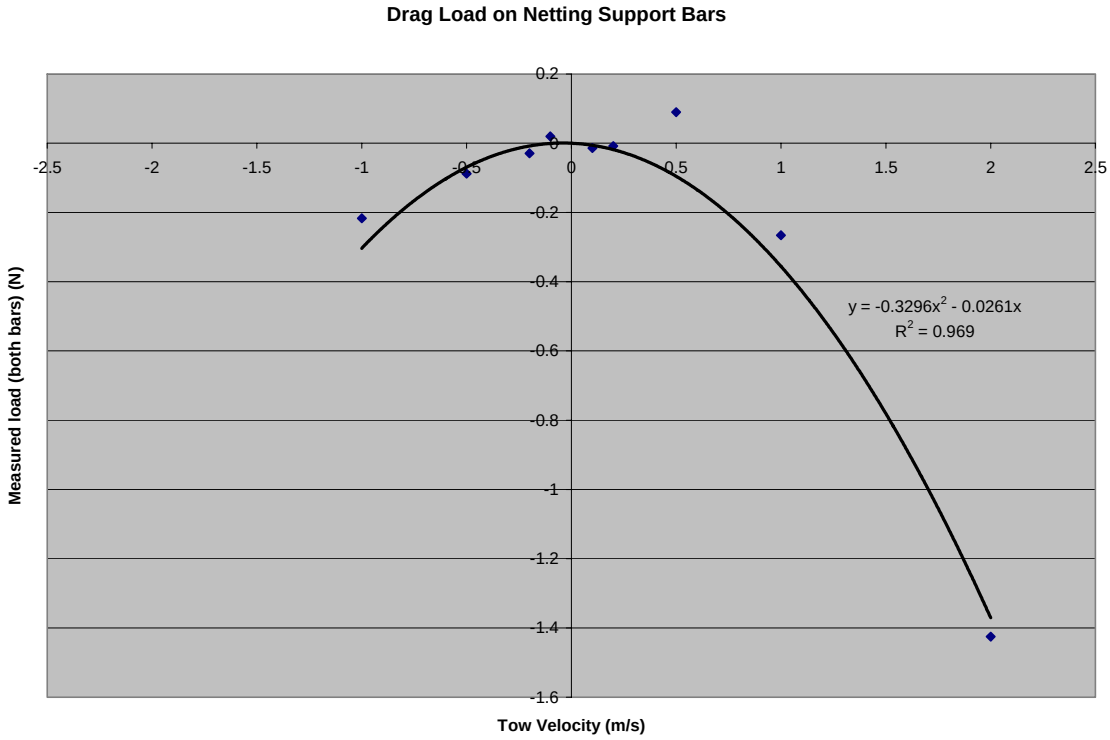
Following a rebuild on the instrumentation for measuring the drag on netting samples that replaced the pair of linear bearings with 8 flat spring steel pieces, which are 2” wide by .031” thick. These are sandwiched between two pieces of ¼” thick stainless steel just slightly shorter than the spring steel. There will still be a traditional style load cell flex link combination to measure the Drag force.

A Beam element model was created in Keycreator and imported into Algor for analysis. Results from the natural frequency and static stress are shown in Appendix A, Algor Results. The testing environment, with which this piece of apparatus could be subjected to, is quite variable. From slow steady state

current in the OEB and MUN Flume Tank, to high speed towing in either the Towing tank, Ice tank, Or Mun Tank. There will even be waves and current combined in the OEB, the waves would be in the rage of 0.3 Hz to 1 Hz. The Algor Modal analysis confirms that mode 1 – mode 4 is in the range of 20-22Hz, which is far above what the wave maker can generate. The load plot is a measure of how little load this apparatus could measure, a 1lb load was placed on the simulated net at the very bottom of the vertical struts and load on the load cell measured, in this case each load cell measured 0.4996lbs, for a total of .99914 lbs. In the displacement plot a 100lb load is placed on the same simulated net to determine the max displacement of the flex link. This measurement is also what the top and bottom parts of the dynamometer would move in relation to each other.

Shielding

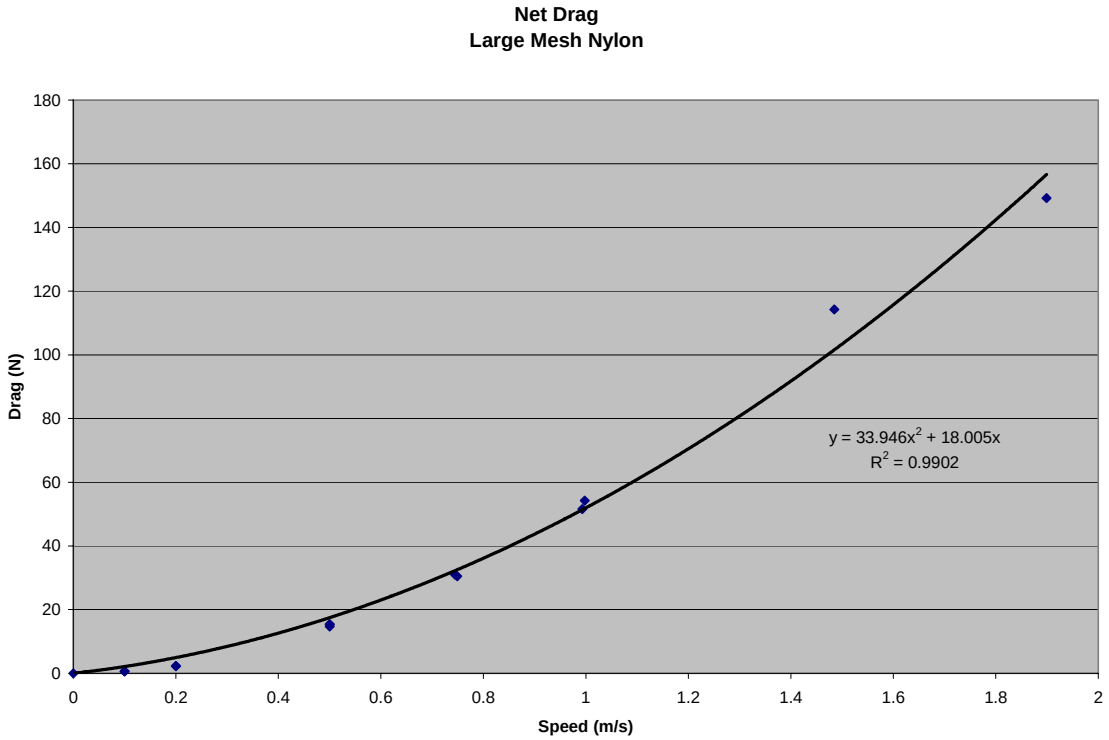
The shielding for the load measuring elements provided by the fairings has been shown in tests to reduce the load on the Net Support Bars to less than 1.5 N on both bars combined (see figure below) for tow speeds up to 2 m/s.



Steady Drag Tests

In terms of steady drag tows the device has shown excellent repeatability and an ability to discriminate loads of 1 N or less. The attached plots and statistics show results from low speed drag tests in both directions on a sample of large mesh nylon netting. The average values are less than 1 N and the device returns to its resting load within 0.5 N.

In addition the complete series of drag tests covering a range of speeds on this sample of netting are shown to be consistent without regard for tow direction. With reference to the chart below, the points below 1 m/s tow speed are all double values, one forward and one reverse. The negligible difference in values indicates that the device consistently returns to zero, does not exhibit any hysteresis or stickiness and is consistent in measurement.



Unsteady Drag Tests

Additional tests on the same netting sample were conducted in waves. Raw data is attached as a plot without statistics and no further analysis has yet been conducted. The data exhibits a bump in each load cycle. This may be associated with the instrumentation passing through zero load, or it may be associated with

the net transition from positive deformation to negative deformation associated with changes in flow direction. At present we believe that the more likely cause is vibration in the supporting structure, which was picked up by the instrumentation.

SUMMARY

The device is performing well and certainly at, if not above, expectations. The sensitivity, repeatability and lack of hysteresis will provide the ability to measure loads under the full range of netting and flow conditions contemplated for the net drag and added mass study.

DRAWINGS

Project 2070 Aquaculture Master Drawing List

DOC #	DOC Type	Owner	File Name	Description
XXX	CKD	T.Slade	Net.ckd	Master File Solid Assembly
T01	CKD	T.Slade	2070T01	Vertical Leg Assembly
T02	CKD	T.Slade	2070T01	Vertical Leg Fabrication
T03	CKD	T.Slade	2070T01	Vertical Leg Machining
T04	CKD	T.Slade	2070T04	Top Brace Mounting Bar
T05	CKD	T.Slade	2070T04	Top Brace Mounting Bar Fabrication
T06	CKD	T.Slade	2070T04	Top Brace Mounting Bar Machining
T06B	CKD	T.Slade	2070T04	Top Brace Plate Machining
T07	CKD	T.Slade	2070T07	Top Brace Cross Bar
T08	CKD	T.Slade	2070T07	Top Brace Cross Bar Fabrication
T09	CKD	T.Slade	2070T07	Top Brace Cross Bar Machining Left
T10	CKD	T.Slade	2070T07	Top Brace Cross Bar Machining Right
T11	CKD	T.Slade	2070T11	Top Four Bar
T12	CKD	T.Slade	2070T11	Top Four Bar Fabrication
T13	CKD	T.Slade	2070T11	Top Four Bar Machining
T14	CKD	T.Slade	2070T14	Angle Brace
T15	CKD	T.Slade	2070T14	Angle Brace Fabrication
T16	CKD	T.Slade	2070T14	Angle Brace Machining
T17	CKD	T.Slade	2070T17	Load Cell Mount
T18	CKD	T.Slade	2070T17	Load Cell Mount Fabrication
T19	CKD	T.Slade	2070T17	Load Cell Mount Machining
T20	CKD	T.Slade	2070T20	100lb Flex Link
T21	CKD	T.Slade	2070T21	Net Support
T22	CKD	T.Slade	2070T22	Net Support Part 1
T23	CKD	T.Slade	2070T23	Net Support Part 2
T24	CKD	T.Slade	2070T24	Foil
T25	CKD	T.Slade	2070T24	Foil Fabrication/Machining
T26	CKD	T.Slade	2070T24	Foil Parts
T27	CKD	T.Slade	2070T24	Foil Wedges
T28	CKD	T.Slade	2070T28	OEB Mount
T29	CKD	T.Slade	2070T28	OEB Mount Fabrication
T30	CKD	T.Slade	2070T28	OEB Mount Machining
Flat Links	CKD	T.Slade	Flat_Link	Flat Links Master
XXX	CKD	T.Slade	Flat_link_dyno	Flat link dyno Master File
X01	CKD	T.Slade	2070X01	Vertical Post Assembly
X02	CKD	T.Slade	2070X01	Vertical Post Fabrication
X03	CKD	T.Slade	2070X01	Vertical Post Machining
X04	CKD	T.Slade	2070X04	Ground Side Assembly
X05	CKD	T.Slade	2070X04	Ground Side Fabrication
X06	CKD	T.Slade	2070X04	Ground Side Machining
X07	CKD	T.Slade	2070X04	Load Cell Mounts
X08	CKD	T.Slade	2070X08	Foil Assembly
X09	CKD	T.Slade	2070X09	Flex Links

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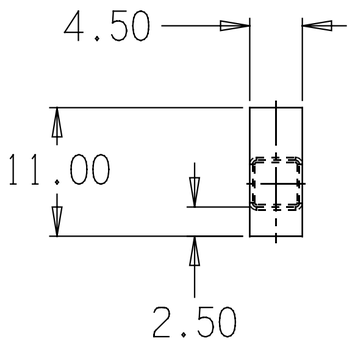

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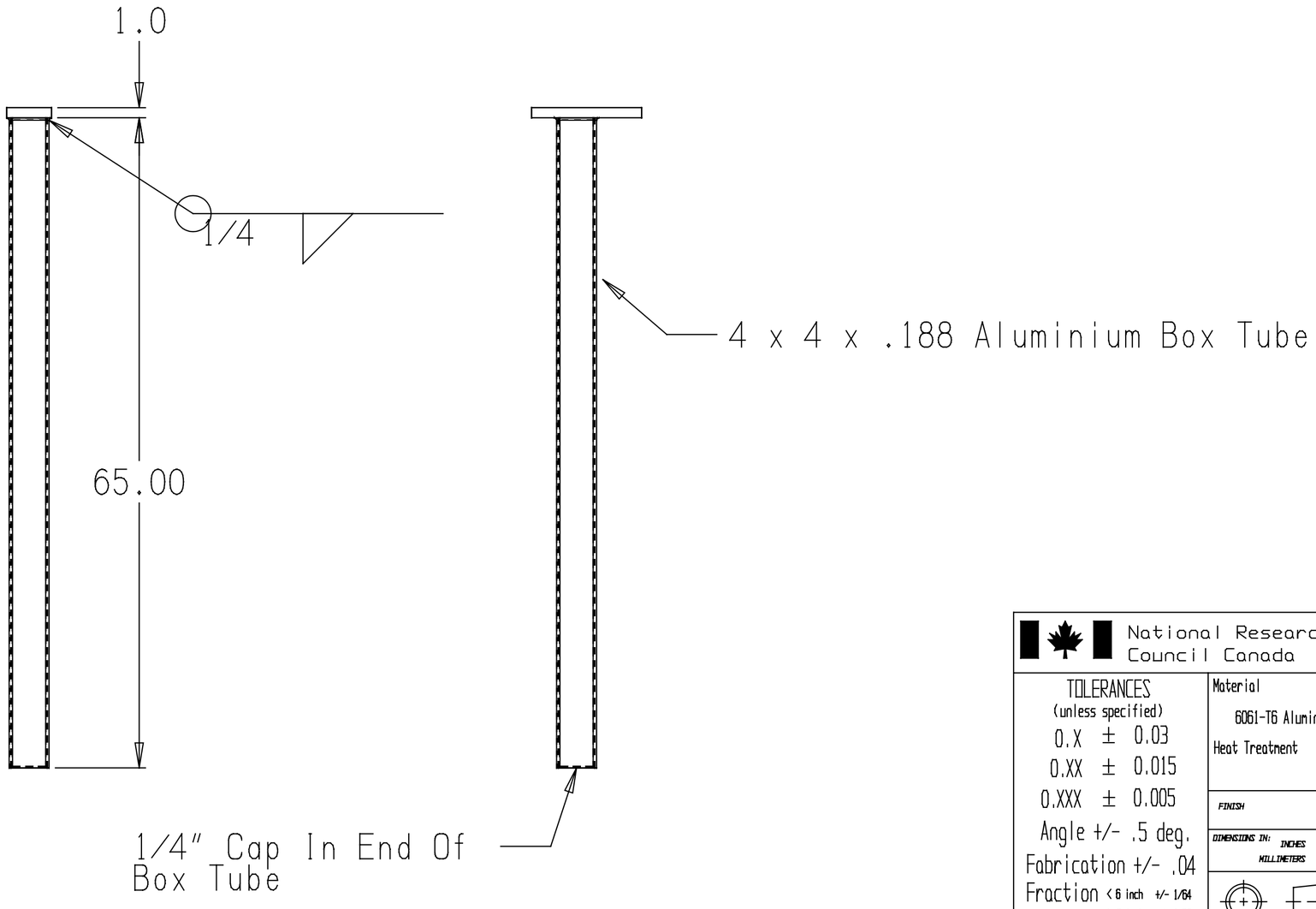

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0.XX ± 0.015	FINISH:
0.XXX ± 0.005	DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
Angle +/- .5 deg.	THIRD ANGLE
Fabrication +/- .04	
Fraction < 6 inch +/- 1/64	
> 6 inch +/- 1/32	

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

TRAX	2070
DRAWN	T.Slade
APPROVED	
Quantity	2
TITLE	Aquaculture Net Drag Vertical Posts Fab.
A2	NUMBER 2070T02 REV
SCALE	1:10
DATE	22-Oct-2004
SHEET	1 OF 1

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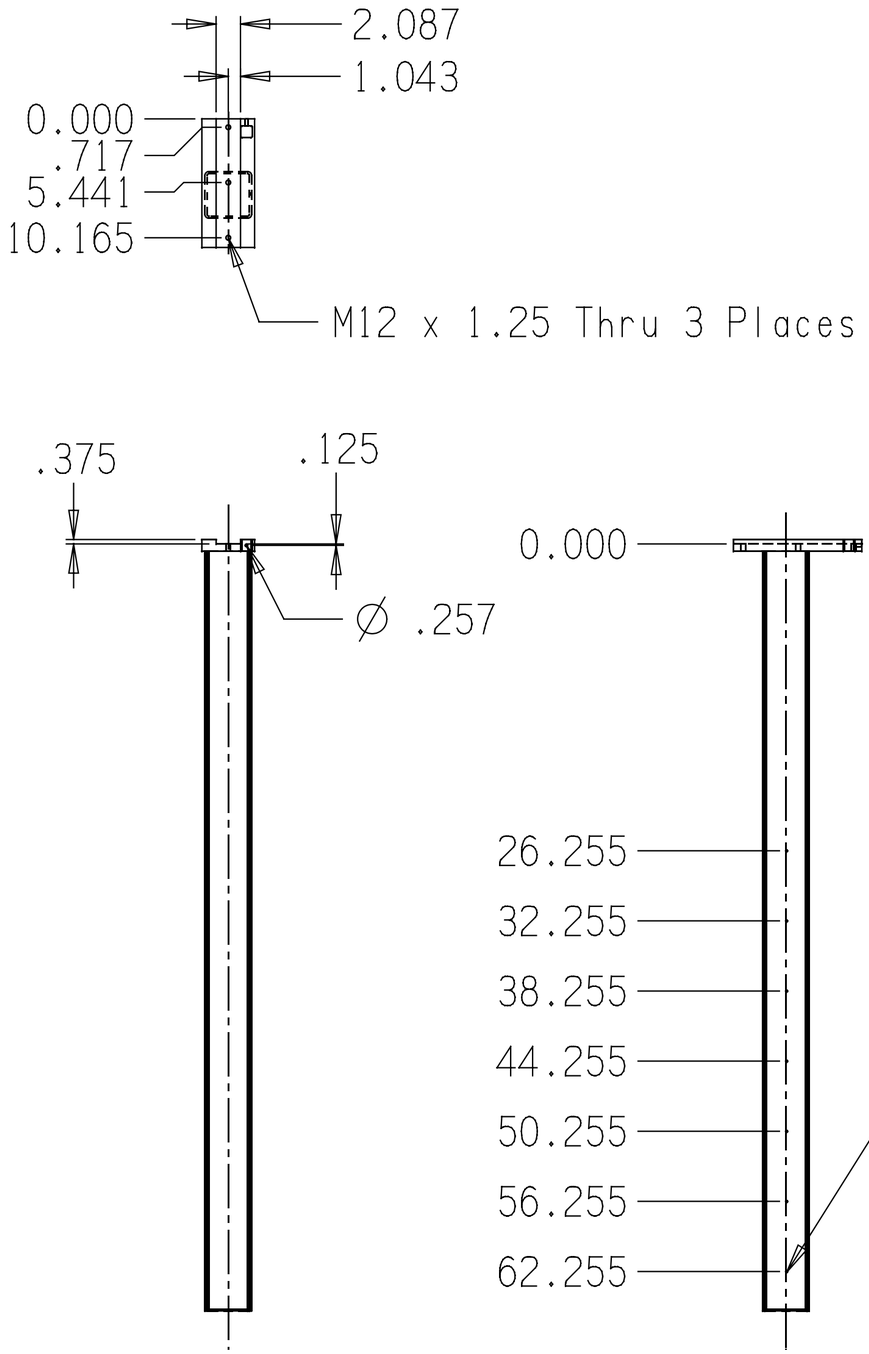

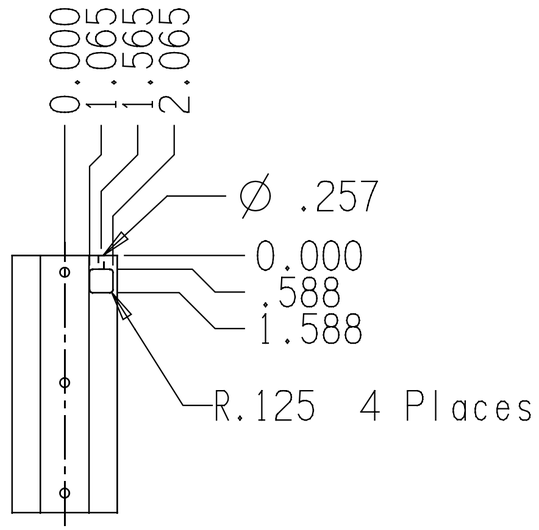

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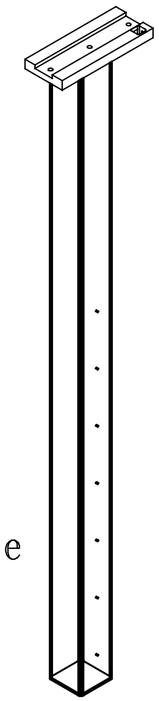

Note :

2 Required / 1 As shown / 1 Mirror Image

National Research Council Canada / Conseil national de recherches Canada — NRC-CNRC			
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NO.	ZONE	DESCRIPTION	DATE	APPROVED
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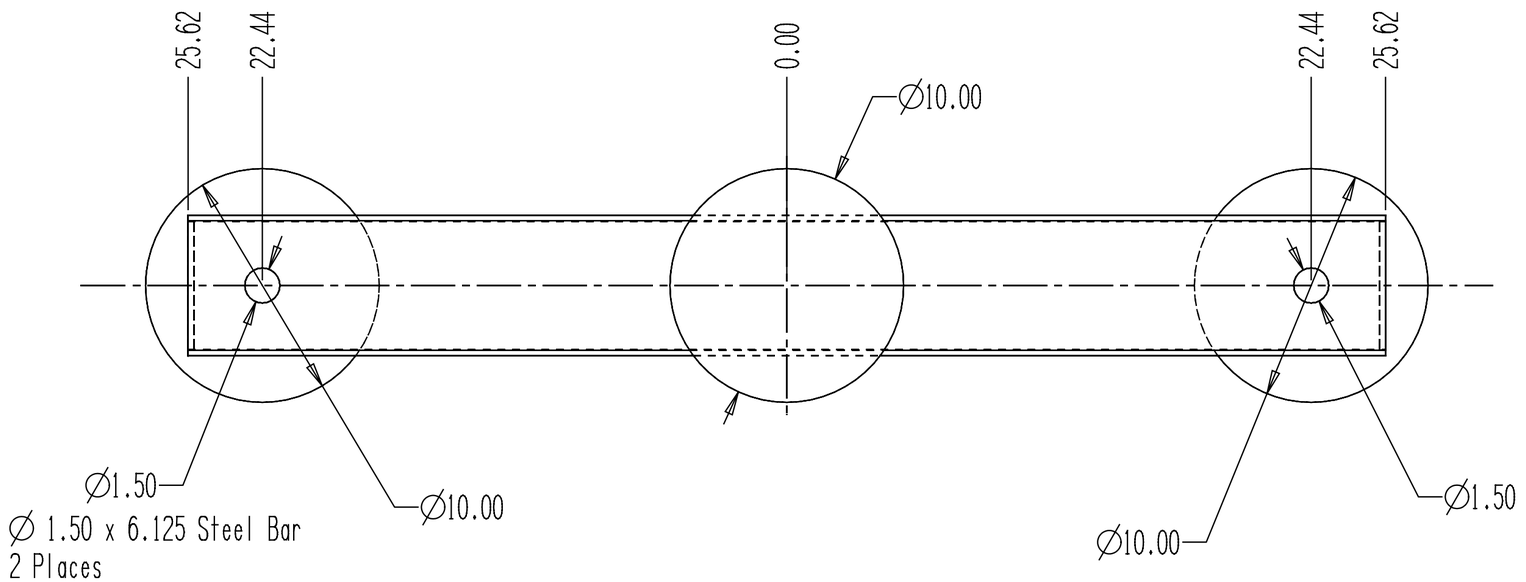
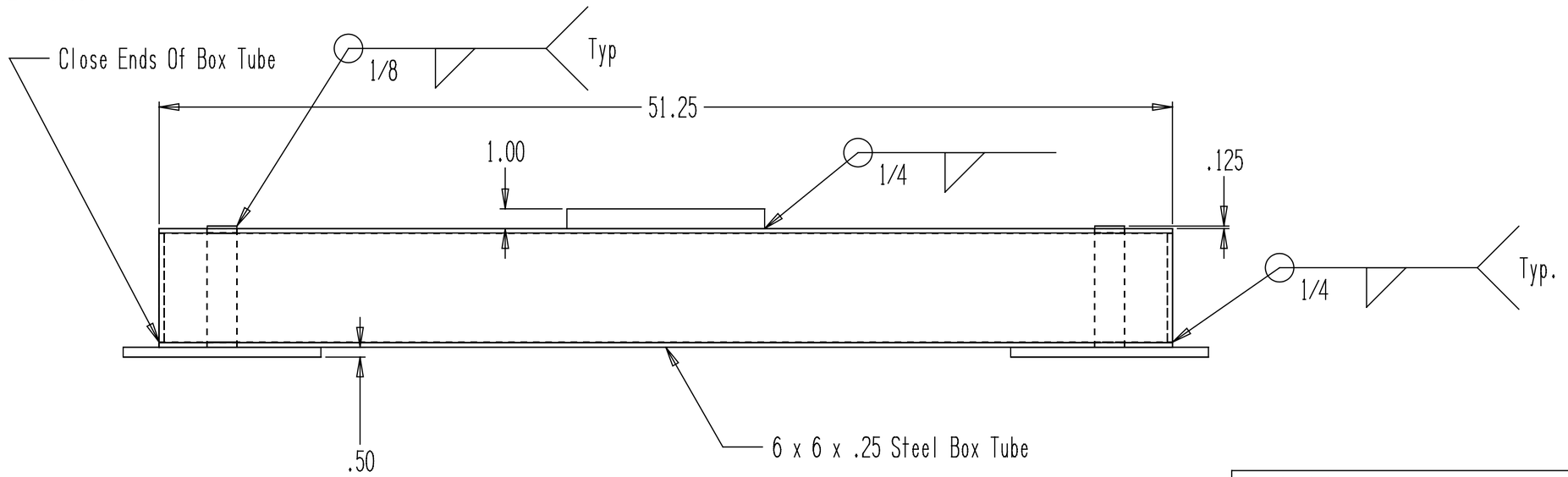
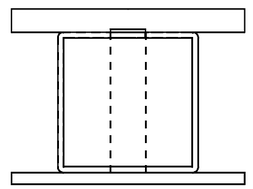


Ø 1.50 x 6.125 Steel Bar
2 Places





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

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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	As Noted Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5

TRAX	TITLE
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APPROVED:	
Quantity: 1	NUMBER: A2 2070T05 REV
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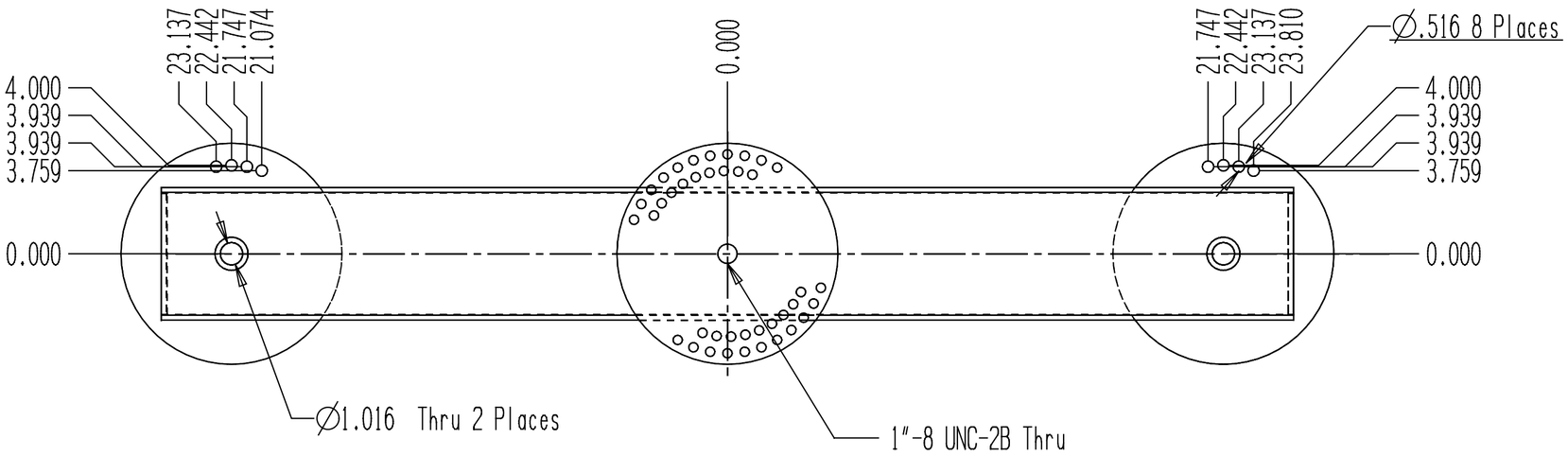

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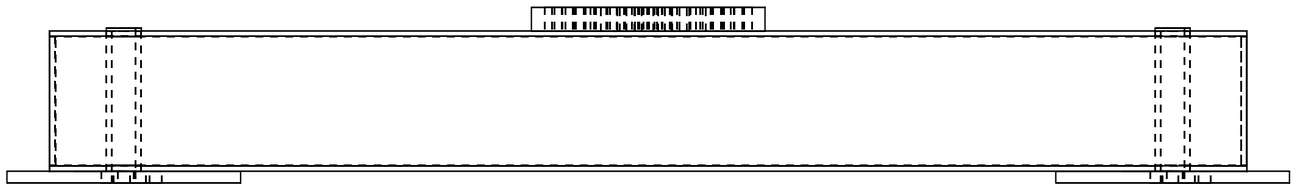

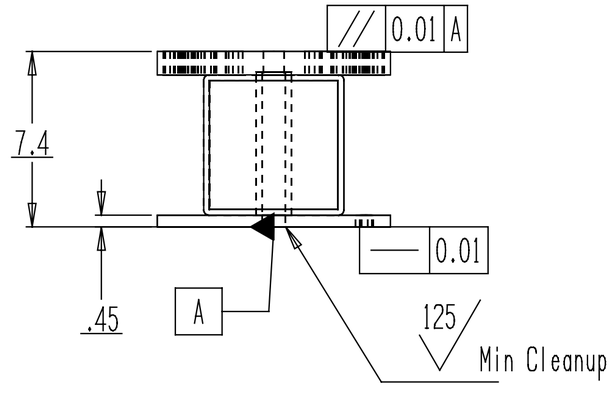

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TITLE: Aquaculture Net Drag Top Brace Machining

A2 | NUMBER 2070T06 | REV

SCALE 1:5 | DATE 22-Oct-2004 | SHEET 1 OF 1

REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED
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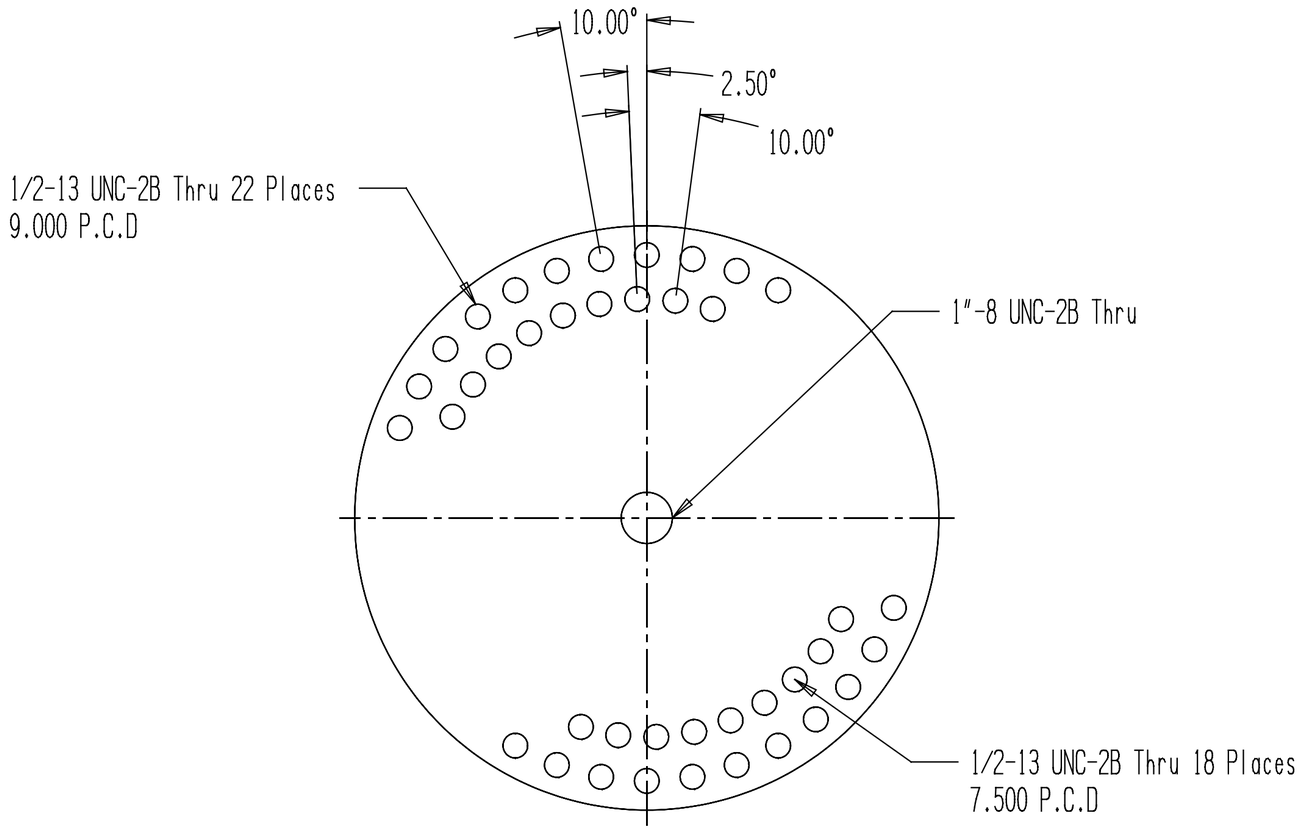

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TOLERANCES (unless specified)
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0.XX ± 0.015
0.XXX ± 0.005
Angle +/- .5 deg.
Fabrication +/- .04
Fraction < 6 inch +/- 1/64
> 6 inch +/- 1/32

Material: As Noted
Heat Treatment
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: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 1

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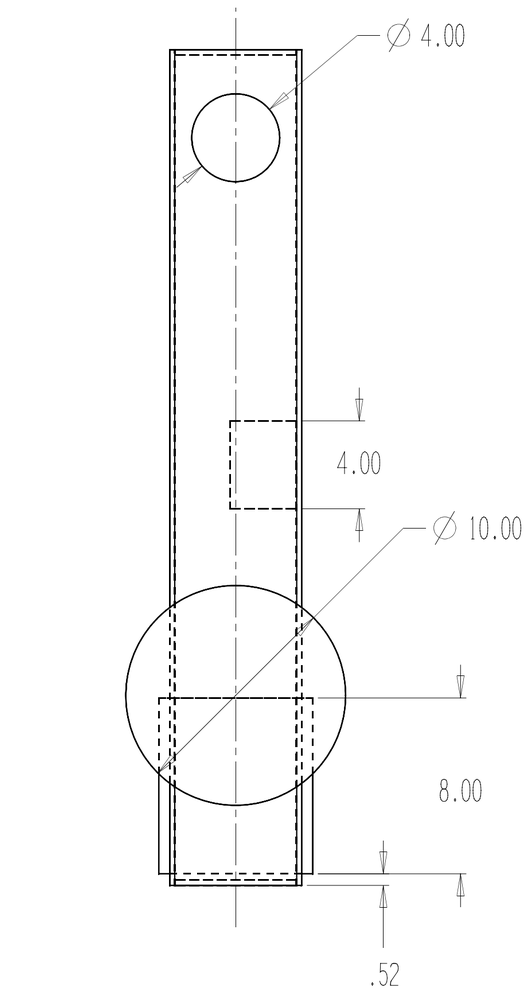

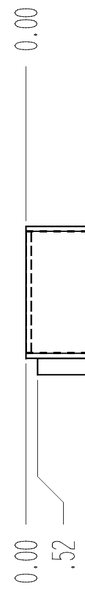

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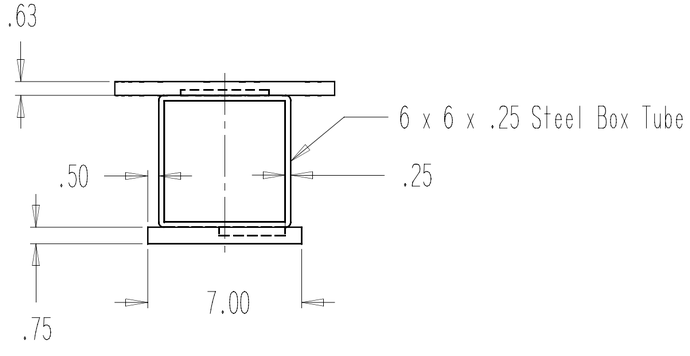

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TOLERANCES (unless specified)
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0.XX ± 0.015
0.XXX ± 0.005
Angle +/- .5 deg.
Fabrication +/- .04
Fraction < 6 inch +/- 1/64
> 6 inch +/- 1/32

Material: As Noted
Heat Treatment
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

TRAK 2070
DRAWN T.Slade
APPROVED
Quantity 2

TITLE: Aquaculture Net Drag Top Brace Cross Bar Fab.
A2 | NUMBER 2070T08 | REV
SCALE 1:5 | DATE 25-Oct-2004 | SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
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Notes:
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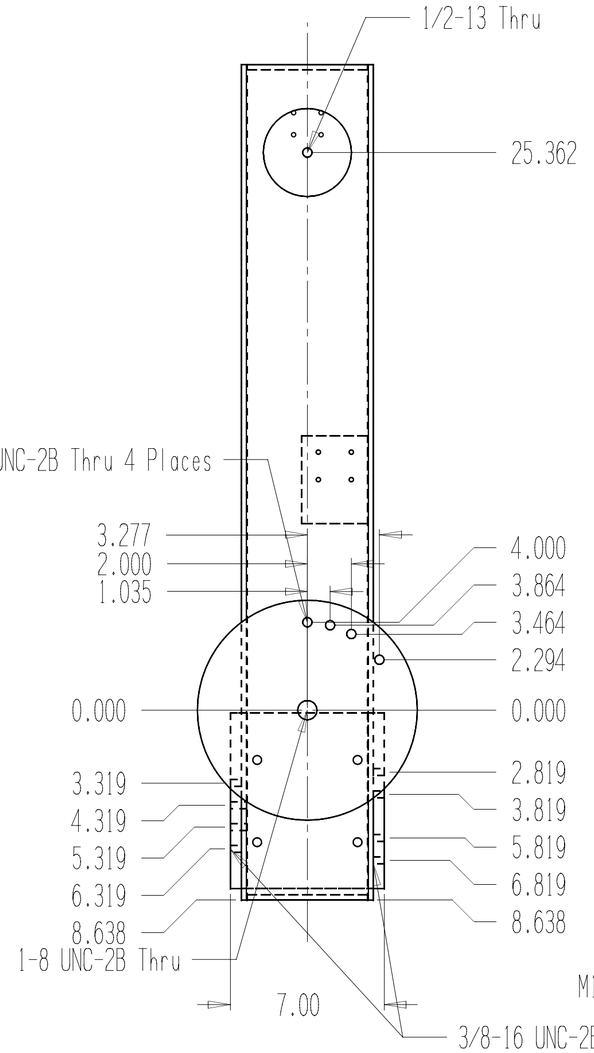

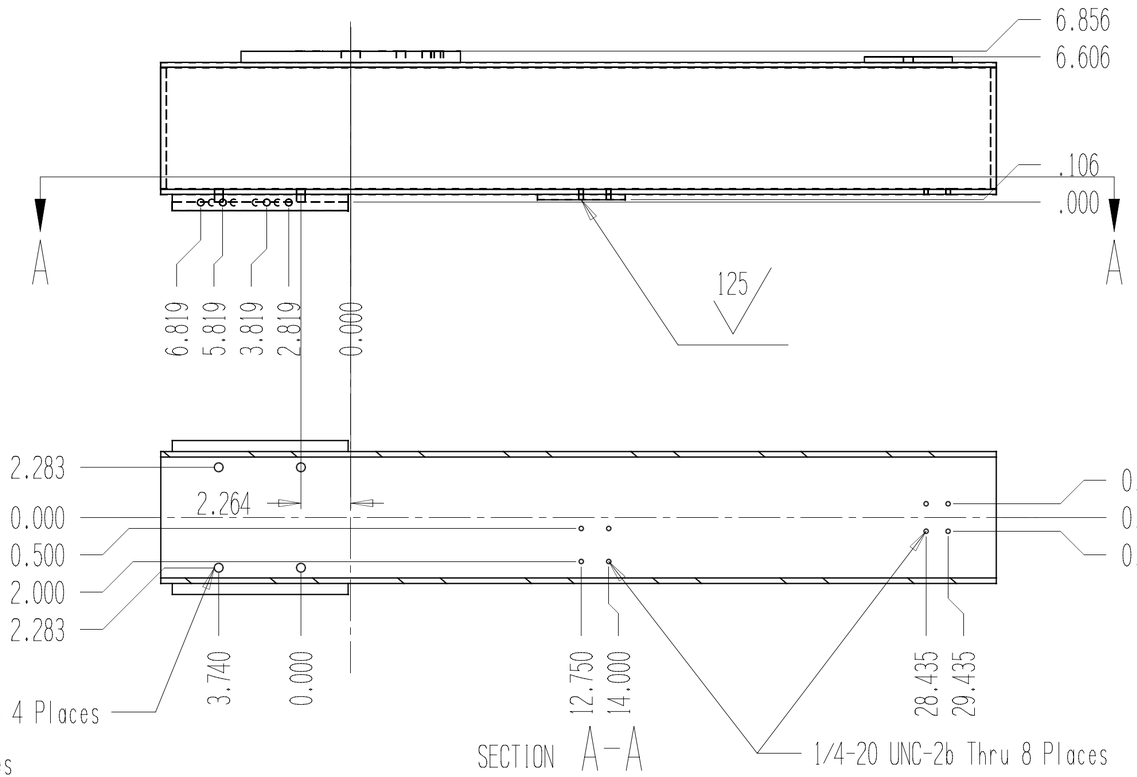

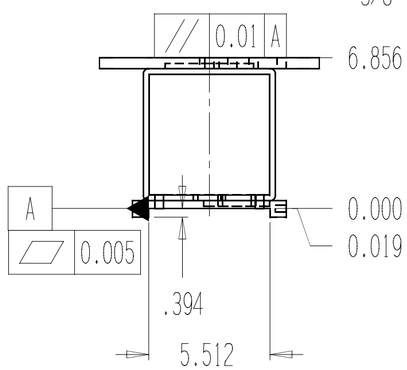

National Research Council Canada / Conseil national de recherches Canada — NRC-CNRC

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

Material: As Noted
Heat Treatment
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: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 1

TITLE: Aquaculture Net Drag Top Brace Cross Bar Mach.
A2
NUMBER: 2070T09
REV:
SCALE: 1:5
DATE: 25-Oct-2004
SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
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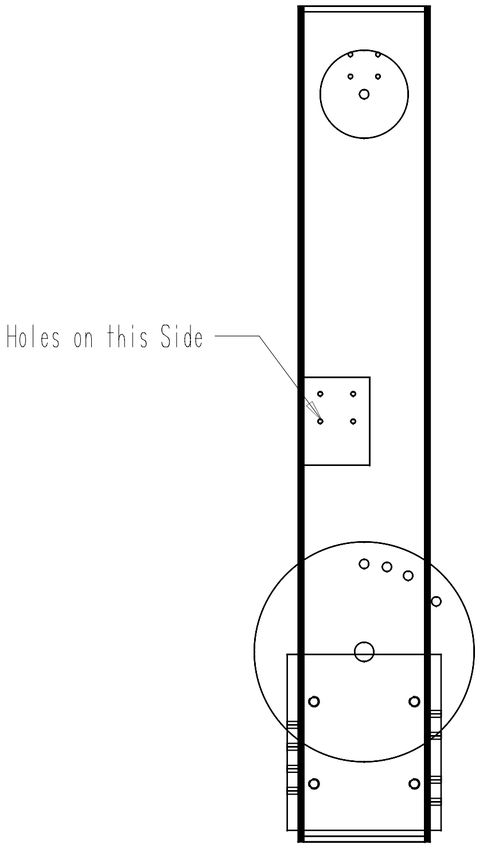
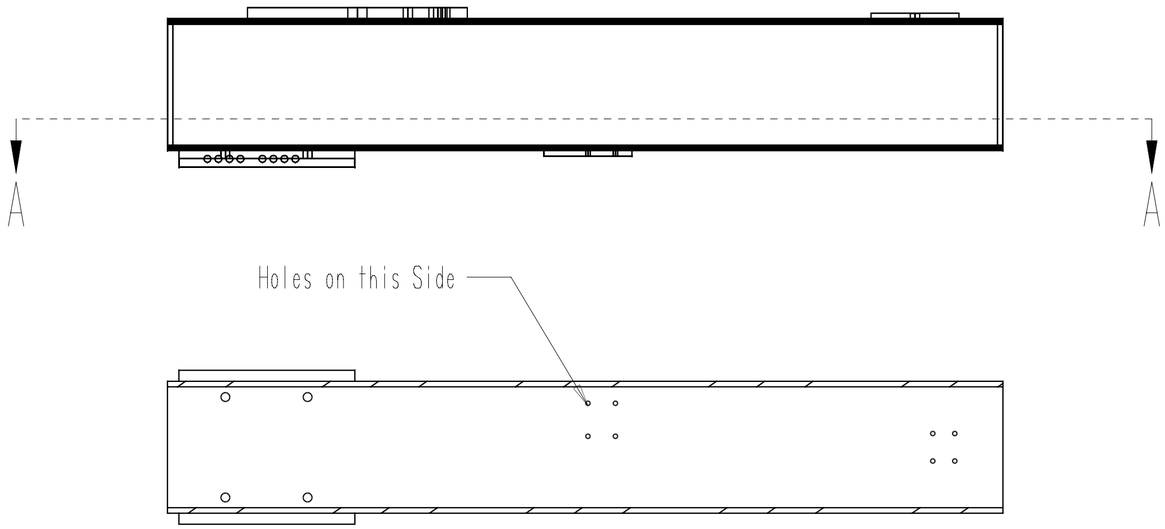
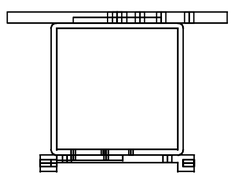




SECTION A-A



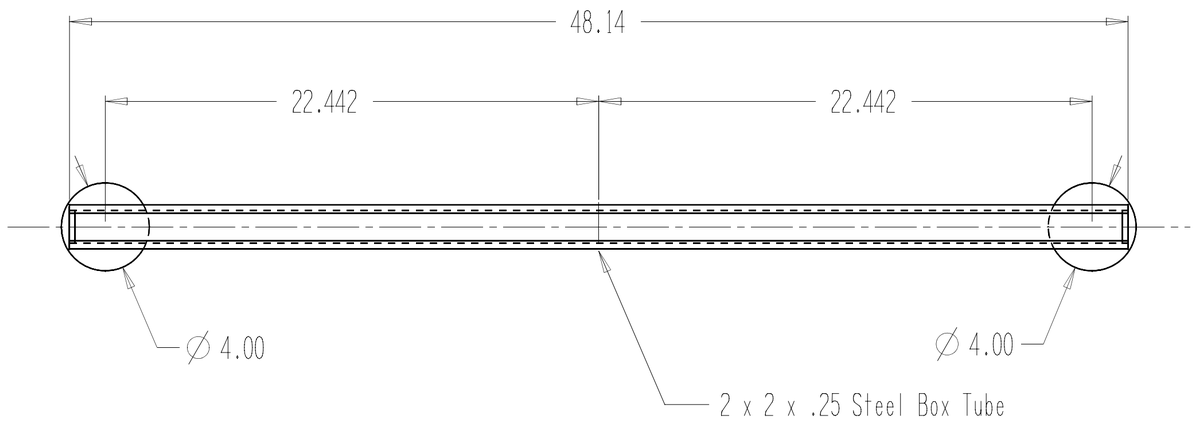
Note:

This Part Same as 2070T09 Except As Shown

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

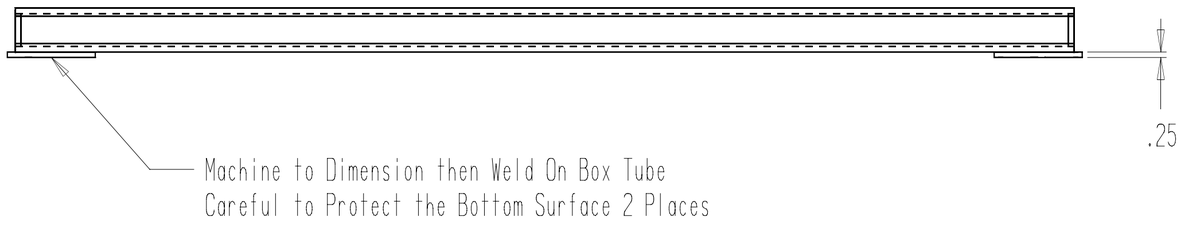
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: As Noted Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAK: 2070 DRAWN: T.Slade APPROVED: Quantity: 1 TITLE: Aquaculture Net Drag Top Brace Cross Bar Mach. A2 | NUMBER: 2070T10 | REV: SCALE: 1:5 | DATE: 25-Oct-2004 | SHEET 1 OF 1

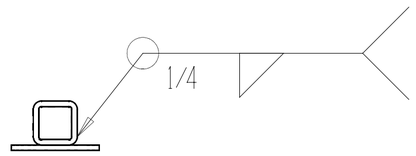
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	



Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T11.ckd





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: As Noted
Heat Treatment:
FINISH:
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

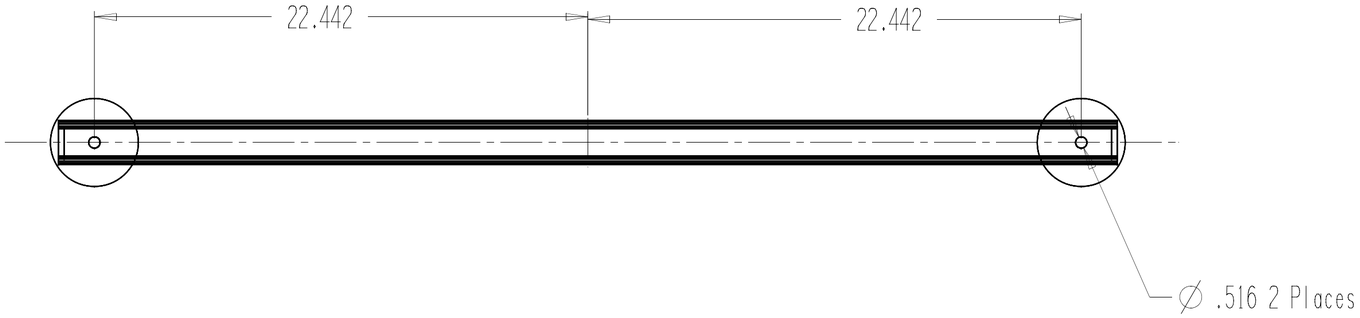
Institute for Marine Dynamics
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

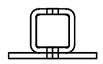
TRAX: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 1

TITLE: Aquaculture Net Drag Top Four Bar Fabrication
A2 | NUMBER: 2070T12 | REV:
SCALE: 1:5 | DATE: 22-Oct-2004 | SHEET 1 OF 1

REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	





Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T11.ckd

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: As Noted
Heat Treatment:
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

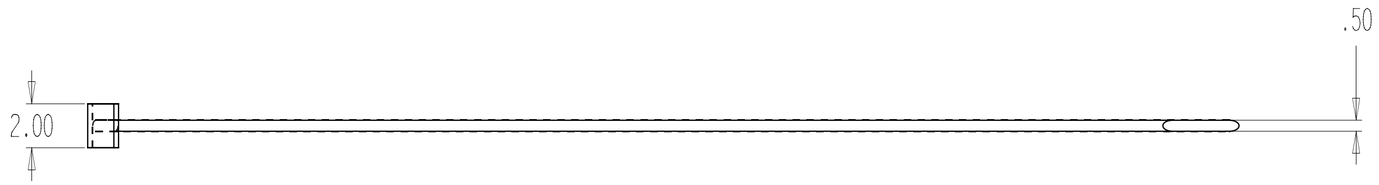
TRAX: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 1

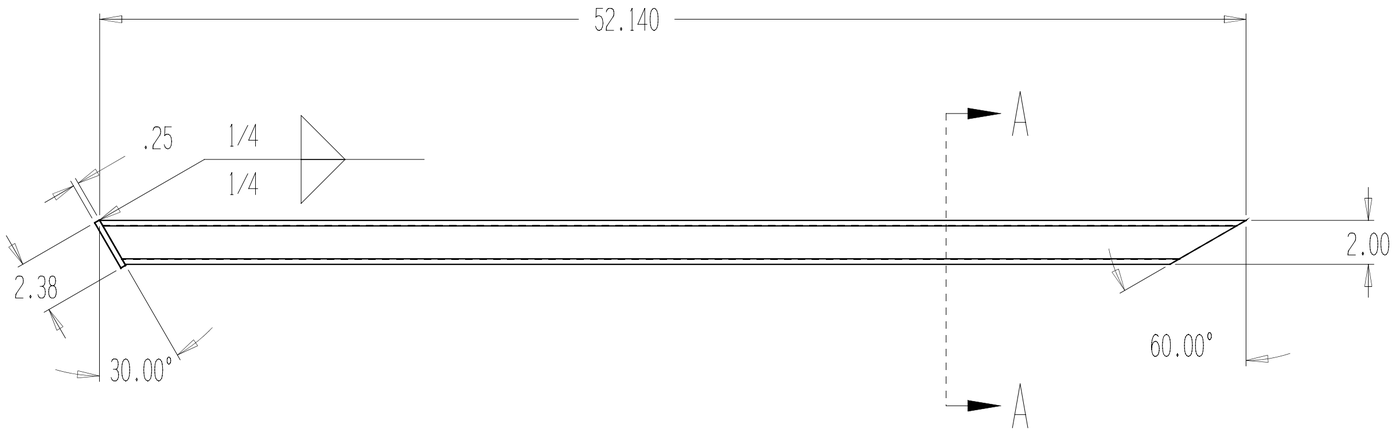
TITLE: Aquaculture Net Drag Top Four Bar Machining
A2 | NUMBER: 2070T13 | REV:
SCALE: 1:5 | DATE: 22-Oct-2004 | SHEET 1 OF 1

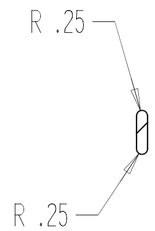
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T14.ckd







SECTION A-A

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

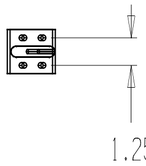
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: 6061-T6 Aluminium Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAX 2070 DRAWN T.Slade APPROVED Quantity 2 TITLE: Aquaculture Net Drag Angle Brace Fabrication A2 NUMBER 2070T15 REV SCALE 1:5 DATE 22-Oct-2004 SHEET 1 OF 1

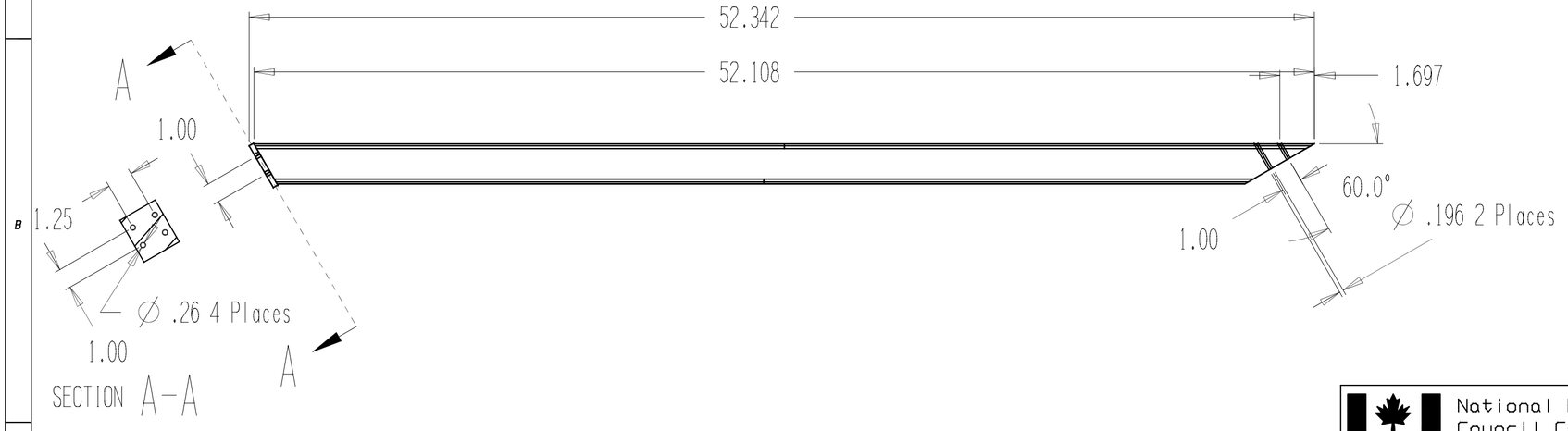
REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T14.ckd





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 Aluminium
Heat Treatment:
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

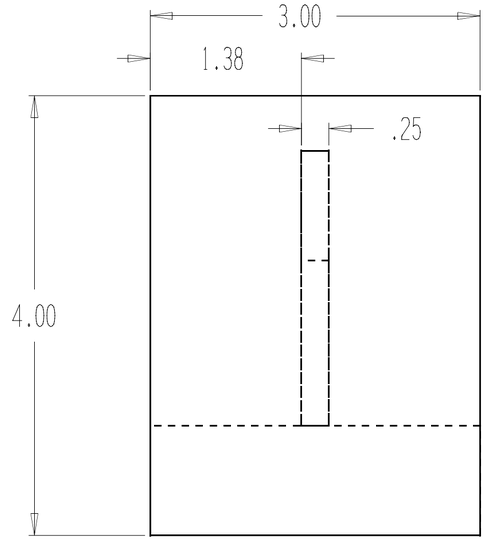
TRAX: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 2

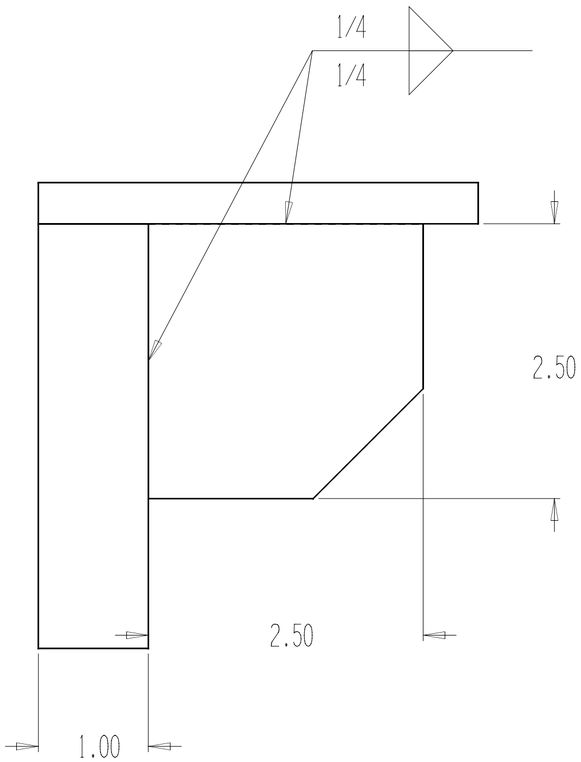
TITLE: Aquaculture Net Drag Angle Brace Machining
A2 | NUMBER: 2070T16 | REV:
SCALE: 1:5 | DATE: 22-Oct-2004 | SHEET 1 OF 1

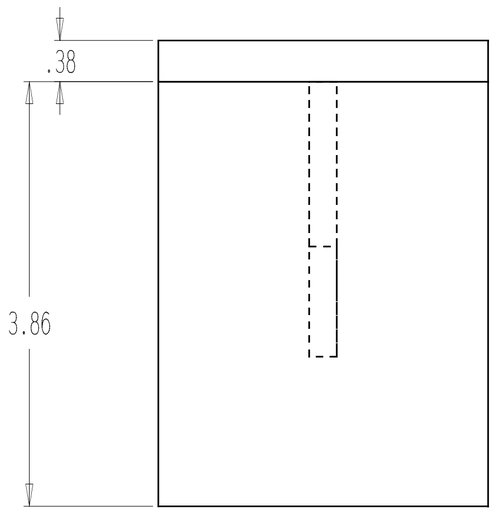
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Remove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T17.ckd







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

Institute for Marine Dynamics
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: 6061-T6 Aluminium
Heat Treatment:
FINISH:
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

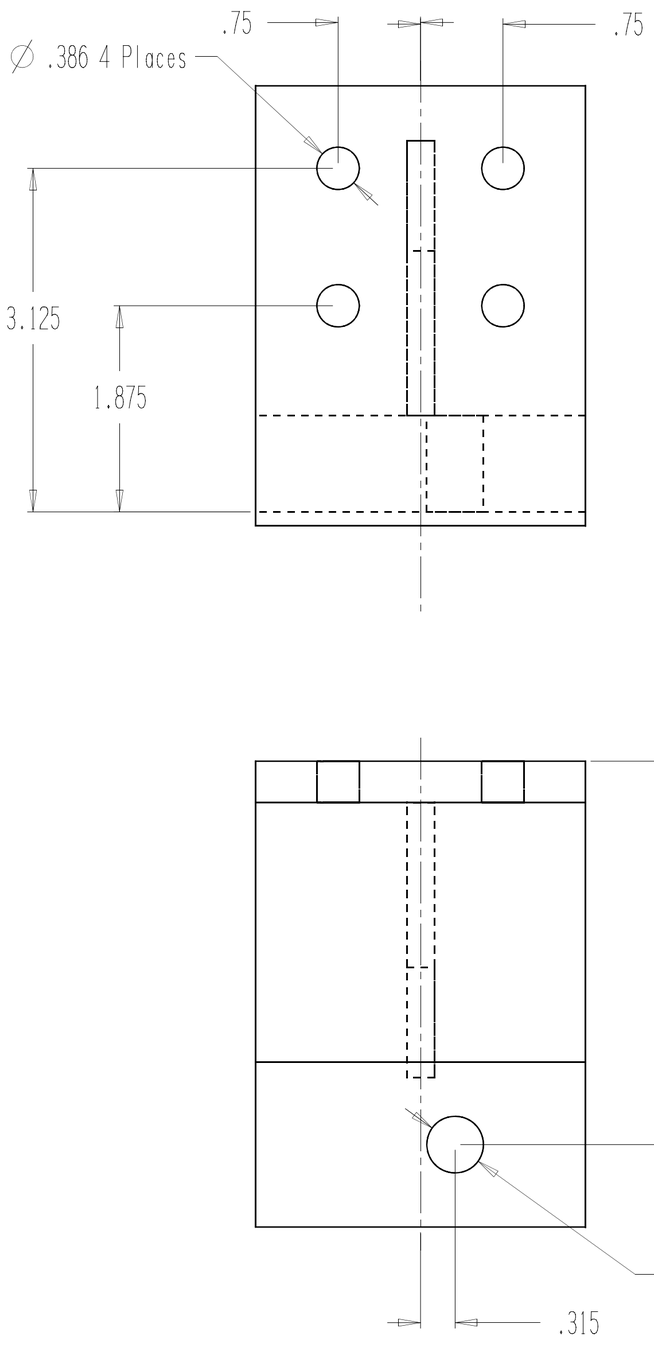
TRAX: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 2

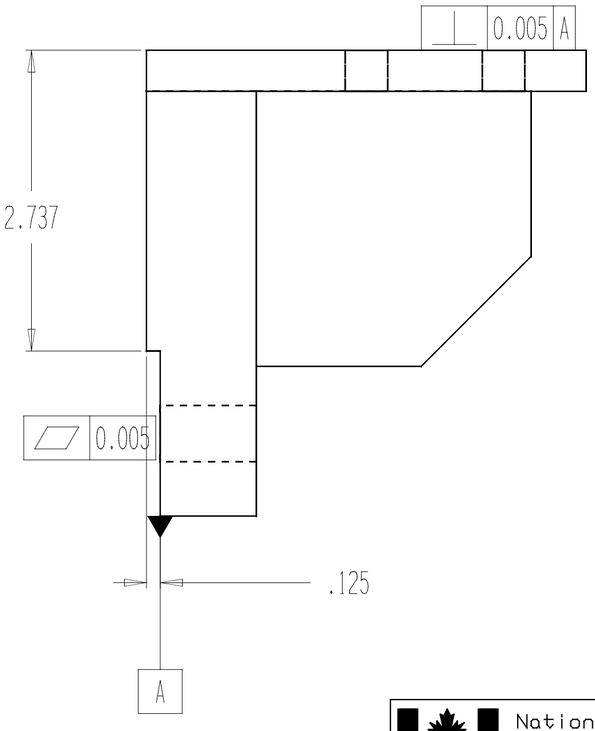
TITLE: Aquaculture Net Drag Load Cell Mount Fab.
A2 | NUMBER: 2070T18 | REV:
SCALE: 1:1 | DATE: 26-Oct-2004 | SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Remove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T17.ckd





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 Aluminium
Heat Treatment:
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

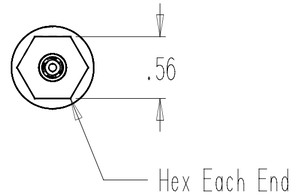
TRAK: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 2

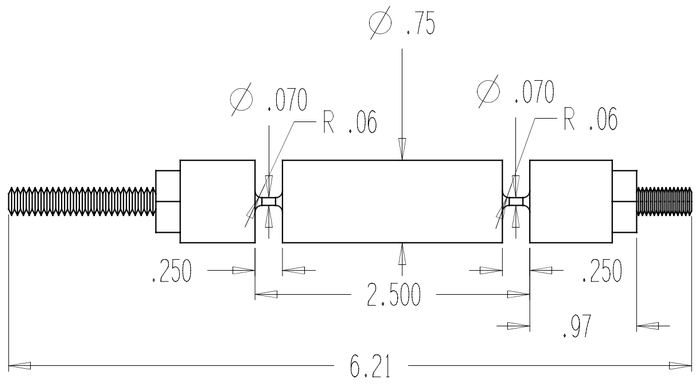
TITLE: Aquaculture Net Drag Load Cell Mount Mach.
A2 | NUMBER: 2070T19 | REV:
SCALE: 1:1 | DATE: 26-Oct-2004 | SHEET 1 OF 1

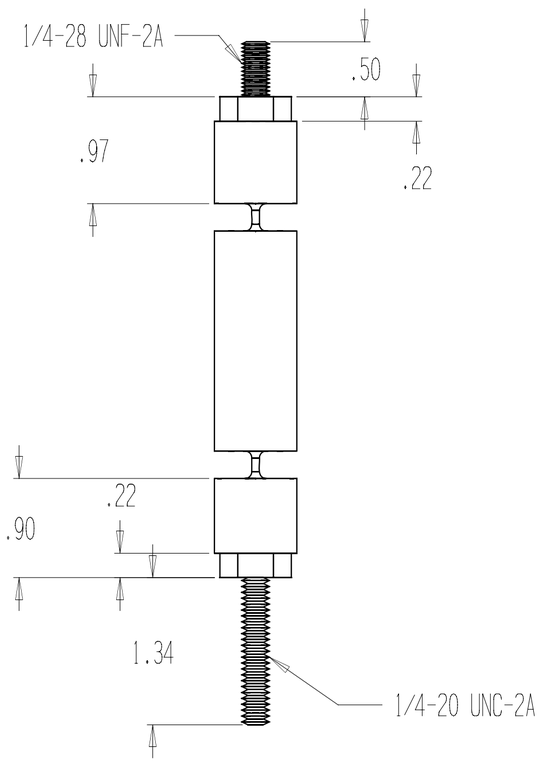
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T20.ckd







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 Alum. Heat Treatment 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 TRAK: 2070 DRAWN: T.Slade APPROVED: Quantity: 4

TITLE: Aquaculture Net Drag 1001b Flex Link

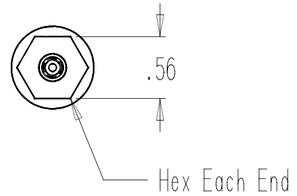
NUMBER: A2 2070T20 REV:

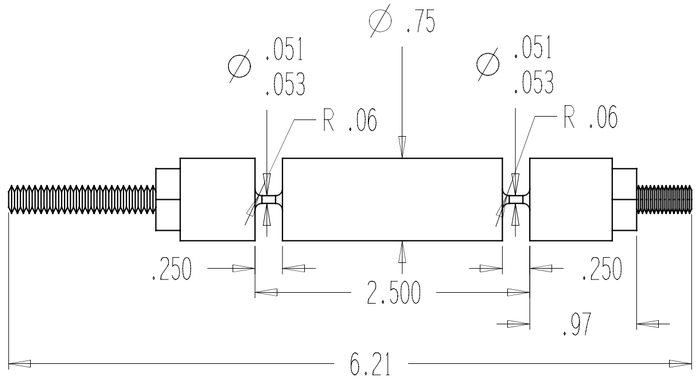
SCALE: 1:1 DATE: 22-Oct-2004 SHEET 1 OF 1

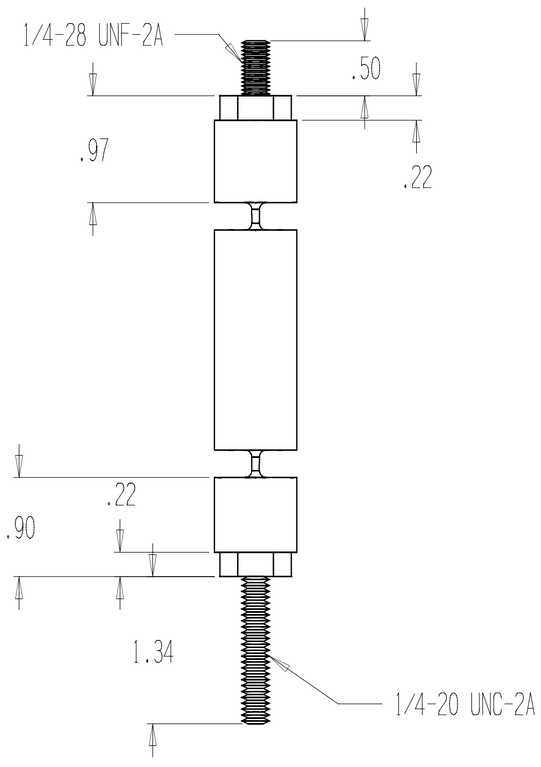
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T20.ckd







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

Institute for Marine Dynamics
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: 7075-T6 Alum.
Heat Treatment:
FINISH:
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

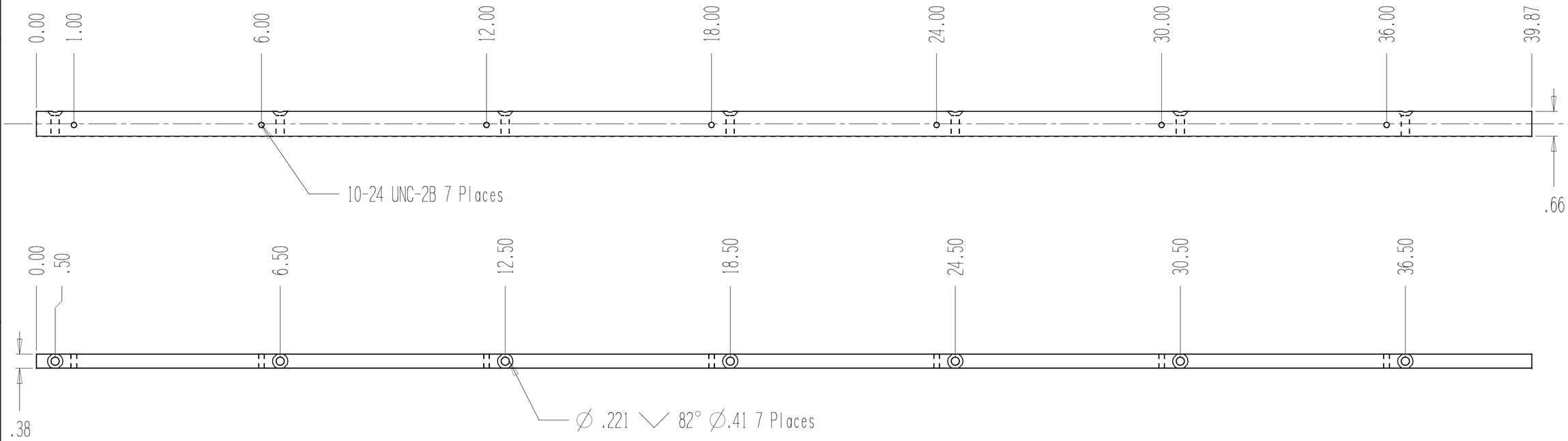
TRAK: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 4

TITLE: Aquaculture Net Drag 1001b Flex Link
NUMBER: A2 2070T20
REV:
SCALE: 1:1
DATE: 22-Oct-2004
SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Remove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T21.ckd



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 Aluminium
Heat Treatment:
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: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 2

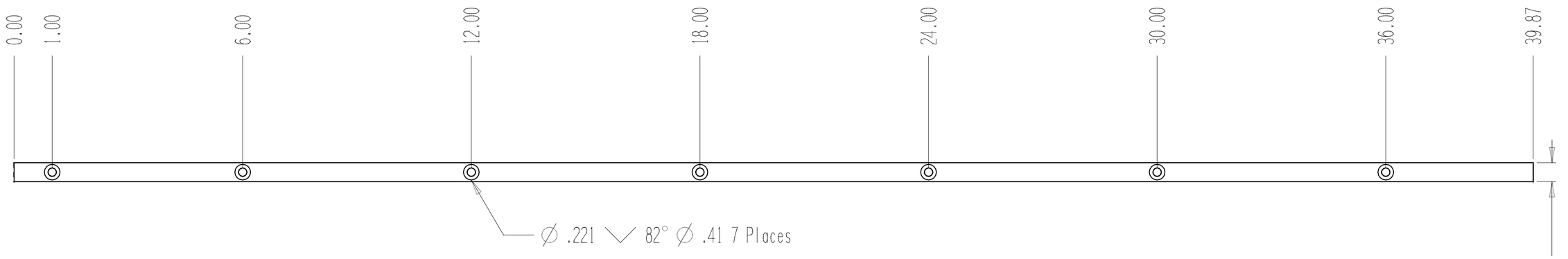
TITLE: Aquaculture Net Drag Net Support Part1
A2 | NUMBER: 2070T22 | REV:
SCALE: 1:5 | DATE: 26-Oct-2004 | SHEET 1 OF 1

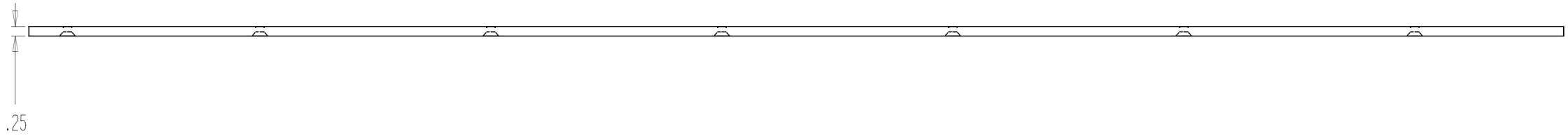
REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T21.ckd

Notes:
Deburr - Renove All Sharp Edges





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

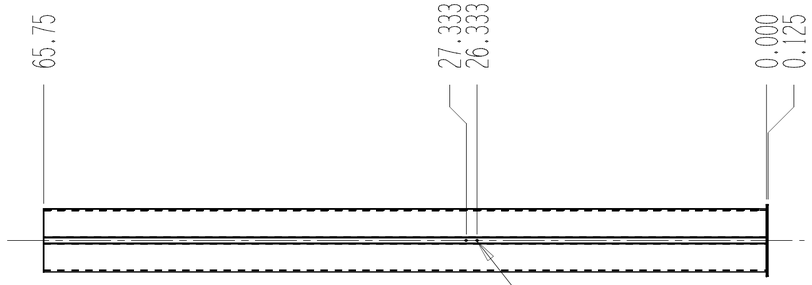
Material: 6061-T6 Aluminium
Heat Treatment:
FINISH:
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

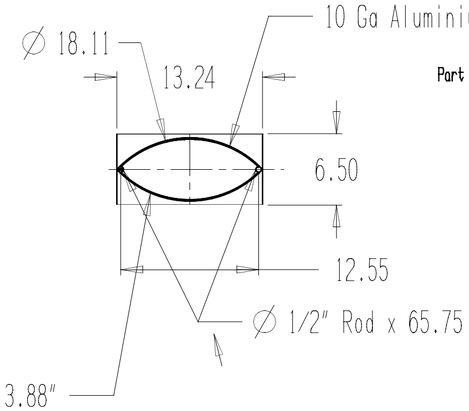
Institute for Marine Dynamics
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

TRAX: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 2

TITLE: Aquaculture Net Drag Net Support Part2
A2 | NUMBER: 2070T23 | REV:
SCALE: 1:5 | DATE: 26-Oct-2004 | SHEET 1 OF 1

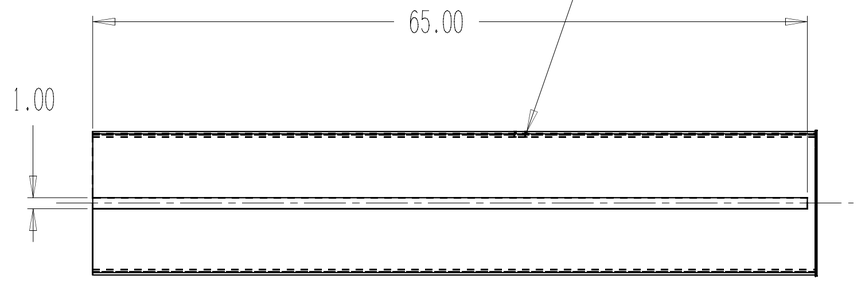
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

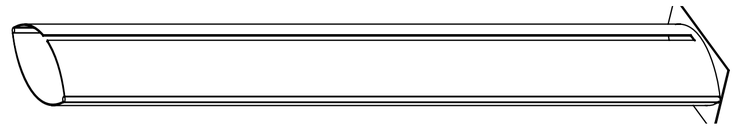




Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T24.ckd



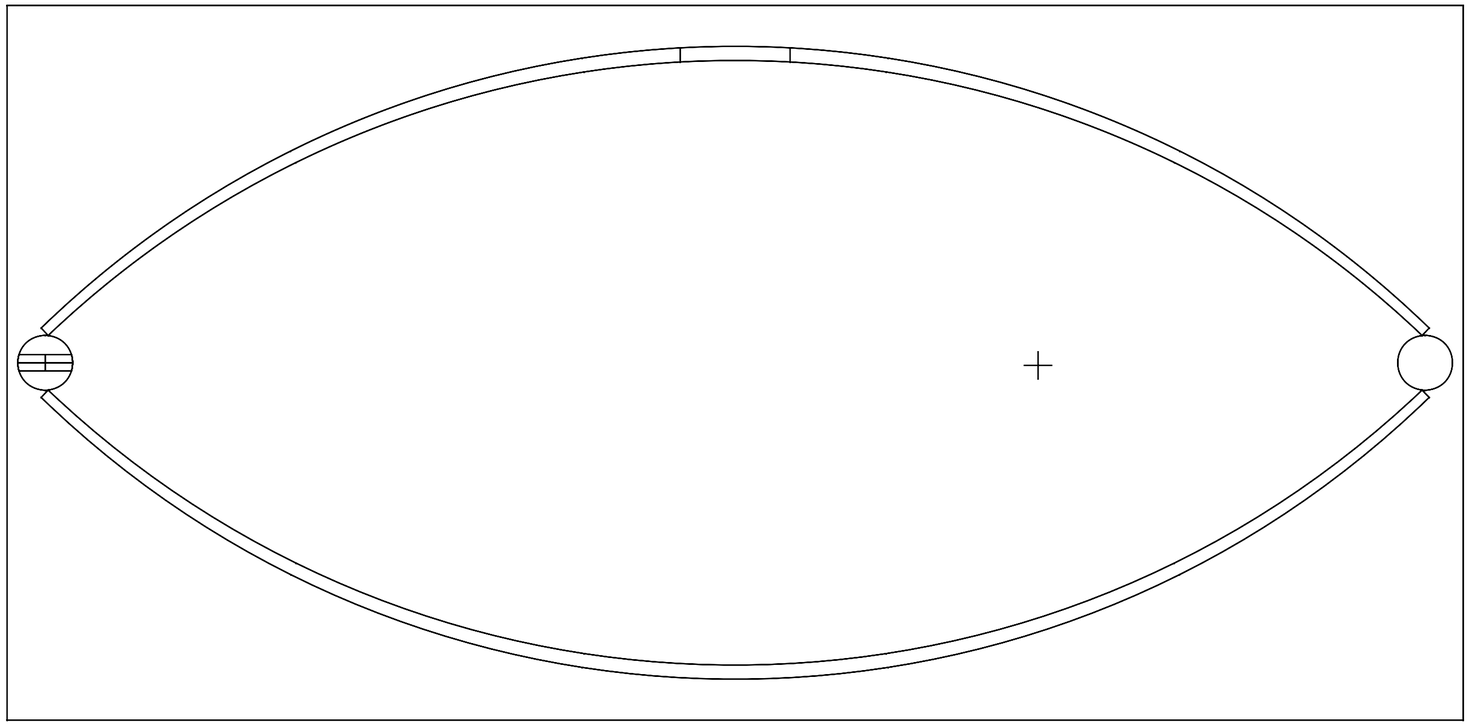


National Research Council Canada / Conseil national de recherches Canada — NRC-CNRC			
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: 6061-T6 Aluminium Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAX 2070 DRAWN T.Slade APPROVED Quantity 1	TITLE: Aquaculture Net Drag Foil Fab/Machining A2 NUMBER 2070T25 REV SCALE 1:10 DATE 27-Oct-2004 SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T24.ckd



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 Aluminium
Heat Treatment:
FINISH:
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

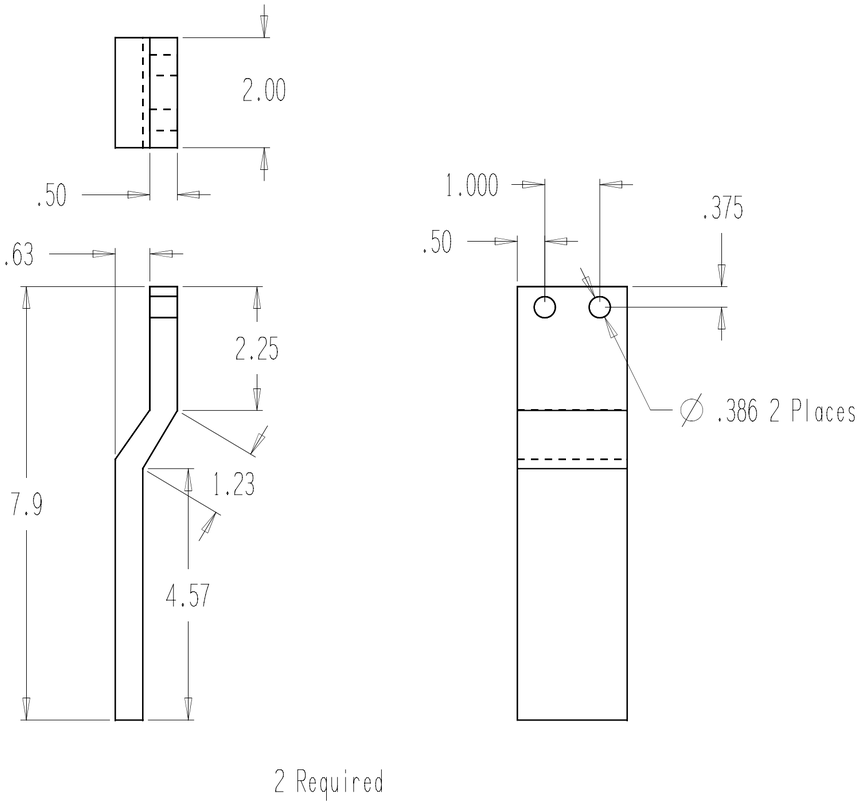
Institute for Marine Dynamics
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

TRAX: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 1

TITLE: Aquaculture Net Drag Foil Fab/Mach. Template
A2
NUMBER: 2070T25B
REV:
SCALE: 1:1
DATE: 27-Oct-2004
SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges



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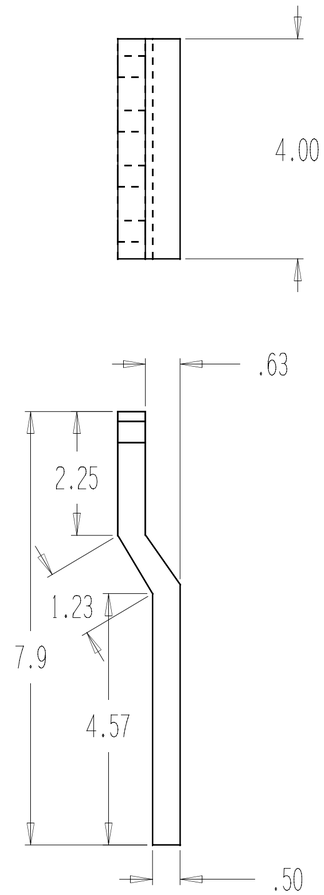

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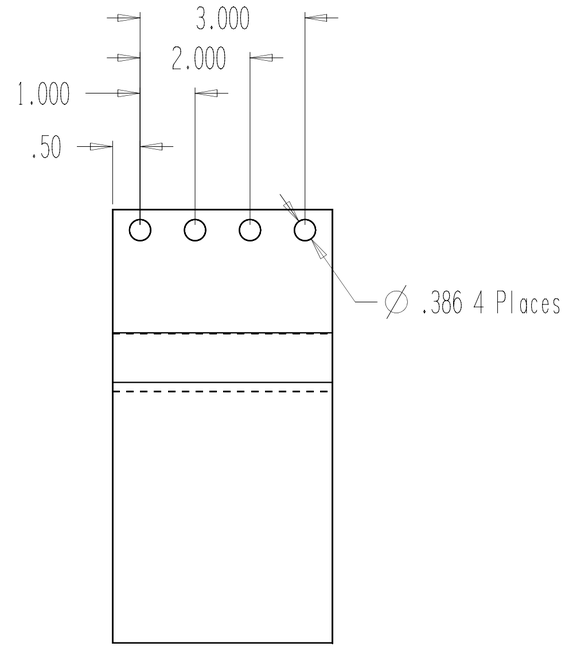


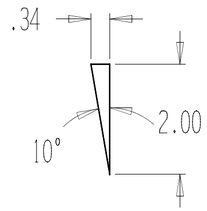
Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T24.ckd

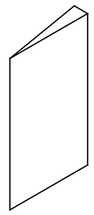
National Research Council Canada | Conseil national de recherches Canada | NRC-CNRC

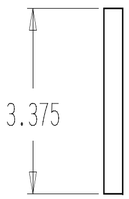
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: 6061-T6 Aluminium Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAX 2070 DRAWN T.Slade APPROVED Quantity As Noted	TITLE: Aquaculture Net Drag Foil Parts A2 NUMBER 2070T26 REV SCALE 1:2 DATE 27-Oct-2004 SHEET 1 OF 1

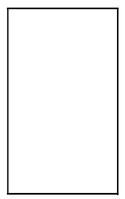
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges









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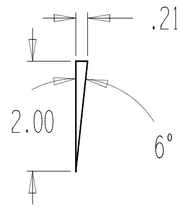
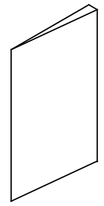
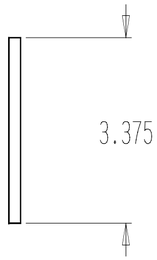
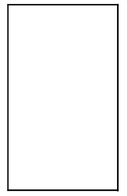








2 Required

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T24.ckd

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 Aluminium Heat Treatment 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 TRAK 2070 DRAWN T.Slade APPROVED Quantity As Noted

TITLE: Aquaculture Net Drag Foil Wedges

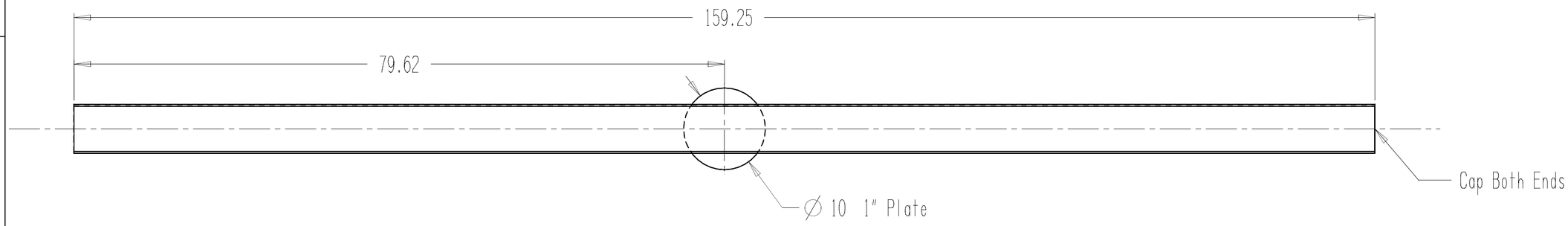
A2 | NUMBER 2070T27 | REV

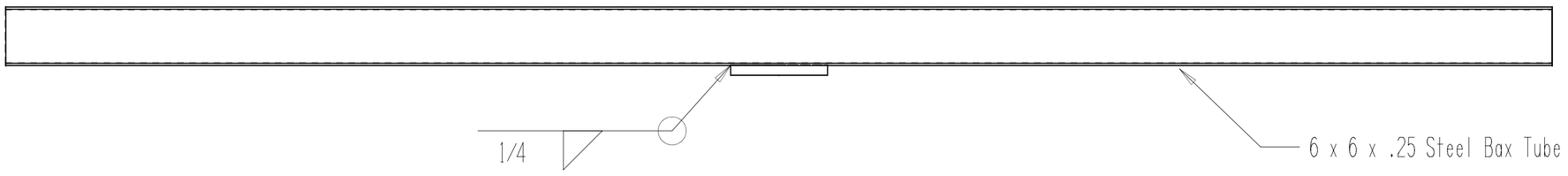
SCALE 1:1 | DATE 27-Oct-2004 | SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_Aquaculture/tslade/cadkey/2070T28.ckd





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: Steel
Heat Treatment:
FINISH:
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

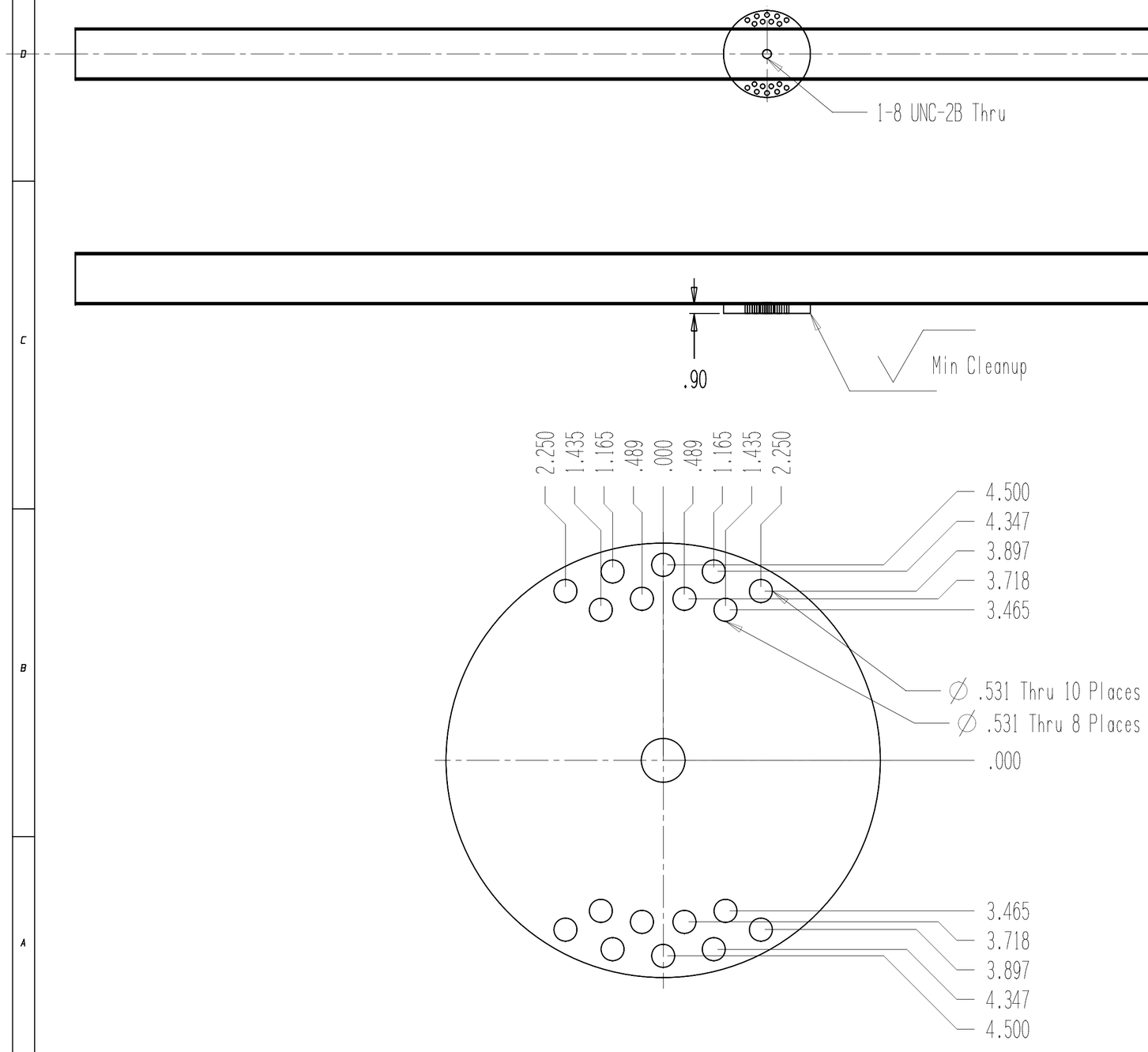
Institute for Marine Dynamics
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

TRAK: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 1

TITLE: Aquaculture Net Drag DEB Mount Fabricating
A2 | NUMBER: 2070T29 | REV:
SCALE: 1:10 | DATE: 24-Nov-2004 | SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Remove All Sharp Edges



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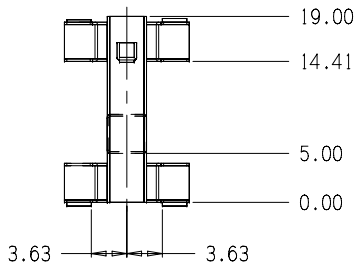
National Research Council Canada | Conseil national de recherches Canada — NRC-CNRC

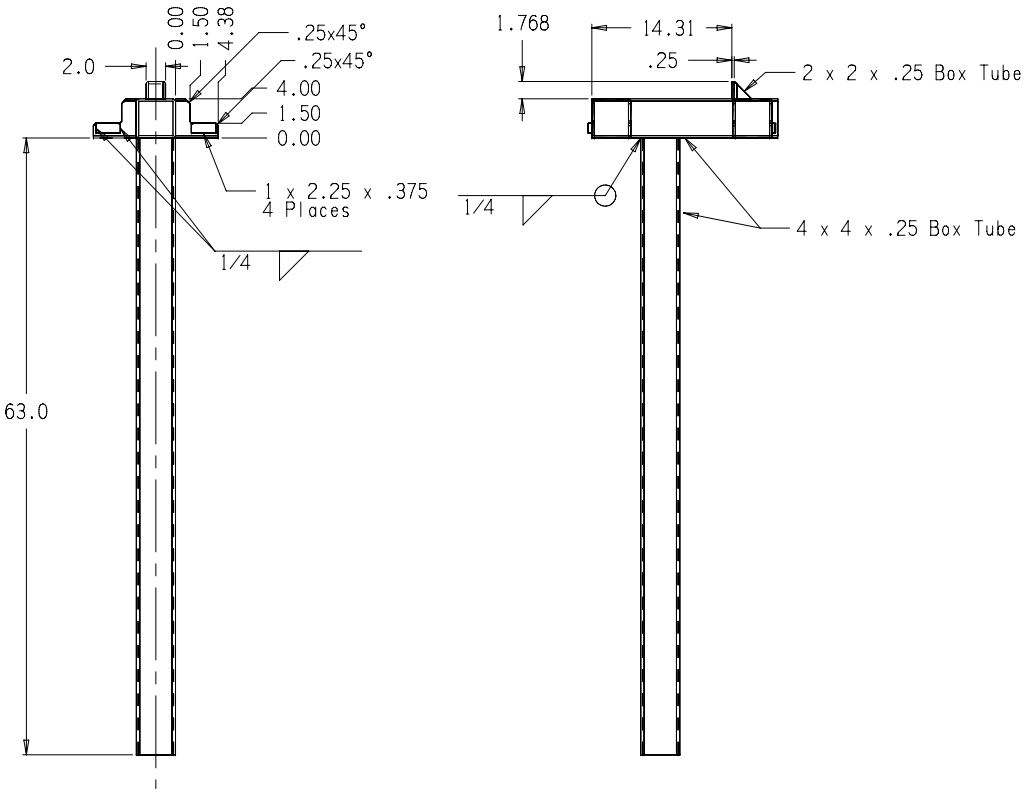
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: Steel Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAX 2070 DRAWN T.Slade APPROVED Quantity 1
TITLE: Aquaculture Net Drag DEB Mount Machining A2 NUMBER 2070T30 REV SCALE 1:10 DATE 24-Nov-2004 SHEET 1 OF 1		

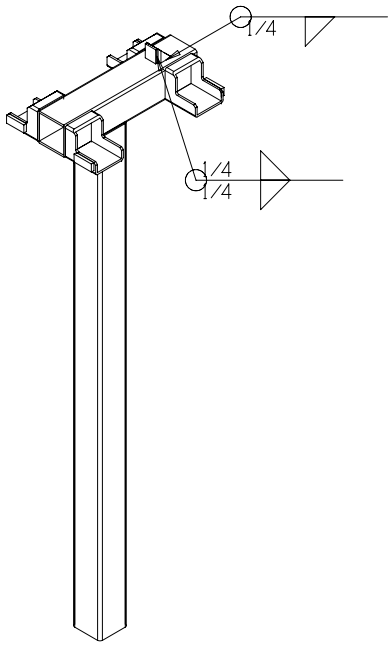
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

Notes:
Deburr - Renove All Sharp Edges

Part File : Projects/2070_aquaculture/cadkey/tslade/2070X01.ckd



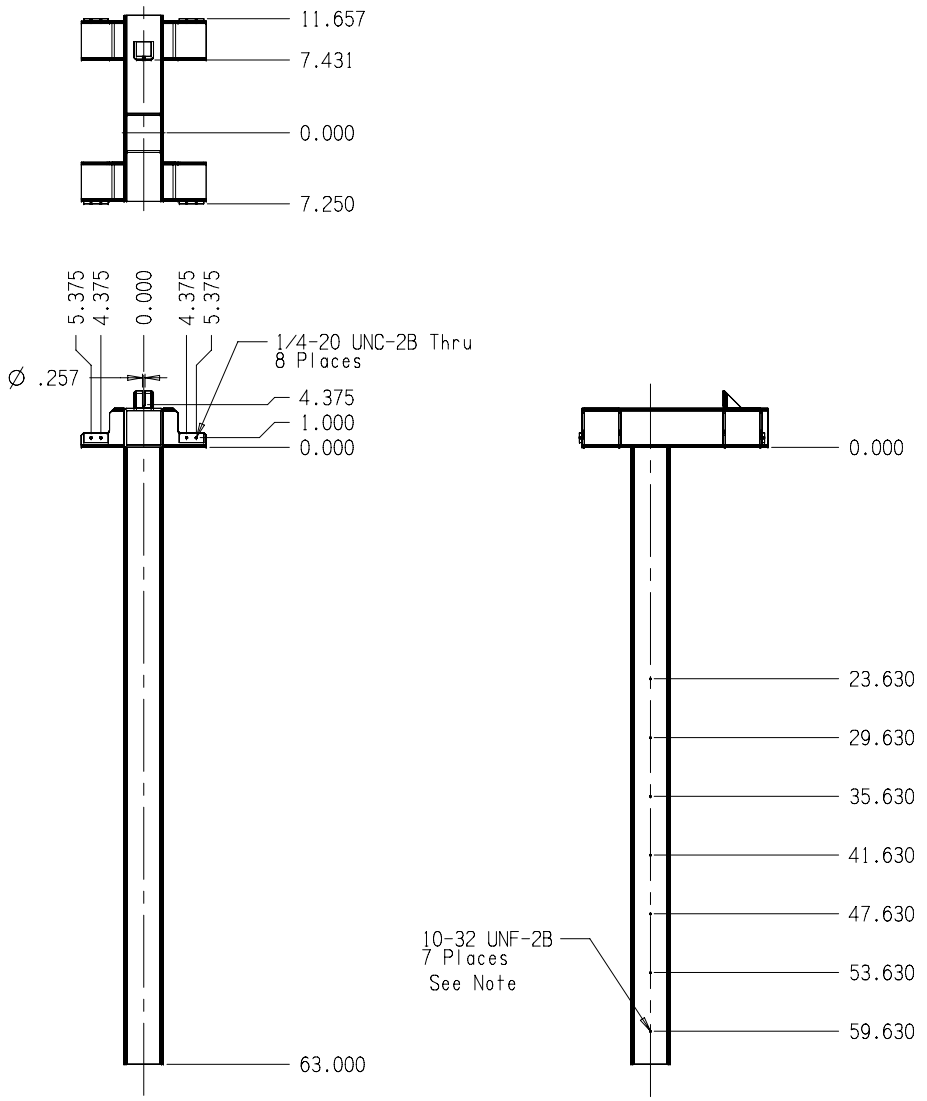




National Research Council Canada | Conseil national de recherches Canada | NRC-CNRC

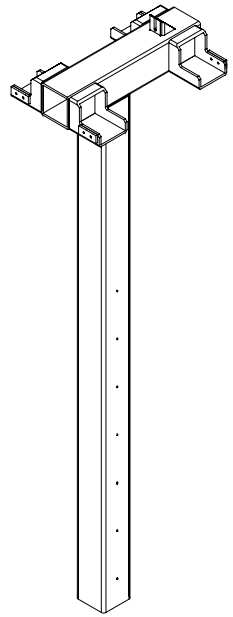
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: 6061-T6 Al. Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAX 2070 DRAWN T.Slade APPROVED Quantity 2 TITLE: Aquaculture Net Drag Vert Posts Fab. A2 NUMBER 2070X02 REV SCALE 1:10 DATE 19-Apr-05 SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-XX-XX	



Notes:
Deburr - Remove All Sharp Edges

Part File : Projects/2070_aquaculture/cadkey/tslade/2070X01.ckd



Note:

2 Required
1 As Shown
1 With 10-32 holes on Opposite face

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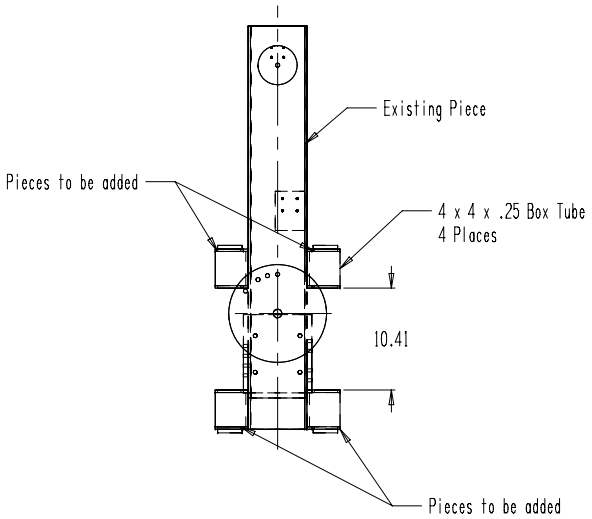
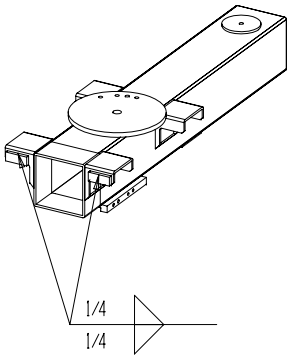
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material 6061-T6 Al. Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAK 2070 DRAWN T.Slade APPROVED Quantity As Noted TITLE Aquaculture Net Drag Vert Posts Machining A2 NUMBER 2070X03 REV SCALE 1:10 DATE 19-Apr-05 SHEET 1 OF 1

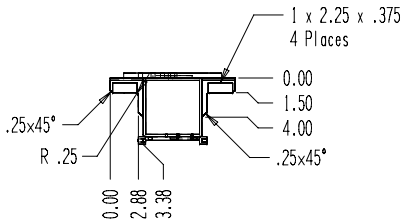
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-XX-XX	

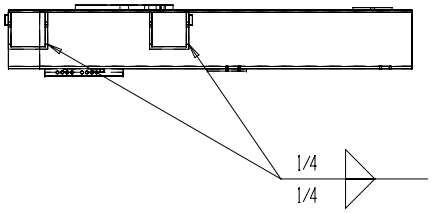
Notes:
Deburr - Remove All Sharp Edges

Part File : Projects/2070_aquaculture/cadkey/tslade/2070X04.ckd









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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: Steel
Heat Treatment
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

TRAK: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 2

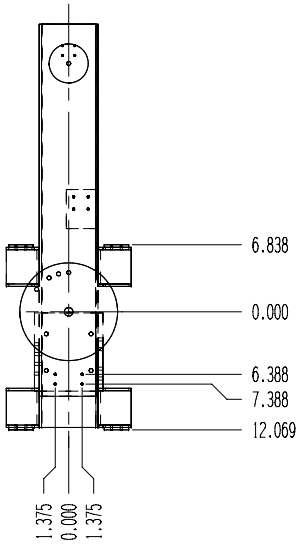
TITLE: Aquaculture Net Drag Ground Side Fabrication

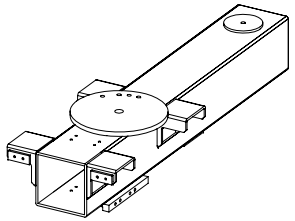
A2 | NUMBER: 2070X05 | REV:
SCALE: 1:10 | DATE: 20-Apr-05 | SHEET 1 OF 1

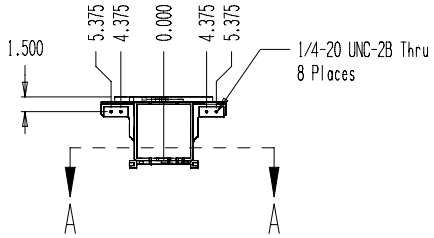
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-XX-XX	

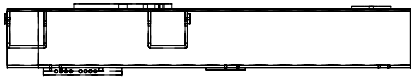
Notes:
Deburr - Remove All Sharp Edges

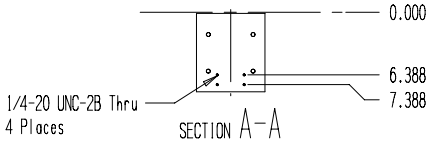
Part File : Projects/2070_aquaculture/cadkey/tslade/2070X04.ckd







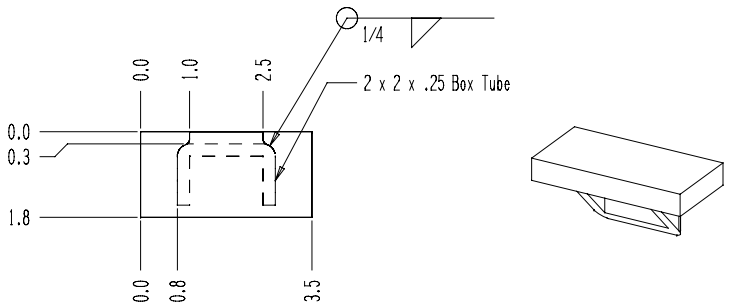


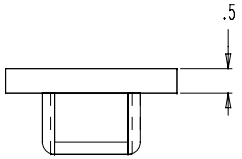


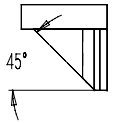
National Research Council Canada / Conseil national de recherches Canada — NRC-CNRC

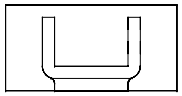
TOLERANCES (unless specified) 0.X ± 0.03 0.XX ± 0.015 0.XXX ± 0.005 Angle +/- .5 deg. Fabrication +/- .04 Fraction < 6 inch +/- 1/64 > 6 inch +/- 1/32	Material: Steel Heat Treatment FINISH DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐ THIRD ANGLE	Institute for Marine Dynamics Kerwin Place, P.O. Box 12093, Postal Station A St. John's, Newfoundland A1B 3T5 TRAK: 2070 DRAWN: T.Slade APPROVED Quantity: 2 TITLE: Aquaculture Net Drag Ground Side Machining A2 NUMBER: 2070X06 REV SCALE: 1:10 DATE: 20-Apr-05 SHEET 1 OF 1

REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-xx-xx	

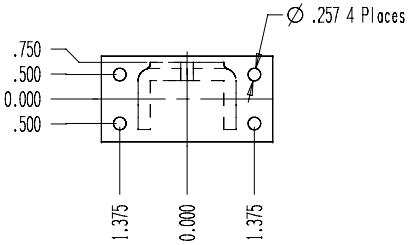


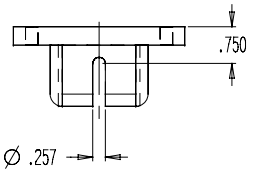


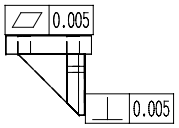


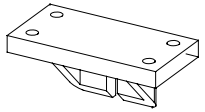


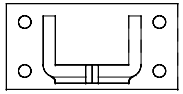
Fabrication











Machining

Notes:
Deburr - Remove All Sharp Edges

Part File : Projects/2070_aquaculture/cadkey/tslade/2070X04.ckd

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

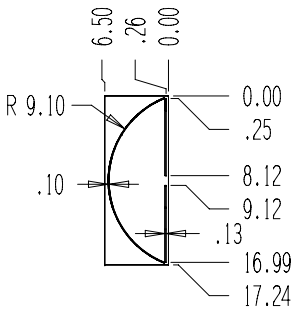
Material: 6061-T6 Al.
Heat Treatment
FINISH
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

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

TRAK: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 2

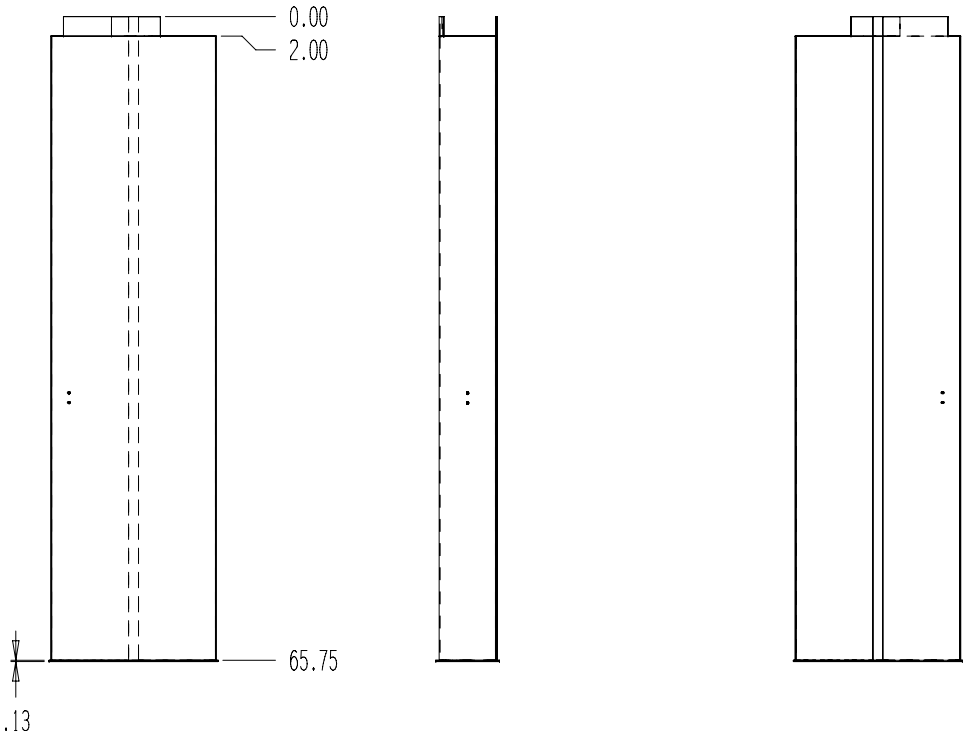
TITLE: Aquaculture Net Drag Load Cell Mounts
A2 | NUMBER: 2070X07 | REV
SCALE: 1:2 | DATE: 20-Apr-05 | SHEET 1 OF 1

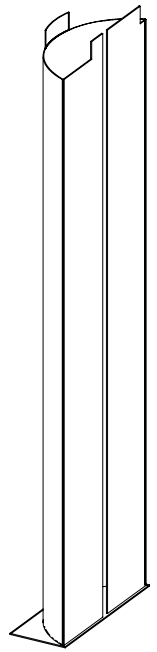
REVISIONS				
NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-XX-XX	



Notes:
Deburr - Remove All Sharp Edges

Part File : Projects/2070_aquaculture/cadkey/tslade/2070X08.ckd





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

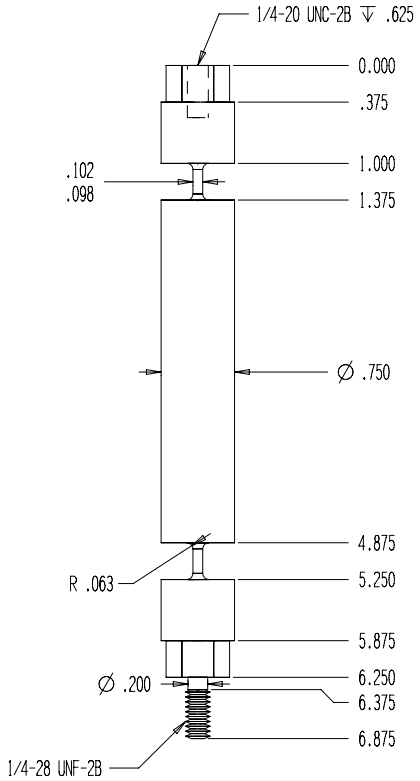
TOLERANCES (unless specified)
0.X ± 0.03
0.XX ± 0.015
0.XXX ± 0.005
Angle +/- .5 deg.
Fabrication +/- .04
Fraction < 6 inch +/- 1/64
> 6 inch +/- 1/32

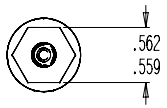
Material: 6061-T6 Al.
Heat Treatment
FINISH
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

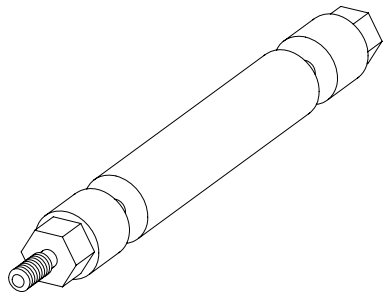
Institute for Marine Dynamics
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

TRAK: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 2

TITLE: Aquaculture Net Drag Foil
A2 | NUMBER: 2070X08 | REV
SCALE: 1:10 | DATE: 21-Apr-05 | SHEET 1 OF 1







REVISIONS

NO.	ZONE	DESCRIPTION	DATE	APPROVED
A0		Issued For Comments	05-XX-XX	

Notes:
Deburr - Remove All Sharp Edges

Part File : Projects/2070_aquaculture/cadkey/tslade/2070X09.ckd

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: 7075-T6 Al.
Heat Treatment
FINISH
DIMENSIONS IN: INCHES ☒ MILLIMETERS ☐
THIRD ANGLE

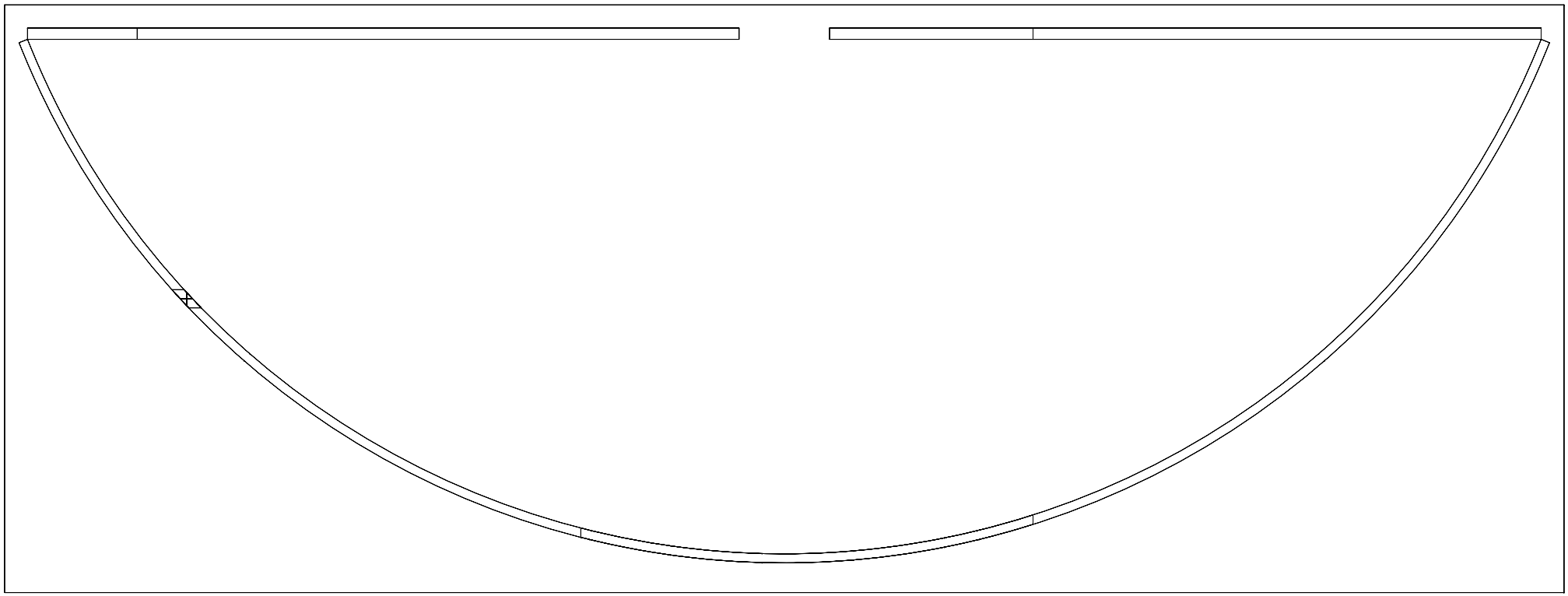
Institute for Marine Dynamics
Kerwin Place, P.O. Box 12093, Postal Station A
St. John's, Newfoundland A1B 3T5

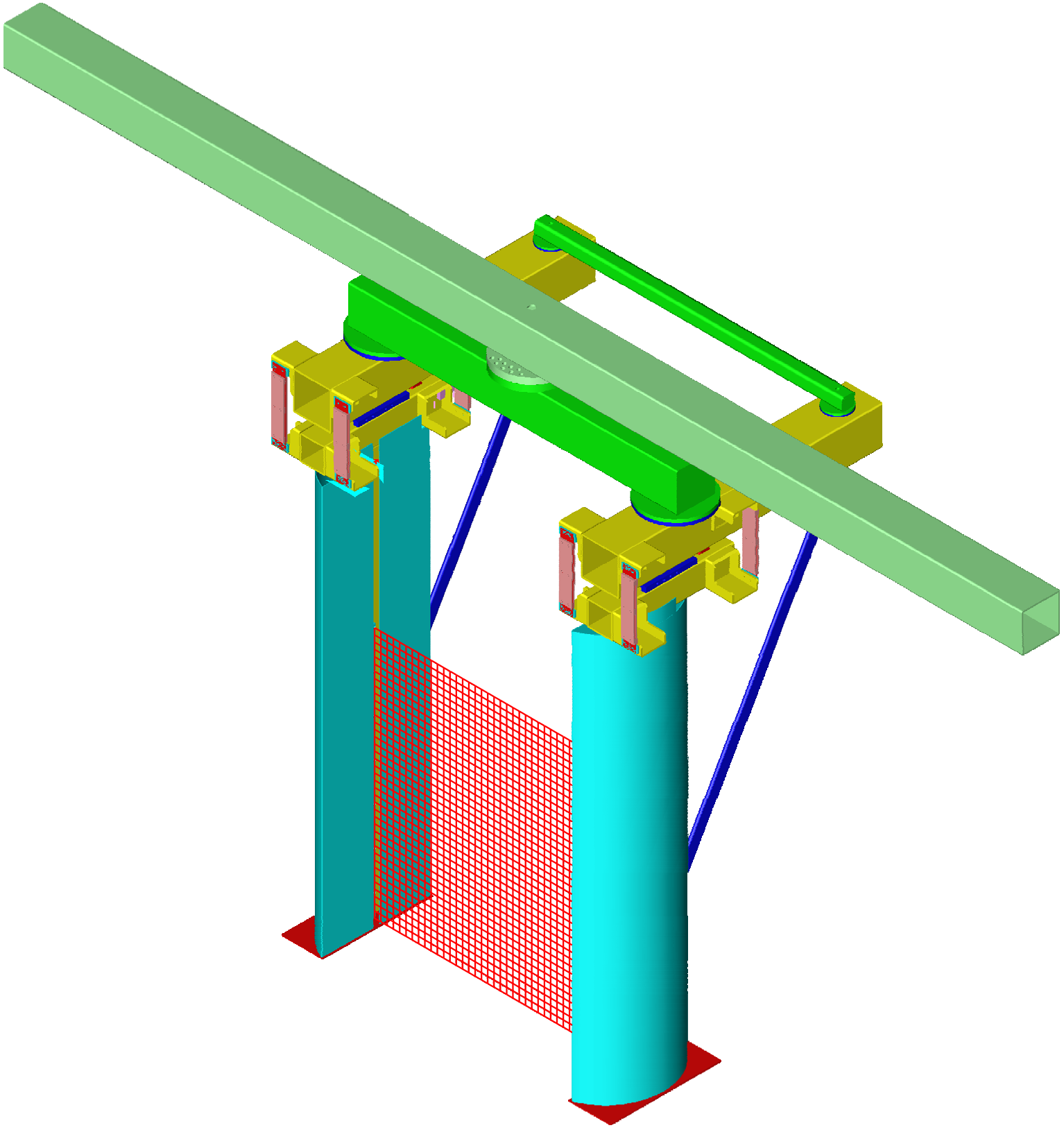
TRAK: 2070
DRAWN: T.Slade
APPROVED:
Quantity: 3

TITLE: Aquaculture Net Drag Flexible Links

A2 | NUMBER: 2070X09 | REV:

SCALE: 1:5 | DATE: 19-Apr-05 | SHEET 1 OF 1



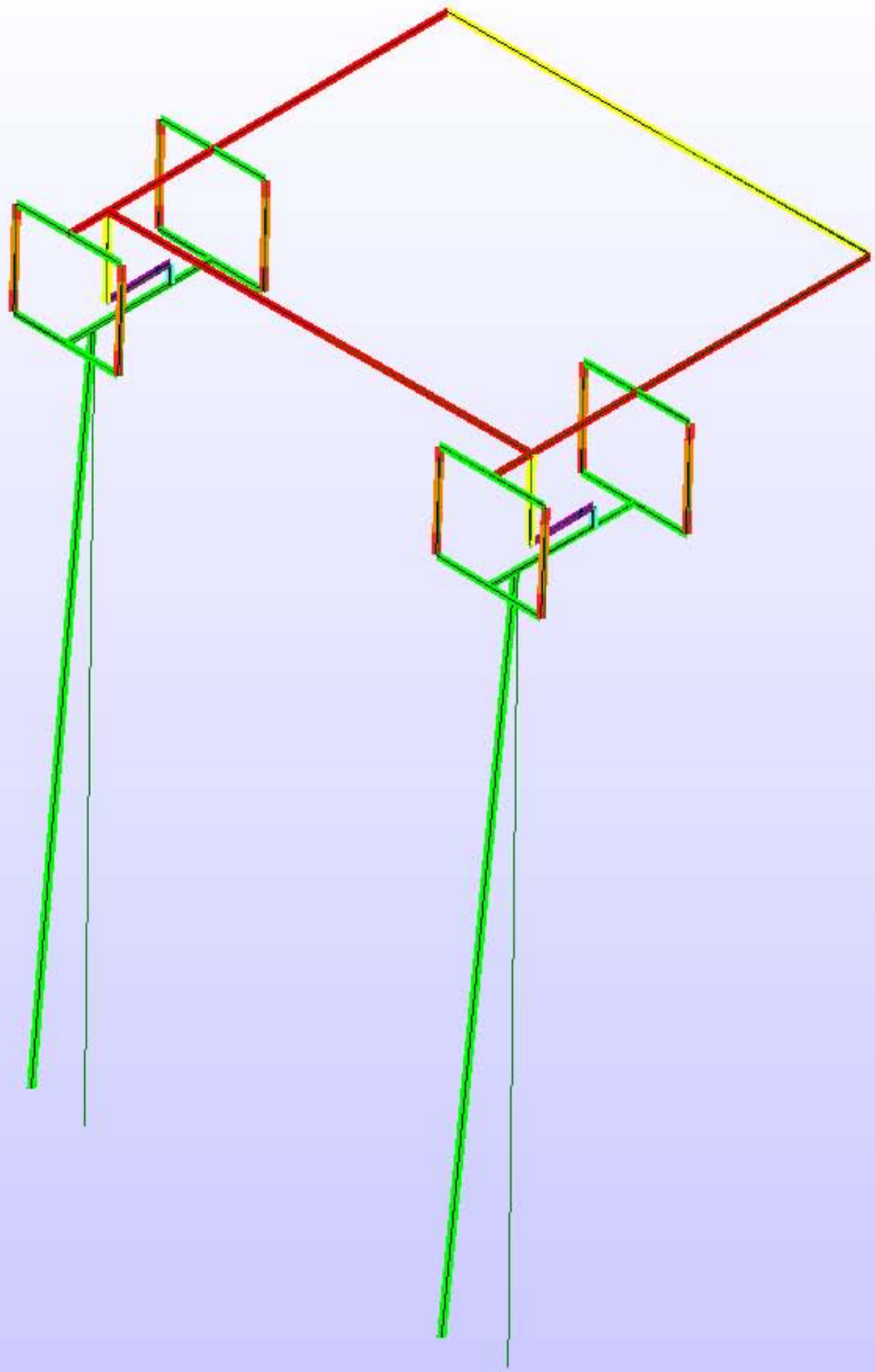


Appendix A

(Algor)

ALGOR
Superview

Modal Analysis Mode 1



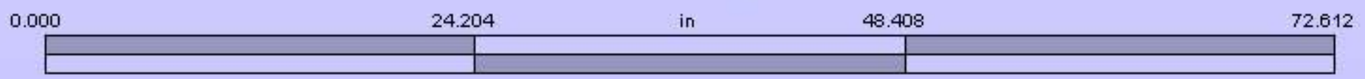
Wave Frequency 0.3 - 1 Hz

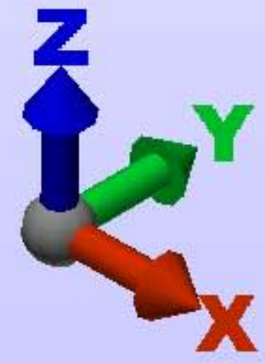
Mode: 1 of 5

Frequency: 21.5772 cycles/s

Maximum Value: Not Available

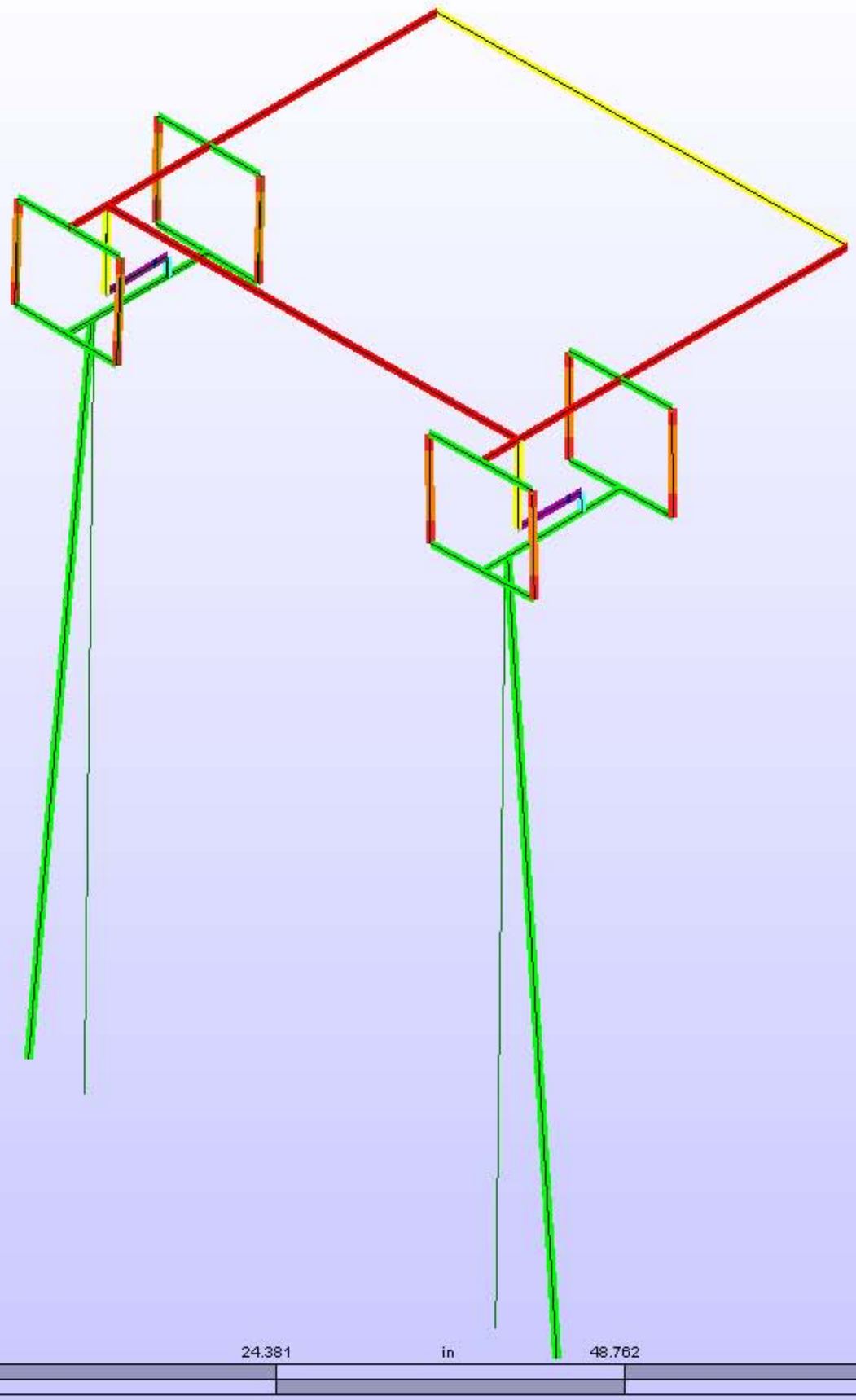
Minimum Value: Not Available





ALGOR
Superview

Modal Analysis Mode 2



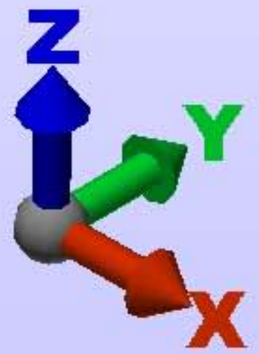
Wave frequency 0.3 - 1 Hz

Mode: 2 of 5

Frequency: 21.6028 cycles/s

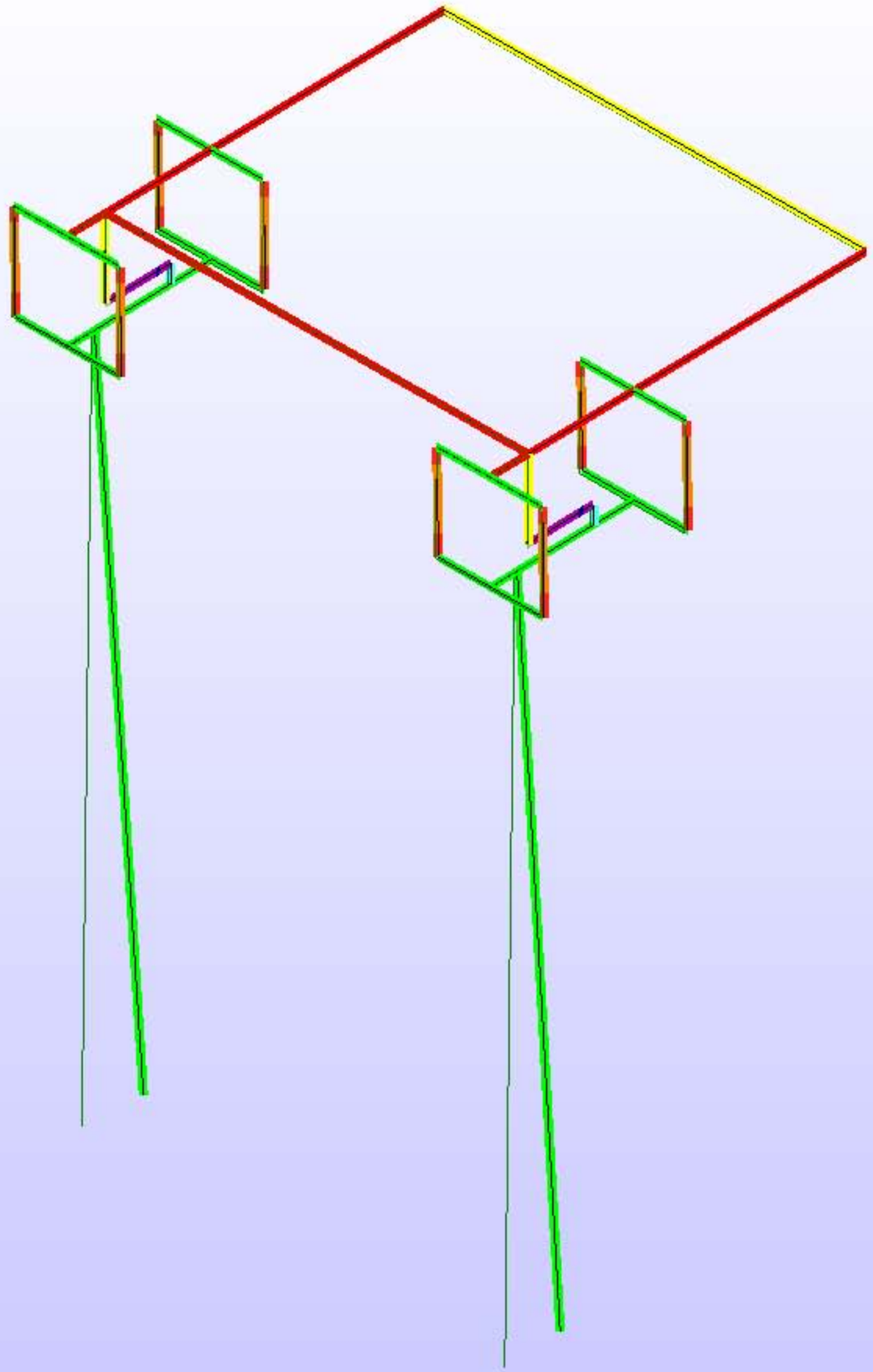
Maximum Value: Not Available

Minimum Value: Not Available



ALGOR
Superview

Modal Analysis Mode 3



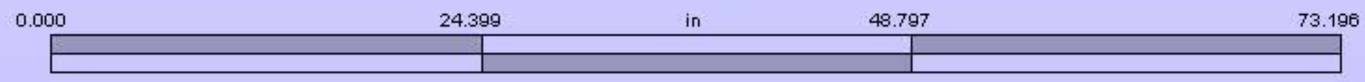
Frequency of Waves 0.3 - 1 Hz

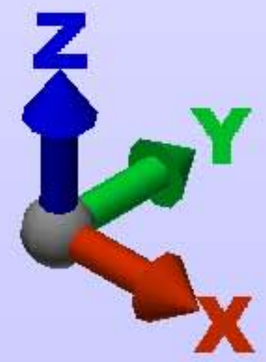
Mode: 3 of 5

Frequency: 22.0842 cycles/s

Maximum Value: Not Available

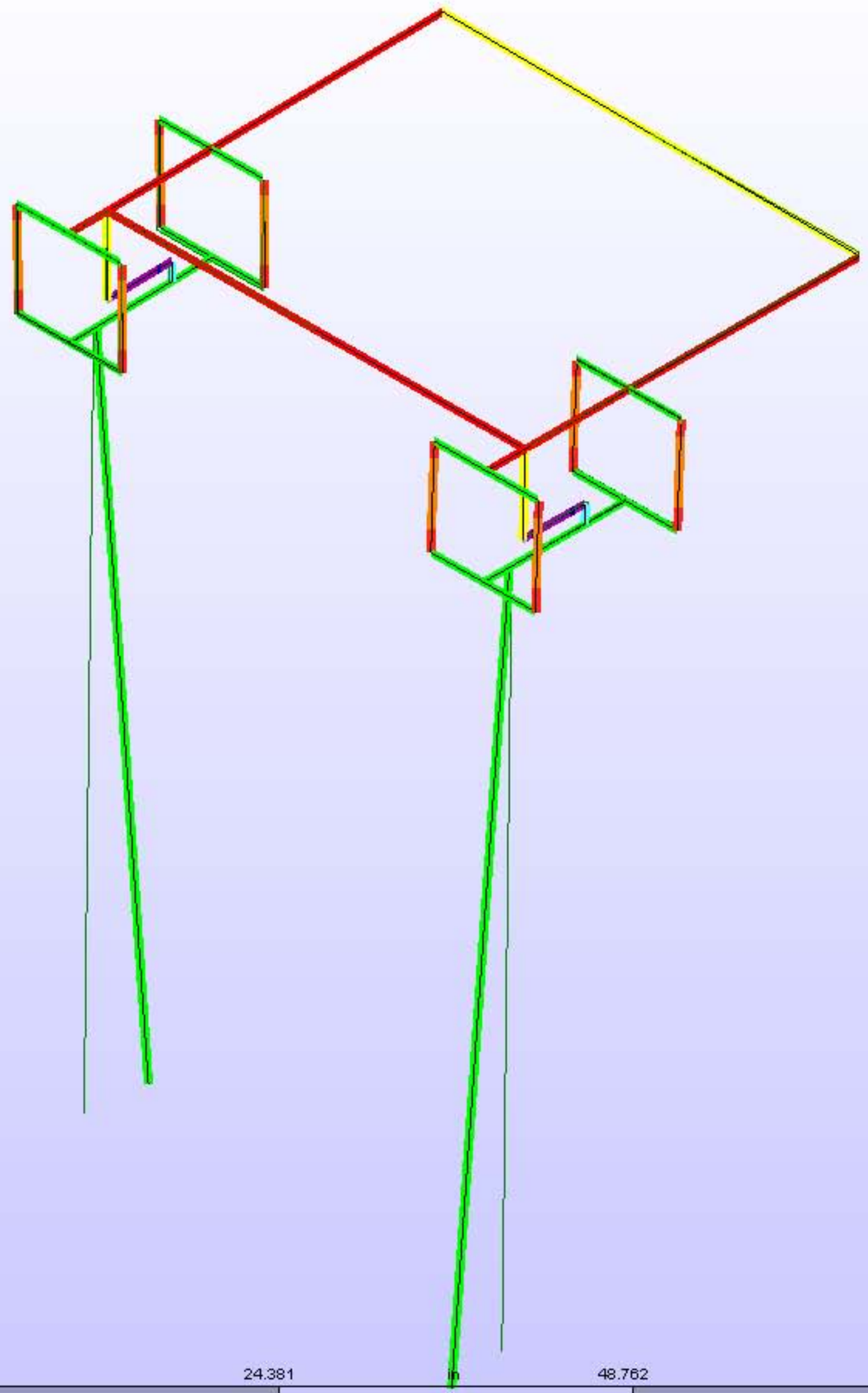
Minimum Value: Not Available





ALGOR
Superview

Modal Analysis Mode 4



Frequency of Waves 0.3 - 1 Hz

Mode: 4 of 5

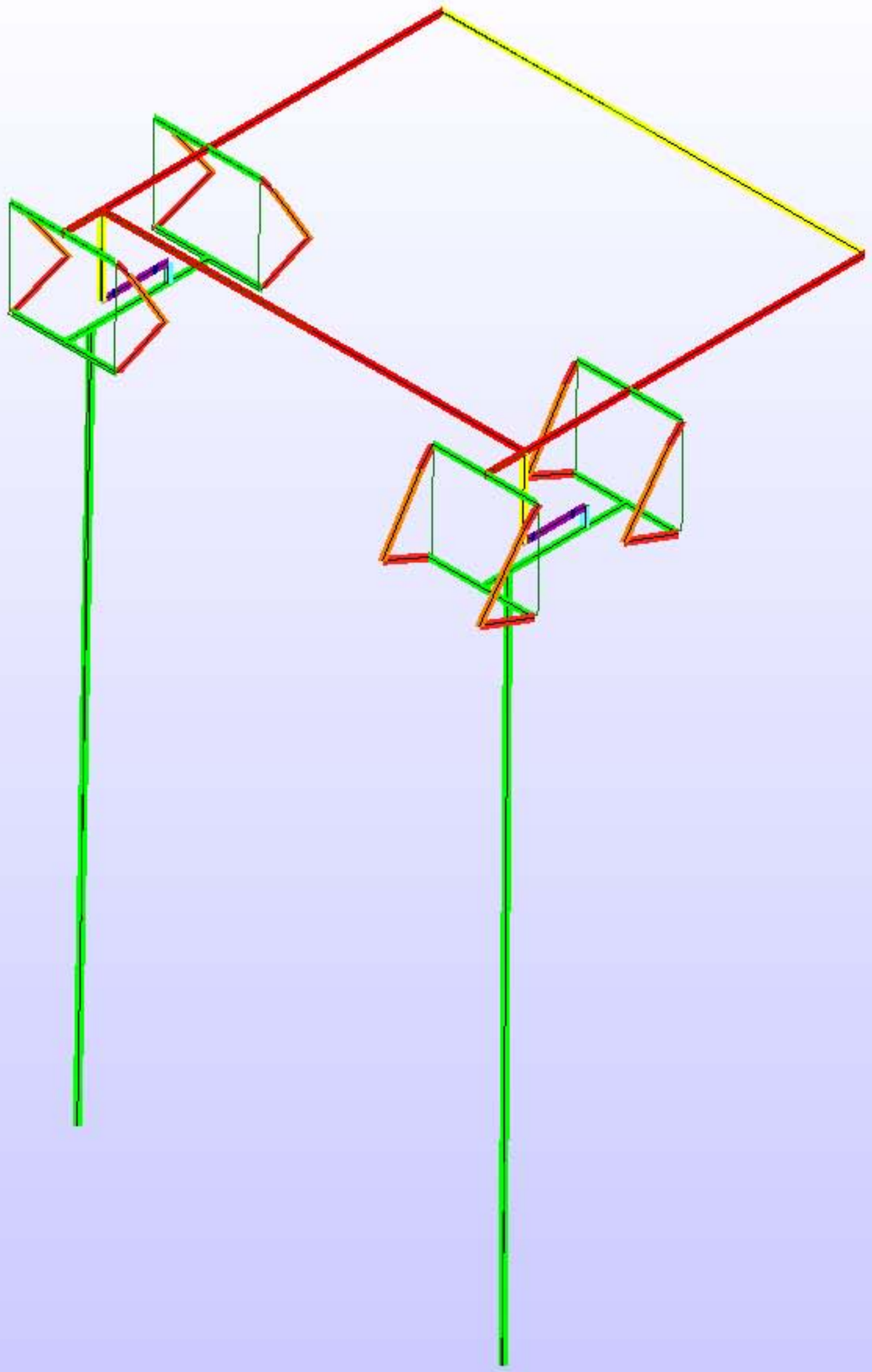
Frequency: 22.5629 cycles/s

Maximum Value: Not Available

Minimum Value: Not Available

ALGOR
Superview

Modal Analysis Mode 5



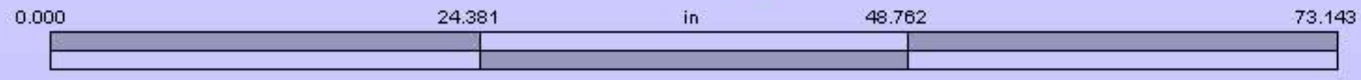
Frequency of Waves 0.3 - 1 Hz

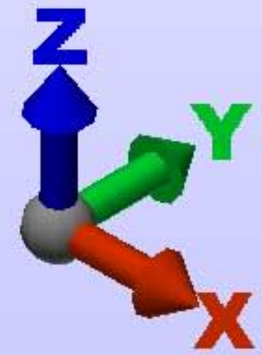
Mode: 5 of 5

Frequency: 52.3782 cycles/s

Maximum Value: Not Available

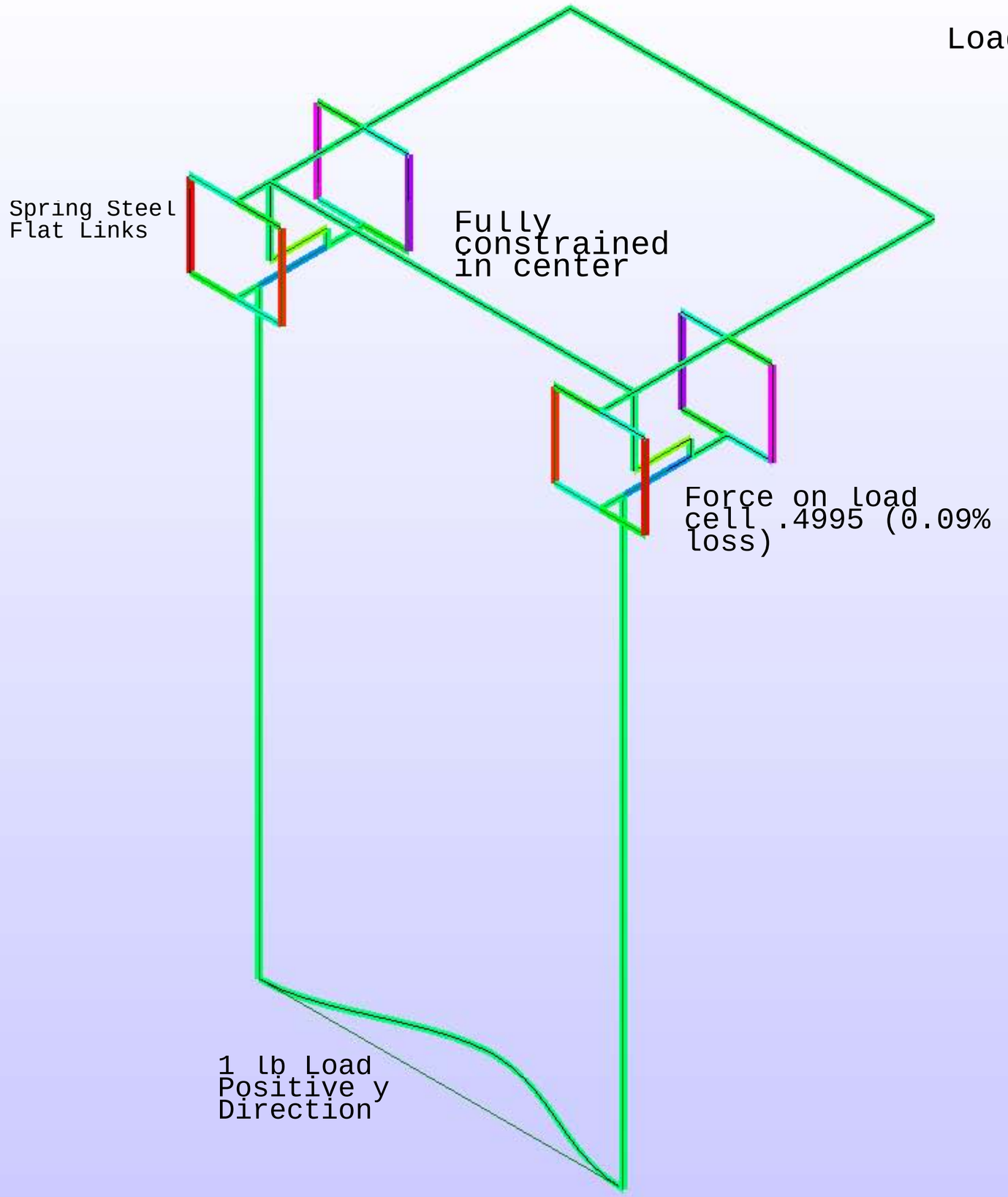
Minimum Value: Not Available





ALGOR
Superview

Load Plot



Load Case: 1 of 1

Maximum Value: 1.25027 lbf

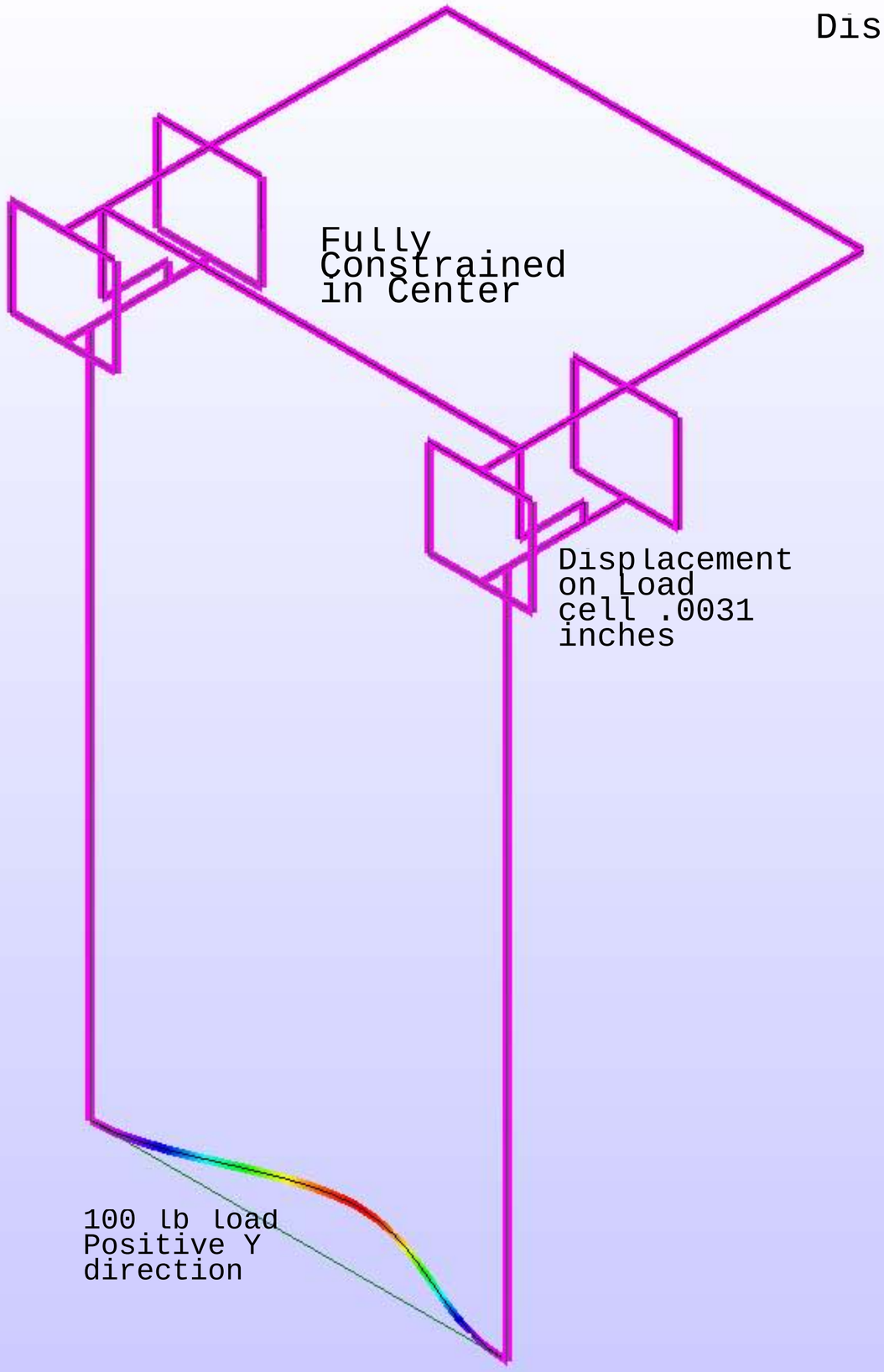
Minimum Value: -1.2984 lbf

ALGOR
Superview

Displacement Plot

Nodal Displacement
Magnitude
in

653.1345
587.8211
522.5076
457.1942
391.8807
326.5673
261.2538
195.9404
130.6269
65.31345
0



Load Case: 1 of 1

Maximum Value: 653.135 in

Minimum Value: 0 in

0.000 24.434 in 48.868 73.302

Z
Y
X

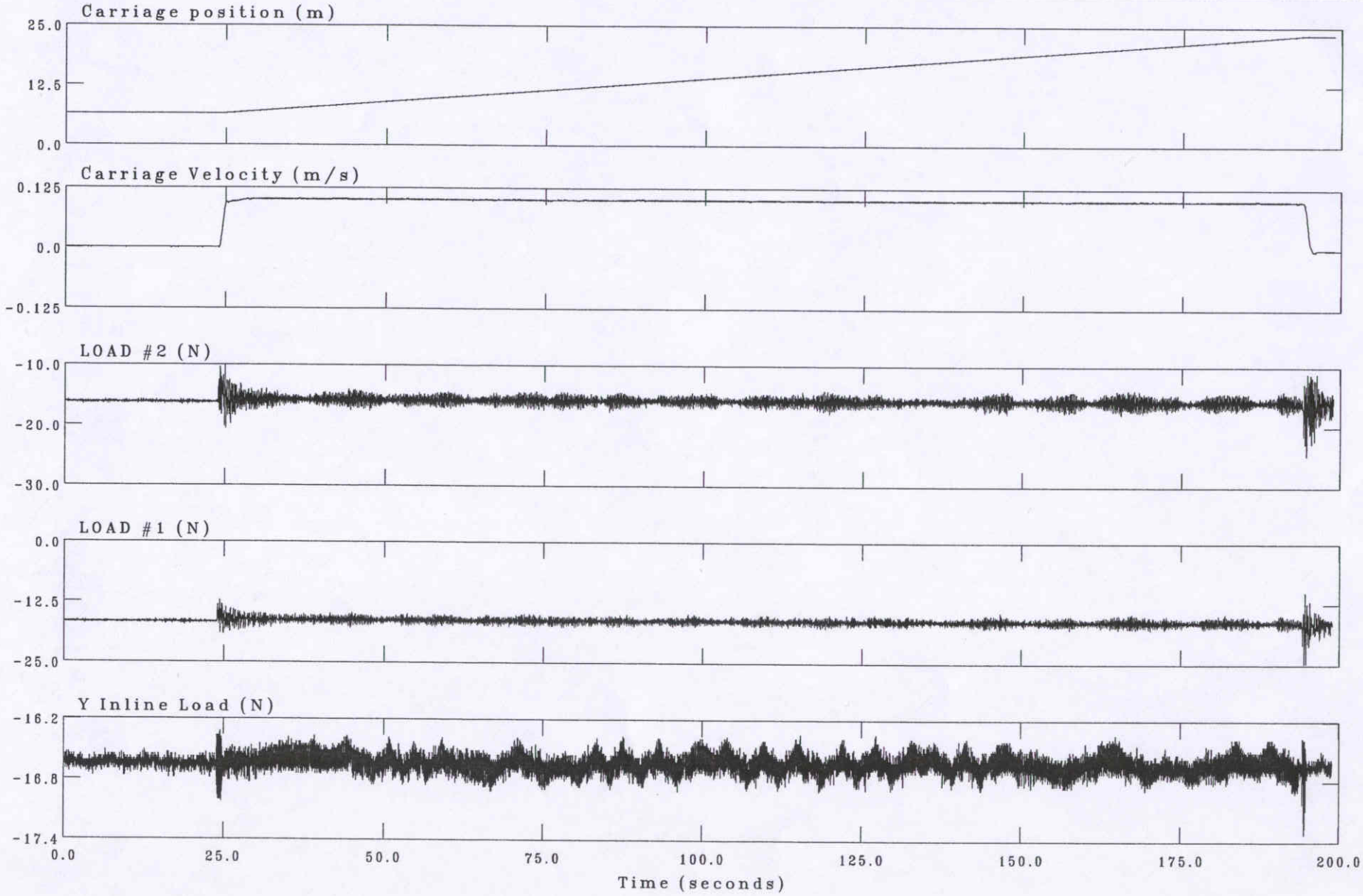
Appendix B

Test Data

NET DRAG

IOT

Analyzed: 08-DEC-2005 09:11:04
Acquired: 8-DEC-2005 08:44:29



National Research Council Canada
Institute for Ocean Technology

GENERATED BY: MEADUSC	CHECKED BY:	APPROVED BY:

Figure 1 TG2_0P1_FWD_001

Analysis Date/Time = 8-DEC-2005 09:12:39
Acquired Date/Time = 8-DEC-2005 08:44:29
Input File = CH_S1
Output File = TG2_0P1_FWD_001
Number of Samples = 904
Segment Start Time = 2.7400 seconds
Segment End Time = 20.800 seconds

Description	Unit	Min	Max	Mean	S.D.	Chan
Y Inline Load	N	-16.789	-16.511	-16.647	0.044634	1
LOAD #1	N	-16.959	-16.384	-16.643	0.089479	2
LOAD #2	N	-16.408	-15.891	-16.141	0.086266	3
Carriage Velocity	m/s	0.00054491	0.0016130	0.0011350	0.00016138	4
Carriage position	m	6.4733	6.4905	6.4805	0.0024924	5

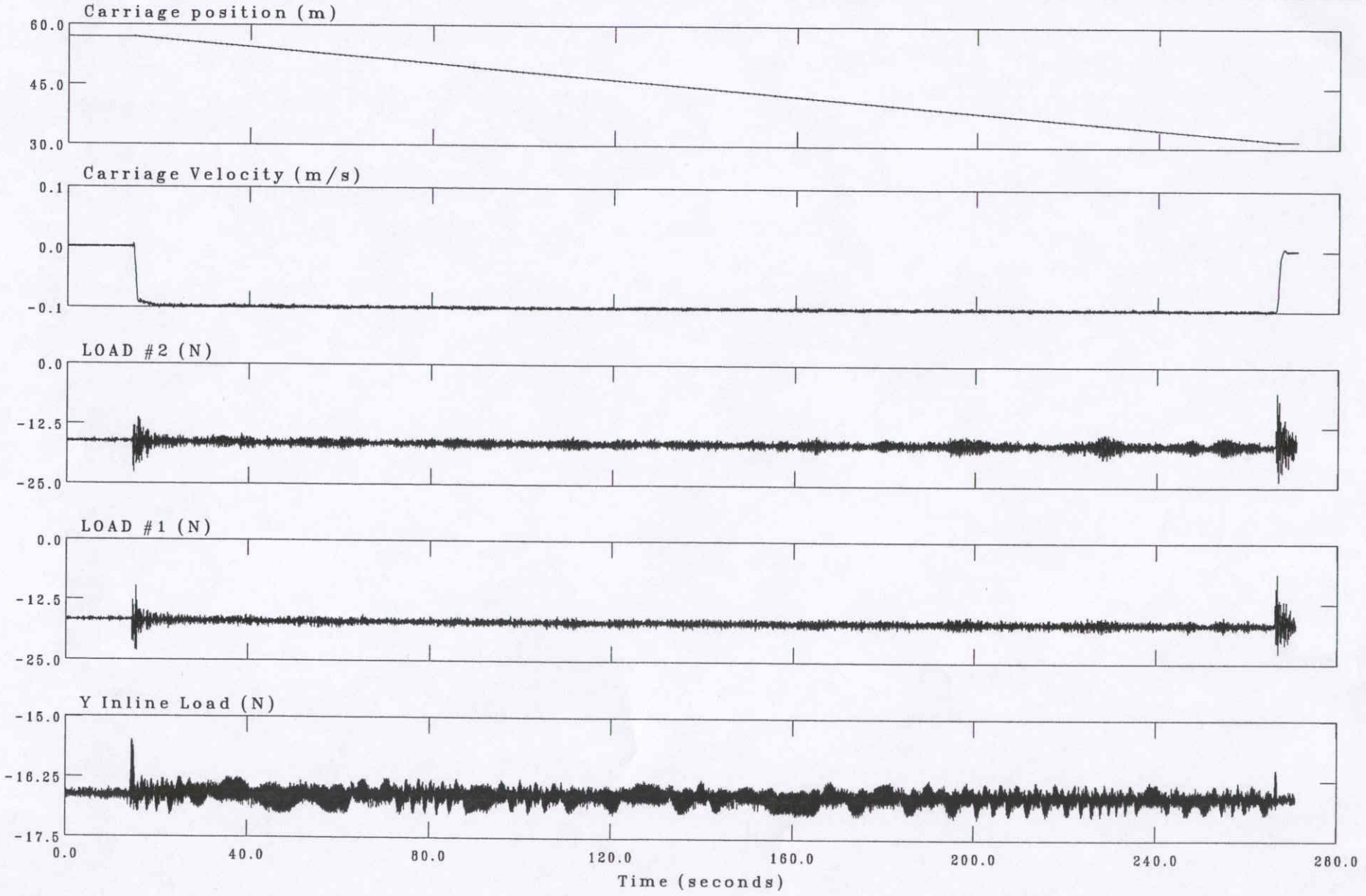
Analysis Date/Time = 8-DEC-2005 09:12:40
Acquired Date/Time = 8-DEC-2005 08:44:29
Input File = CH_S2
Output File = TG2_0P1_FWD_001
Number of Samples = 7293
Segment Start Time = 39.100 seconds
Segment End Time = 184.94 seconds

Description	Unit	Min	Max	Mean	S.D.	Chan
Y Inline Load	N	-16.917	-16.340	-16.642	0.098657	1
LOAD #1	N	-17.902	-14.636	-16.302	0.44373	2
LOAD #2	N	-17.747	-13.800	-15.817	0.61191	3
Carriage Velocity	m/s	0.099731	0.10301	0.10090	0.00044531	4
Carriage position	m	7.9181	22.495	15.208	4.2071	5

NET DRAG

IOT

Analyzed: 08-DEC-2005 09:21:36
Acquired: 8-DEC-2005 08:57:43



National Research Council Canada
Institute for Ocean Technology

GENERATED BY: MEADUSC	CHECKED BY:	APPROVED BY:

Figure 1 TG2_0P1_REV_001

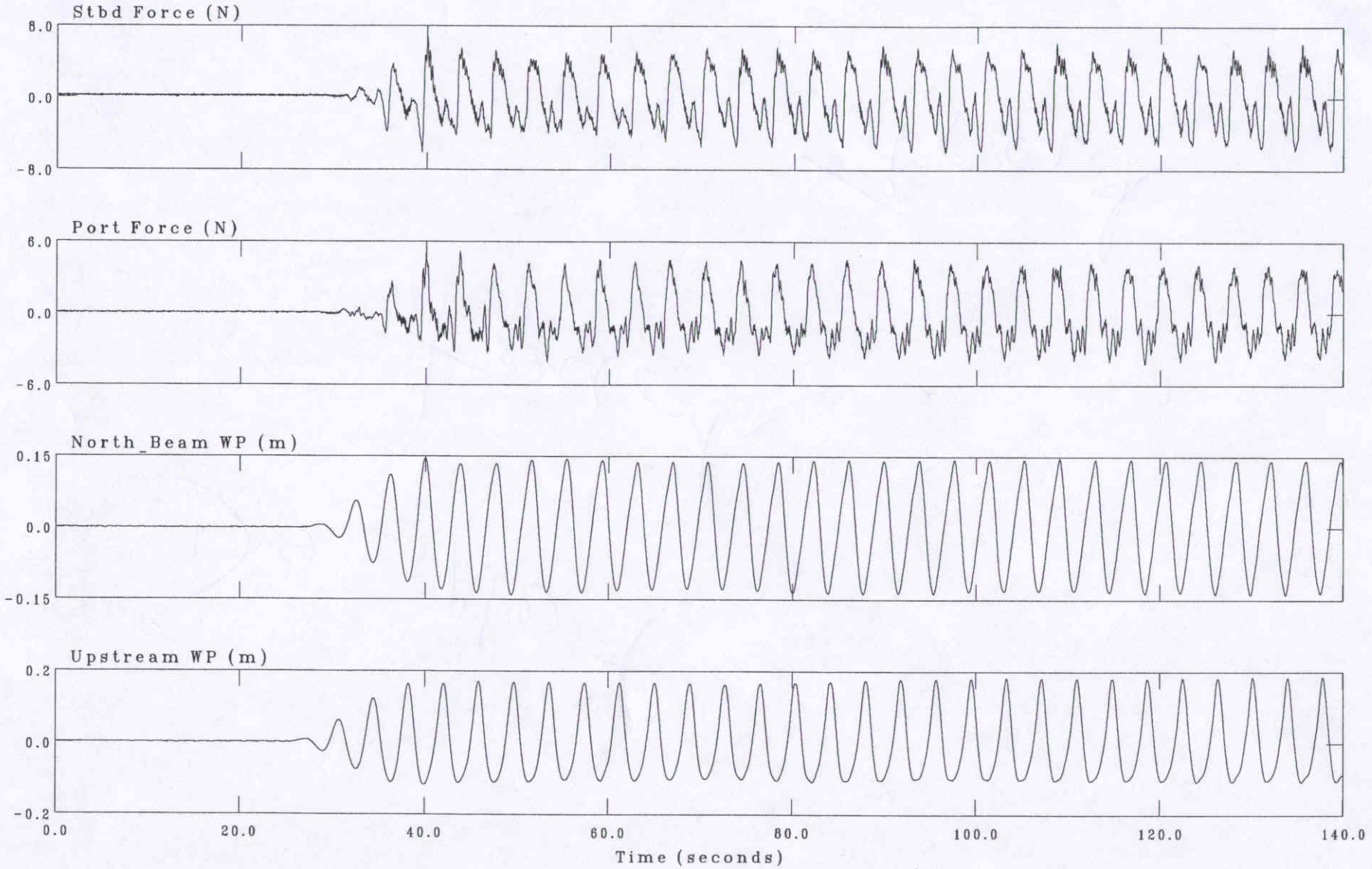
Analysis Date/Time = 8-DEC-2005 09:23:29
Acquired Date/Time = 8-DEC-2005 08:57:43
Input File = CH_S1
Output File = TG2_0P1_REV_001
Number of Samples = 438
Segment Start Time = 2.9000 seconds
Segment End Time = 11.640 seconds

Description	Unit	Min	Max	Mean	S.D.	Chan
Y Inline Load	N	-16.768	-16.468	-16.627	0.055211	1
LOAD #1	N	-16.890	-16.407	-16.642	0.081726	2
LOAD #2	N	-16.361	-15.821	-16.123	0.087623	3
Carriage Velocity	m/s	0.00077379	0.0017656	0.0012312	0.00019456	4
Carriage position	m	56.916	56.936	56.928	0.0028902	5

Analysis Date/Time = 8-DEC-2005 09:23:31
Acquired Date/Time = 8-DEC-2005 08:57:43
Input File = CH_S2
Output File = TG2_0P1_REV_001
Number of Samples = 10382
Segment Start Time = 30.060 seconds
Segment End Time = 237.68 seconds

Description	Unit	Min	Max	Mean	S.D.	Chan
Y Inline Load	N	-17.067	-16.254	-16.633	0.14246	1
LOAD #1	N	-18.615	-15.280	-16.945	0.41694	2
LOAD #2	N	-19.156	-13.941	-16.424	0.54761	3
Carriage Velocity	m/s	-0.099863	-0.095895	-0.098197	0.00057021	4
Carriage position	m	34.697	55.442	45.063	5.9838	5

Aquaculture phase 11



National Research Council Canada
Institute for Ocean Technology

GENERATED BY: S.MCKAY	CHECKED BY:	APPROVED BY:

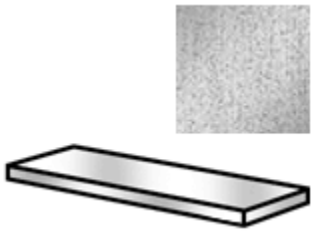
Figure {FIGURE_NUMBER} WL_W7_001

Appendix C

Equipment / Miscellaneous

Stainless Steel

This product matches all of your selections.



Part Number: 2416K99 $36.79 Each

Shape	Sheets, Bars, Strips, and Cubes
Sheets, Bars, Strips, and Cubes Type	Plain
Sheets, Bars, Strips, and Cubes Form	Rectangular Strip
Thickness	.031"
Thickness Tolerance	±.0015"
Length	60"
Length Tolerance	±1"
Width	2"
Width Tolerance	±.0005"
Material	Wear-Resistant High-Strength Stainless Steel (Type 301)
Finish/Coating	Unpolished (Mill)
Tolerance	Standard
System of Measurement	Inch
Material Certification	Without Material Certification
Condition/Temper	Spring Temper
Hardness	382 Brinell
Yield Strength	147,000 psi
Specifications Met	Not Rated

Spring Steel to Decouple Forces

From: Sheldon Mercer [sheldonm@engr.mun.ca]
Sent: May 3, 2005 2:23 PM
To: trent.slade@nrc.ca
Subject: hardness test

Trent,

Sorry this took so long. I done six hardness test. Three Rockwell C and three Rockwell A. The results are as follows:

Rockwell C: 40,40,40
Rockwell A: 69,70,69

The chart that I have indicates both in the same region.

The Rockwell C test left a small extrusion spot on the opposite side of the test piece after the test was completed. When you come by to pick up the piece I'll show you.

Sheldon Mercer
Engineering Technologist III
Faculty of Engineering and Applied Science
Memorial University of Newfoundland
St. John's, NL, Canada
Tel: (709)737-8913
Fax: (709)737-4042
E-mail: sheldonm@engr.mun.ca

Hardness Test Conducted on the Spring Tempered Stainless Steel Used to decouple the Load Forces.

ADVANCED MOTION & CONTROLS LTD.

Factory Automation Products

Advanced Motion & Controls Ltd.
26 Saunders Road
Barrie, ON L4N 9A8
Phone: 705-726-2260 Fax: 705-726-5829
Toll Free: 1-800-461-5679
www.advancedmotion.com

SALES QUOTE

Sales Quote Number: SQ000907
Sales Quote Date: 10/18/04
Page: 1

Sell
To: NATIONAL RESEARCH INSTITUTE
SCOTT REID
KERWIN PLACE, BOX 12093
POSTAL STATION "A"
ST. JOHN'S, NFLD A1B 3T5
Canada
Phone: 709 772 2479 Fax: 709 772 2462

Ship
To: NATIONAL RESEARCH INSTITUTE
KERWIN PLACE, BOX 12093
POSTAL STATION "A"
ST. JOHN'S, NFLD A1B 3T5
Canada

GST# / TPS# R100093004
QST# / TVQ# 143164408RT

Customer ID NATI2479
Terms

Ship Via

SalesPerson House Account - Barrie

Item No.	Description	Unit	Qty.	Unit Price	Total Price
HSR55+780L	GK RAIL	EACH	1	473.96	473.96
HSR55LBSSC1	GK BLOCK	EACH	1	368.18	368.18
	2-3 WEEKS DELIVERY				
SHS55LCSSC1	BLOCK ONLY	EACH	1	468.00	468.00
SHS55+780L	RAIL	EACH	1	600.00	600.00
	DELIVERY ON THE ABOVE 2 ITEMS IS 2-3 WEEKS				

Technical Sales Rep
800-461-5679 Ext. 307
blilley@advancedmotion.com

Amount Subject to Sales Tax	Amount Exempt from Sales Tax	Tax Breakdown:			
1,910.14	0.00	GST/TPS	286.52	Subtotal:	1,910.14
				Invoice Discount:	0.00
				Total Tax:	286.52
Entered By: B_LILLEY				Total (CAD):	2,196.66

INTERTECHNOLOGY INC.

An ISO 9001:2000 Registered Company

1 Scarsdale Road, Don Mills, Ontario, M3B 2R2 Fax: 416-445-1170

TORONTO AREA (416) 445-5500, EXT. 257, TOLL FREE 1-800-465-1600

Montreal (514) 333-0930 Ottawa (613) 723-1828 Winnipeg (204)895-2037 Calgary (403) 254-0095 Vancouver (604)270-9538

Website: www.intertechnology.com, **E-Mail:** sales@intertechnology.com

QUOTATION

TO:	Inst. Ocean Technology	**DATE:**	October 21, 2004		
ADDRESS:	1 Kerwin Road	**FROM:**	**John Manocchio, Ext. 257**		
CITY:	St. Johns	**QUOTE NO:**	91-43919		
PROV.:	N.F.	**DUTY:**	NA	**TAXES:**	Extra
P.C.:		**VALID FOR:**	30 days		
CONTACT:	Tim Ennis	**FUNDS:**	Canadian		
TEL:	709-772-5649	**F.O.B.:**	Don Mills, Ontario		
FAX:	709-772-2462	**TERMS:**	Net 30 days OAC		
REF:		**DELIVERY:**	Stock		

ITEM	QTY	DESCRIPTION	UNIT PRICE
1	2	Sensortronics S-Beam Load Cell • Capacity: 0 to 100 lbs. • 3 mV/V output • 20 ft. standard cable	$429.00 each

Sincerely,
INTERTECHNOLOGY INC.

John Manocchio, Ext. 257
Inside Sales Representative
JM:bh

NOTICE TO CUSTOMERS: All Purchase Orders must indicate a method of shipment, including Courier Name and Account number. Exclusion of Courier information will prompt goods to be shipped prepaid and charged. **Please note that hazardous goods can ONLY be shipped via Purolator ground.** Intertechnology does not declare value for transit insurance unless specified in writing by Customer.

Our terms, unless otherwise shown, are net 30 days. Any unpaid balance, 30 days after shipment will be subject to charges calculated at a rate of 8% per annum above the then effective prime rate until paid in full.

US Customers - Supply Federal Tax ID Number
Overseas Customers - Supply VAT Registration Number
Ontario Customers - Supply PST Exemption information

SENSORTRONICS

Our people make the difference.

MODEL 60001

S-BEAM LOAD CELL

APPLICATIONS

- Tank, bin and hopper weighing
- Level and inventory monitoring
- Truck scale conversions
- Tension and compression measurements

FEATURES

- Rated capacities of 25 to 20,000 pounds
  50 kilograms to 5 metric tons
- Stainless steel version is model 60050
- Integral loading bracket
- Designed for single or multiple load cell applications
- Constructed of high quality alloy tool steel
- Nickel plated for outstanding corrosion resistance
- Trade certified for NTEP Class III:5,000 Divisions and
  Class III:10,000 Divisions available
- ***Sensorgage***™ sealed to IP67 standards
- ***Cell Guard***™ Two Year Warranty
- Factory Mutual System Approved for Classes I, II, III;
  Divisions 1 and 2; Groups A through G.
  Also, ***Non-Incendive*** ratings (No Barriers!).
- ISO 9001 Certified manufacturing facilities

ISO 9001

NTEP

Factory Mutual System Approved

OIML

IP 67

Model 60001 Performance Specifications

Rated Capacities (lbs): 25, 50, 75, 100, 150, 200, 250, 300, 500, 750, 1K, 1.5K, 2K, 2.5K, 3K, 5K, 10K, 15K, 20K
(kgs/metric tons): 50kgs, 100kgs, 250kgs, 1t, 2.5t, 5t

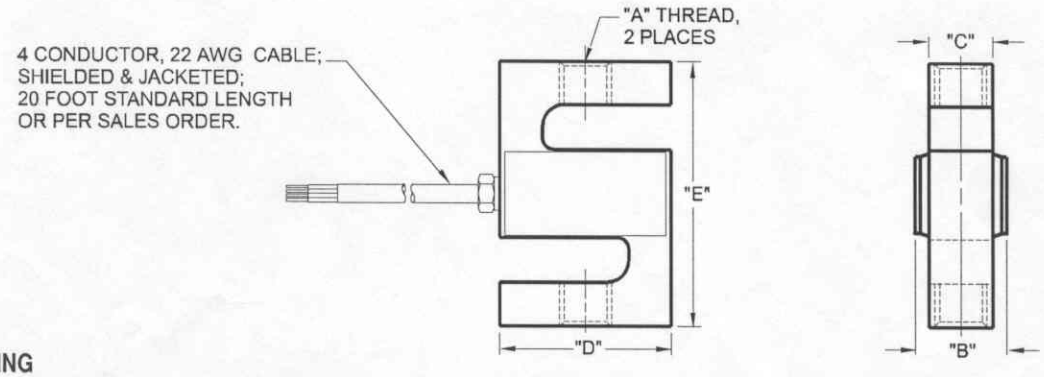
Full Scale Output (FSO):

lbs	kgs/metric tons
25 - 3K: 3.0 mV/V + 25% / - 10%	50kg - 1t: 3.0 mV/V + 25% / - 10%
5K - 20K: 3.0 mV/V ± 0.25%	2.5t - 5t: 3.0 mV/V ± 0.25%

Accuracy Class:	Standard	NTEP III	NTEP IIIL	OIML R60 [1]
Max. No. Verification Intervals	--	5,000 Multiple	10,000 Multiple	3,000
Combined Error % FSO	≤ .03	--	--	--
Non-Linearity % FSO	≤ .03	--	--	--
Hysteresis % FSO	≤ .02	--	--	--
Creep Error % FSO	≤ .03 in 20 minutes	--	--	--
Temperature Effect on:				
• Zero % FSO/°F	≤ 0.0015	--	--	--
• Output % of Load/°F	≤ 0.0008	--	--	--

Non-Repeatability % FSO	≤ .01
Zero Balance % FSO	≤ 1.0
Insulation Resistance	> 1000 Mohms at 50 VDC
Compensated Temperature Range	14° to 104°F / -10° to 40°C
Operating Temperature Range	0° to 150°F / -18° to 65°C
Storage Temperature Range	-60° to 185°F / -50° to 85°C
Input Resistance	343-450 Ohms
Output Resistance	349-355 Ohms
Recommended Excitation Voltage	10 Volts DC
Maximum Excitation Voltage	15 Volts DC
Sideload Rejection Ratio	500:1
Safe Sideload	30% of Rated Capacity
Safe Overload	150% of Rated Capacity
Ultimate Overload	300% of Rated Capacity
Sealing	Meets IP67 Standards
Material	Alloy Tool Steel
Finish	Electroless Nickel Plated

Note: [1]OIML 100 - 5K (500kg - 2.5t) capacities only.



WIRING

FUNCTION	COLOR
+ Excitation	Red
– Excitation	Black
+ Output	Green
– Output	White

CAPACITY	A	B	C	D	E	Deflection	Weight
25 - 200	1/4-28 UNF-2B	0.65	0.50	2.00	2.50	0.015 - 0.010	4.0
250 - 300	3/8-24 UNF-2B	0.75	0.50	2.00	3.00	0.010	4.0
500 - 2K	1/2-20 UNF-2B	1.00	0.75	2.00	3.00	0.010 - 0.012	6.5
2.5K - 4K	1/2-20 UNF-2B	1.25	1.00	2.00	3.00	0.012	6.5
5K	3/4-16 UNF-2B	1.25	1.00	3.00	4.25	0.017	6.5
10K	3/4-16 UNF-2B	1.25	1.00	3.50	4.75	0.025	6.5
15K	1-14 UNF-2B	1.50	1.25	4.00	5.50	0.025	9.0
20K	1 1/4-12 UNF-2B	2.25	2.00	5.00	7.00	0.025	9.0
(50 - 100kgs)	M8.0 x 1.25-6H	(16.5)	(12.7)	(50.8)	(63.5)	(0.03 - 0.004)	(1.8)
(250kgs - 1t)	M12 x 1.75-6H	(25.4)	(19.1)	(50.8)	(76.0)	(0.004)	(1.8)
(2.5t)	M20 x 1.5-6H	(31.8)	(25.4)	(76.2)	(108.0)	(0.008)	(2.9)
(5t)	M20 x 1.5-6H	(31.8)	(25.4)	(88.9)	(120.7)	(0.011)	(2.9)

Dimensions are in inches (mm). Capacities are in pounds (kg/t). Deflection is ± 10%. Specifications are subject to change. Certified drawings are available.

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