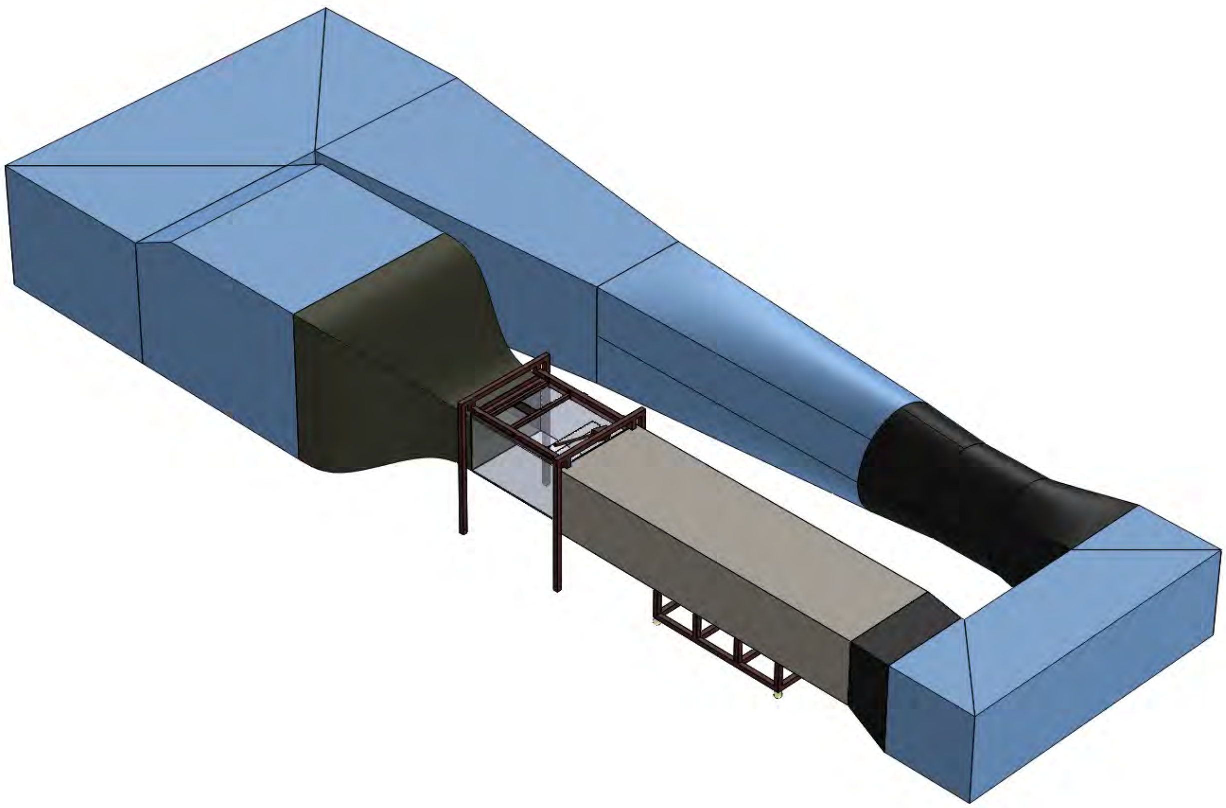
BOEING SUBSONIC WIND TUNNEL OPERATION MANUAL



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Purdue University
School of Astronautics and Astronautics

July 26, 2019

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INTRODUCTION

The Boeing Subsonic Wind Tunnel shown in Figure 1, located in the Aerospace Sciences Laboratory (ASL) at Purdue University, is a closed-return, closed test-section wind tunnel with a 4 ft. x 6 ft. x 8 ft.-long test section. With an empty test section, the wind tunnel is able to reach speeds of 96 mph (43 m/s).

The tunnel is equipped with the following instrumentation:

- Four component force balance
  - Lift, drag, pitch, roll
  - Computer-controlled angle of attack
- Computer-driven two-axis traverse
  - 80 in horizontal travel x 60 in vertical travel
- Pitot probes, seven hole probe, air velocity transducer, temperature transducer
- Smoke wand
- LabVIEW data acquisition system

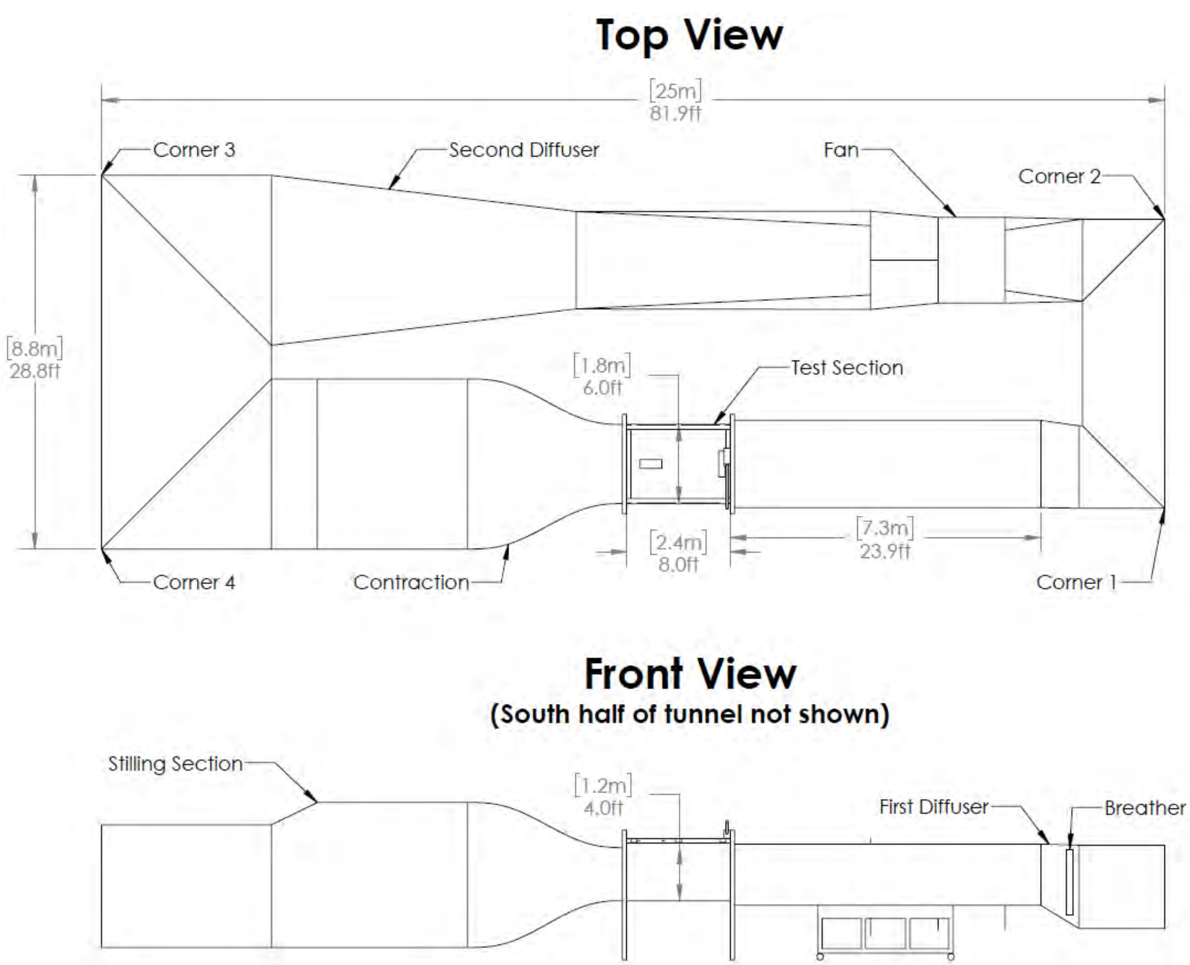


Figure 1: Boeing Subsonic Wind Tunnel overview

WIND TUNNEL PERFORMANCE

Currently the tunnel is able to reach speeds of up to 96 mph (43 m/s). A calibration plot of test section flow speed vs. motor frequency is shown below, and can be used as a baseline for setting the flow speed.

The speed of the flow in the test section (u_2) can be calculated using the equation below, where $(P_1 - P_2)$ is equal to the pressure drop across the contraction and K = 1.127 is a calibration constant. For K = 1.127 metric units must be used.

$$K(P_1 - P_2) = \frac{1}{2}\rho {u_2}^2$$

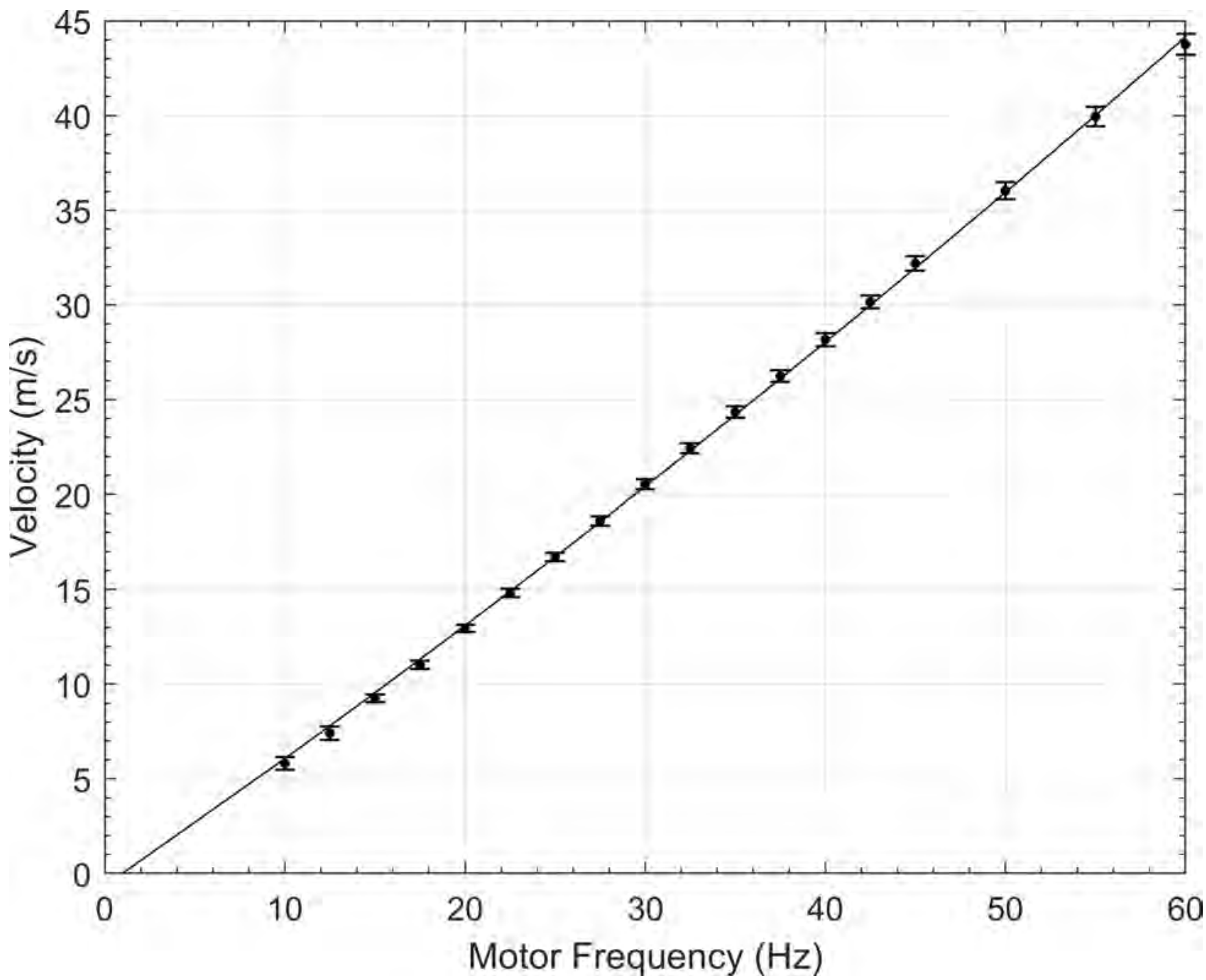


Figure 2: Wind tunnel speed (m/s)

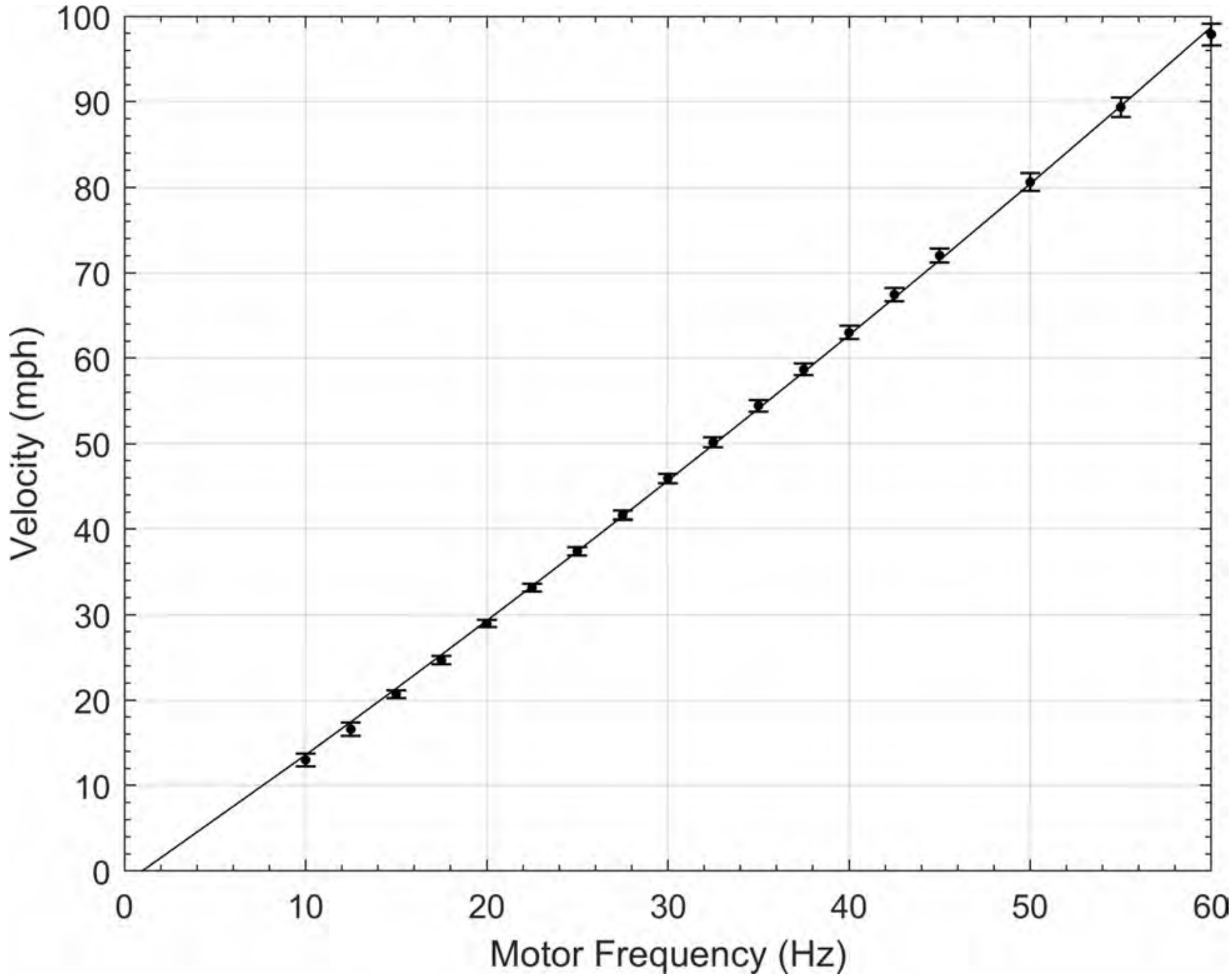


Figure 3: Wind tunnel speed (mph)

OPERATING THE WIND TUNNEL

Startup

At the variable frequency drive (located on the SW corner of the wind tunnel on the concrete platform):

1. Turn the handle clockwise 90 degrees to turn on (cooling fan should turn on)

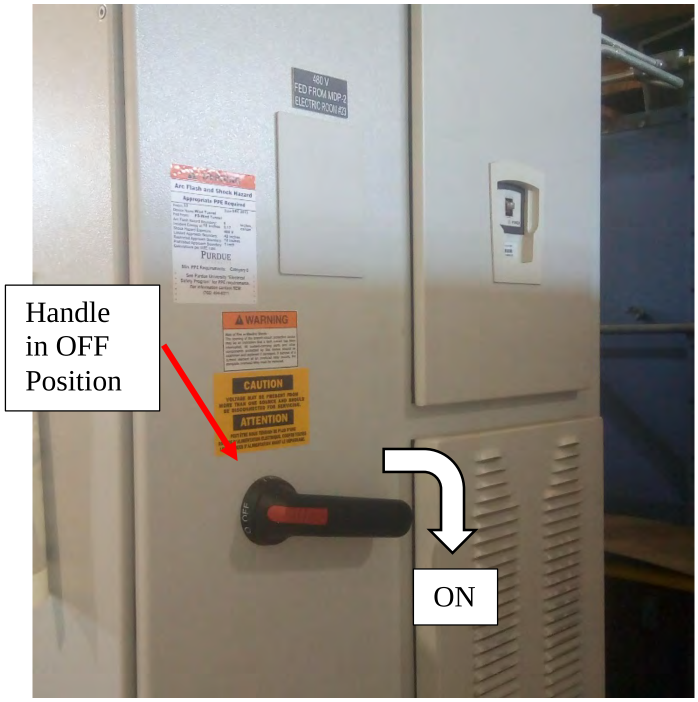


Figure 4: Variable frequency drive

CAUTION Before turning on the tunnel:

2. Make sure the circular hole cover is tightly secured
3. Make sure that all tools have been removed from the tunnel and that there are no loose items (nuts, bolts, etc.) in the tunnel

At the controller (located across from the test section)

4. Pull out emergency button
5. Set frequency to 10 Hz using the up arrow
6. Press the green hand button (tunnel will start)
7. Set tunnel speed using arrows (25 Hz max for teaching labs)

Figure 5: Wind tunnel speed controller

Shutdown

At the controller

1. Lower frequency to zero
2. Push red OFF button
3. Push emergency button in

At the variable frequency drive

4. Rotate handle 90 degrees counter clockwise to OFF position

MAIN TUNNEL COMPONENTS

Safety Exit from Tunnel

In the unlikely situation that a person is in the test section of the tunnel and the main door cannot be opened, a safety exit door is available at the bottom of the contraction section, near the stilling section of the tunnel.

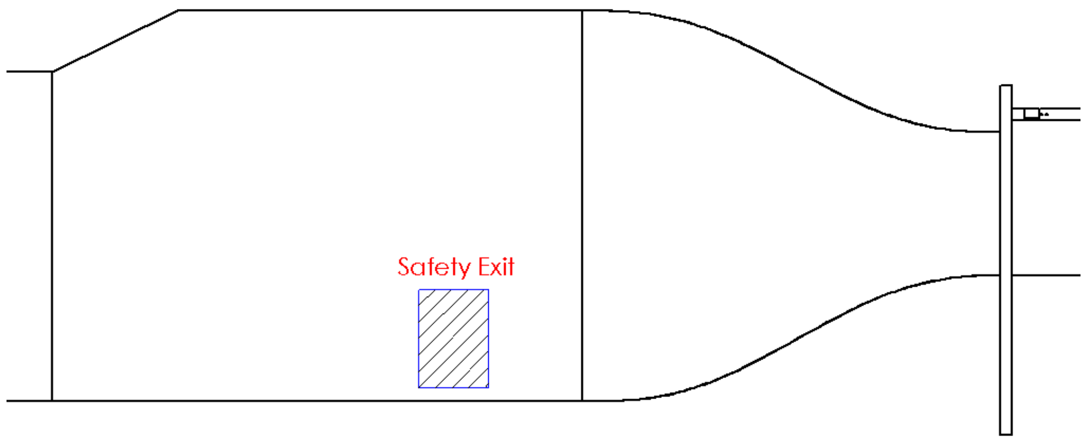


Figure 6: Safety Exit Location

The safety exit door is equipped with a Southco rotatory latch to keep the door closed. The door can be opened from the inside of the tunnel using a push button actuator, which is flush mounted to the tunnel wall next to the safety exit door. The latch can also be opened from the outside of the tunnel by pulling up on the latch cable.

When closing the safety exit door, insure that the latch is fully engaged by lightly pulling on the door. The latch does feature a two-stage engagement to provide latching if the door is not fully closed, but the tunnel should only be run if the door is fully closed.

Stilling Section – Screens and Honeycomb

The stilling section of the wind tunnel is designed to reduce the size of the turbulent fluctuations and straighten and increase the uniformity of the flow entering the test-section. The honeycomb is used to reduce any large swirl components of the upstream flow. The screens reduce turbulence and establish a uniform test-section profile [1]. This part of the tunnel is divided into the seven sections as shown below, where the first two stations are not part of the stilling section, but are part of the diffuser used to increase the tunnel cross section size to the size of the contraction inlet. The dotted lines represent screens made from aluminum wire cloth with the properties as follows in Table 1. The honeycomb wall at Station 3 is 4 inches thick and made of polycarbonate, with a ½-inch cell diameter. This honeycomb was supplied by Plascore and has a total density of 3lbs/ft^3.

Table 1: Stilling Section Screen Sizes

Mesh Size (wires/inch)	Wire Diameter (in)	Porosity
8M	0.035	51.8%
16M	0.011	67.9%
28M	0.0075	62.4%
43M	0.005	61.6%
50M	0.0045	60.1%

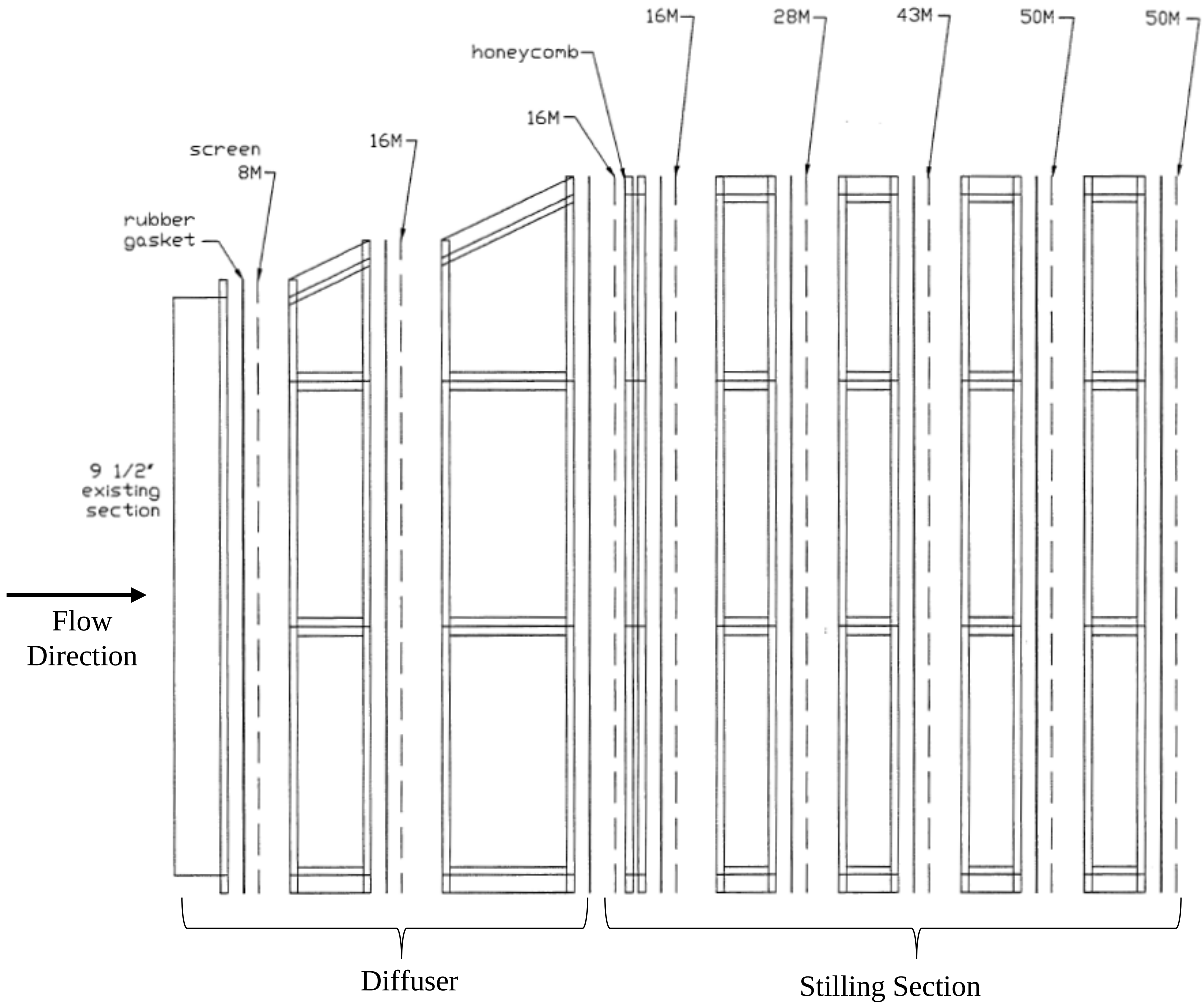


Figure 7: Honeycomb and screen configuration

Contraction

The contraction section of the tunnel is used to increase the air speed entering the test section and has a total contraction ratio (A_{in}/A_{out}) of 5.96:1. It is constructed of four individual fiberglass sides, which are fastened together at the corners.

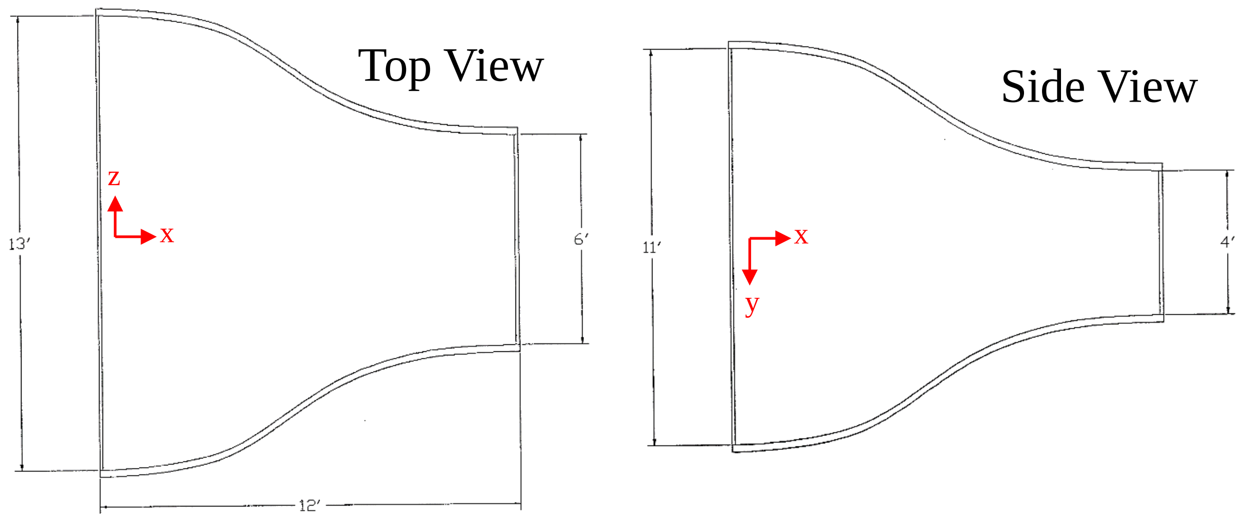


Figure 8: Contraction dimensions

The shape of the contraction contour follows a cubic fit with X = 0.45 [2]

$$H(x) = \begin{cases} (H_{in} - H_{out})\left[1 - \frac{1}{X^2}\left(\frac{x}{L}\right)^3\right] + H_{\text{out}} \rightarrow \frac{x}{L} < X \\ (H_{in} - H_{out})\left[\frac{1}{(1-X)^2}\left(1 - \frac{x}{L}\right)^3\right] + H_{\text{out}} \rightarrow \frac{x}{L} > X \end{cases}$$

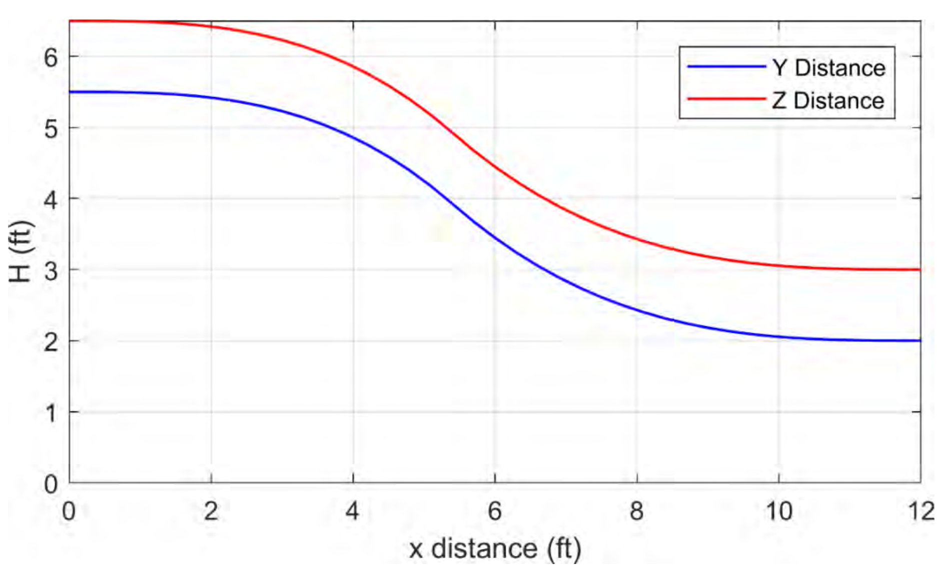


Figure 9: Contraction contour profile

The walls of the contraction are made of a three-layer fiberglass laminate construction as shown below. The middle layer of the wall contains a Divinycell H-60 foam core and is sandwiched between six layers of cloth, which are 60% resin.

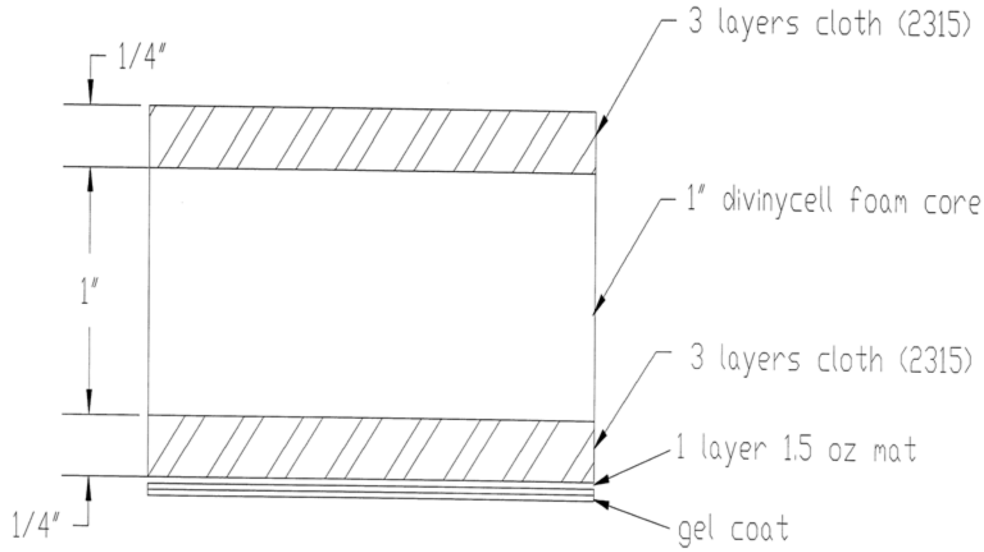


Figure 10: Contraction wall construction

First Diffuser

The first diffuser is situated between the downstream end of the test-section and the first corner. It contains five angled plates to prevent the flow from separating, shown below.

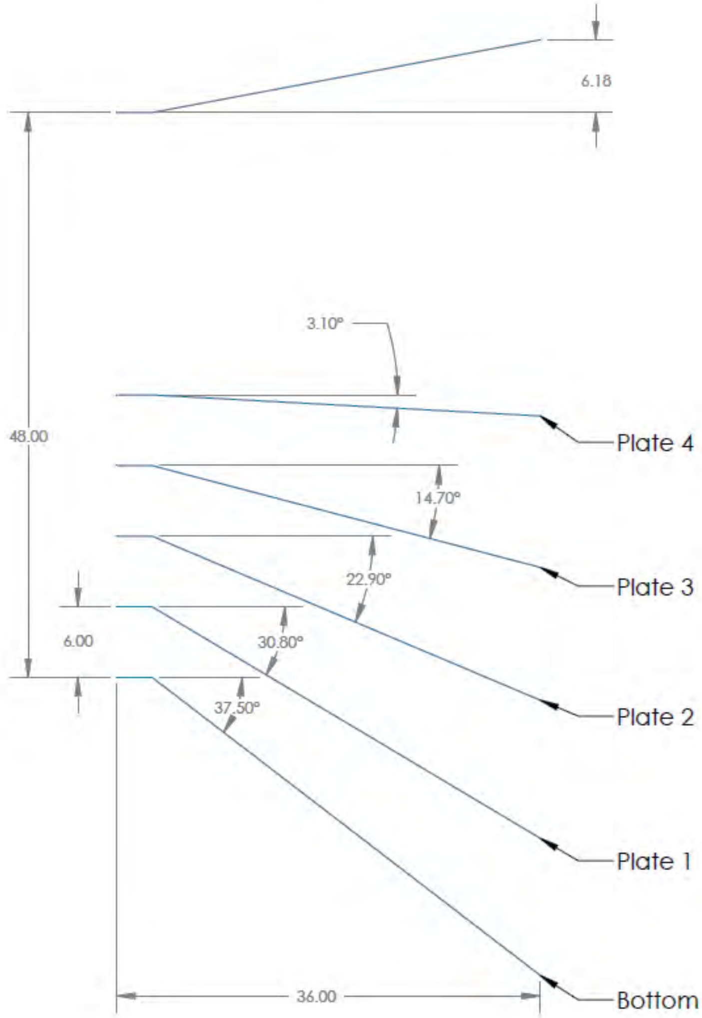
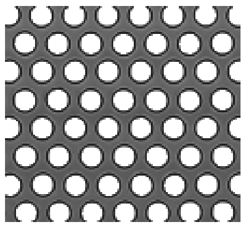


Figure 11: Diffuser

Breather

The downstream end of the diffuser contains a breather section, which is constructed from a perforated aluminum sheet with the following characteristics:

- 3/16" hole diameter
- 51% open area
- Staggered arrangement
- ¼" center-to-center spacing



The breather section allows air into the tunnel. This keeps the static pressure within the tunnel close to atmospheric pressure and also helps to control the temperature in the tunnel.

Turning Vanes

In Corners 1, 2, and 3 of the wind tunnel, there are turning vanes that span the entire height of the tunnel. These turning vanes are used to minimize pressure losses as the air turns the corner and to mitigate separation of the boundary layer through the turn. The turning vanes in Corners 1 and 3 both contain support bars that link the individual turning vanes, reducing any fluttering of the turning vanes.

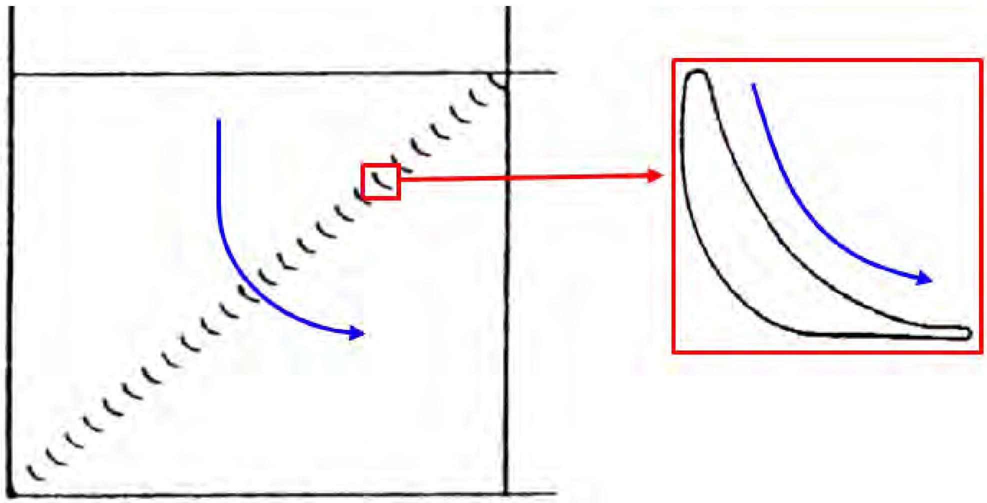


Figure 12: Top view of corner turning-vanes showing flow direction

Wind Tunnel Fan

The wind-tunnel fan unit consists of an Axico Anti-Stall Vaneaxial Fan, run by an MAX-E1 AC Motor with a variable-speed drive. The fan (FPDA-2-200-8-10-1160-300) consists of 10 blades with variable pitch, which allows for changing the fan rpm vs tunnel flow speed curve. The maximum manufacturer service for this fan is 1188 RPM (60 HZ). The motor manufacturer's maximum power is 300 HP. The wind tunnel fan is run by an ABB drive (ACH550- PDR-368A-4+B055) located at the southwest corner of the wind tunnel

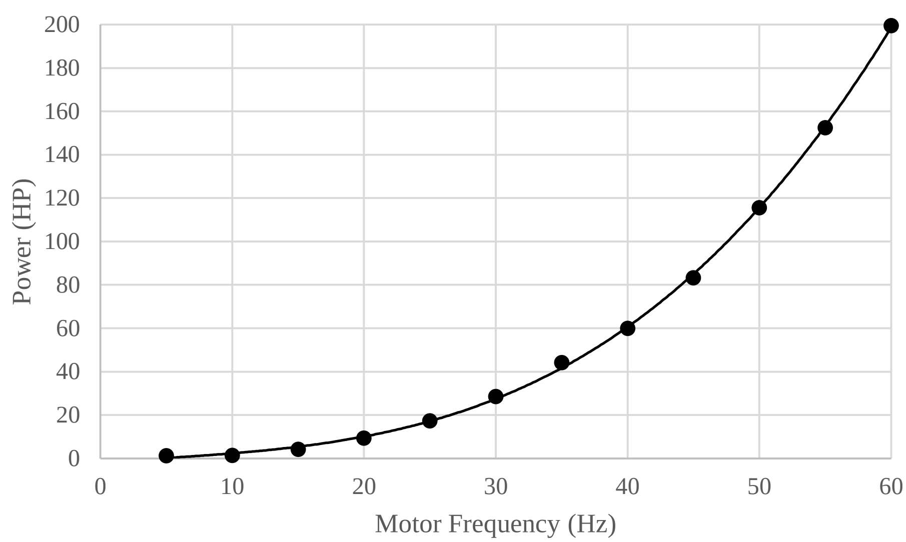


Figure 13: Wind tunnel motor power curve

General Maintenance

The propeller in an axial flow fan must be kept reasonably clean if it is to perform properly. Fans handling fresh air for ventilating purposes will seldom need cleaning. Fans exhausting process air should be cleaned as required. Dirt or chemical deposits will usually build up evenly on a propeller and although performance is affected, vibration is usually acceptable until the deposits become thick enough to break away in crust-like pieces. When this happens, the propeller may be thrown out of balance and the resulting vibration could be serious. Accumulations should be removed by solvent cleaning or scraping. If the propeller has been coated, be careful not to cut through this protective covering. The vaneaxial fan is constructed with a set of guide vanes adjacent to the propeller. These should be cleaned at the same time the propeller is cleaned. The guide vanes are important to the performance of the fan and should be inspected carefully. They may accumulate dirt even under conditions where the propeller remains clean.

Per the manufacturer's instructions, the fan motor should be lubricated every 3000 hrs. or every five years. The motor was last greased on May 8, 2019.

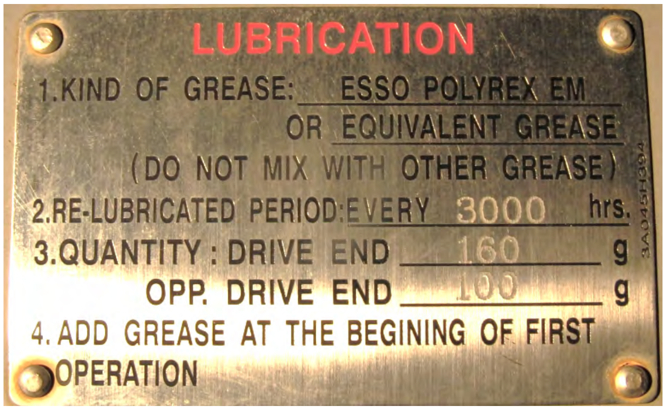


Figure 14: Fan motor lubrication instructions

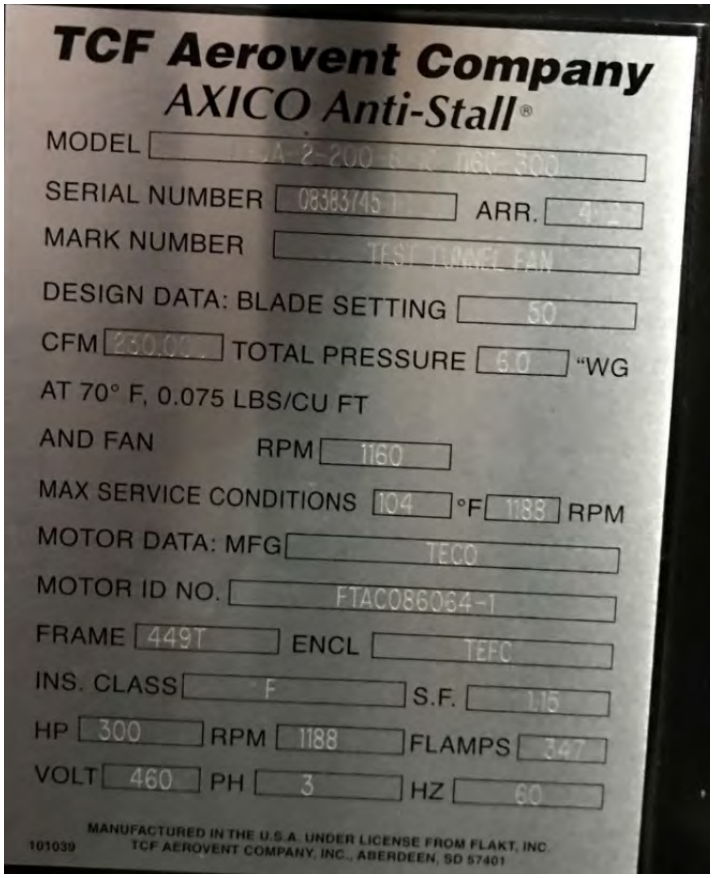


Figure 15: Tunnel Fan Plate

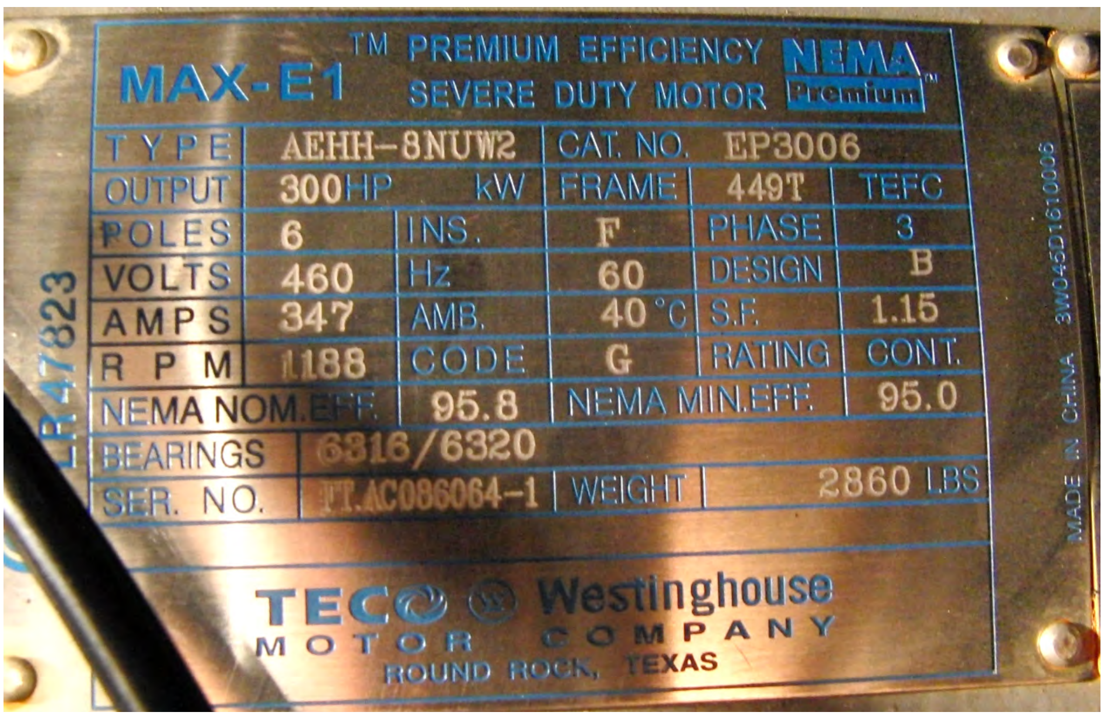


Figure 16: Tunnel Fan Motor Plate

MODEL MOUNTING AND INSTALLATION

Although the force balance is designed to allow for different mounting strut positions, it is strongly recommended that the standard mounting positions be used whenever possible. If other mounting positions are needed, the wooden hole covers should be used, rather than putting holes in the standard Plexiglas hole cover.

For dimensioned drawings of the test section and mounting struts, see “Selected Part Drawings” at the end of this manual.

Strut Installation

1. Turn all four latches from the latched to the unlatched position

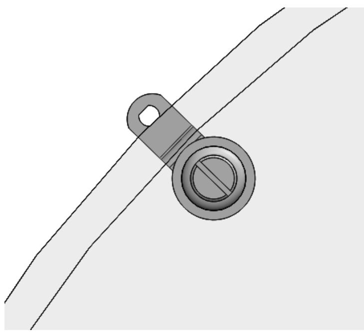


Figure 17: Latched hole cover position

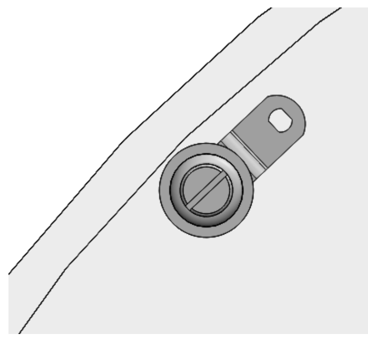


Figure 18: Unlatched hole cover position

2. Grabbing the Plexiglas hole cover by the strut holes, lift and remove the cover from the floor of the tunnel.

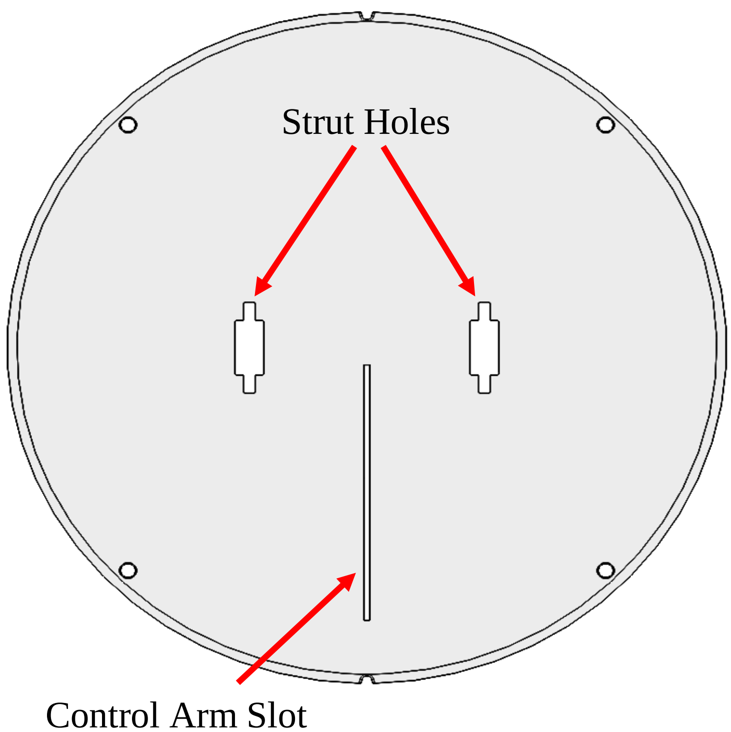


Figure 19: Wind-tunnel hole cover design

3. Using the locating pins on the bottom of the struts, place the struts onto the force balance mounting plate
    - The blunt ends of the struts should be facing forward.

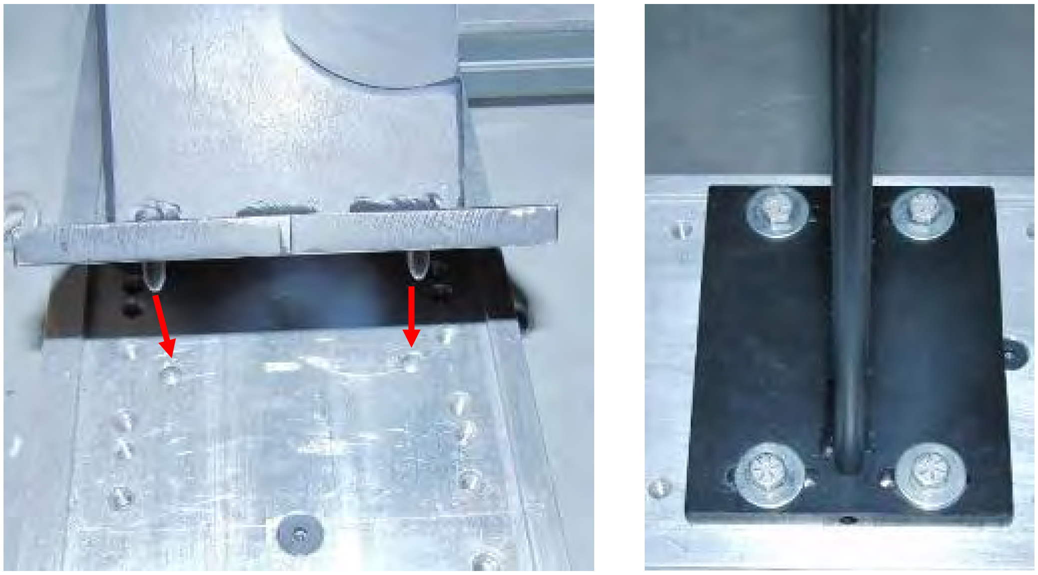


Figure 20: Mount strut installation locating method

4. Secure each strut with four bolts and washers
5. Lower the hole cover over the struts so that the control arm slot is downstream of the struts
    - The hole cover should be lying flush with the tunnel floor.
6. Turn all four latches to the latched position

AOA Control Arm Installation

1. Slide the thin end of the AOA control arm through the control arm slot in the hole cover

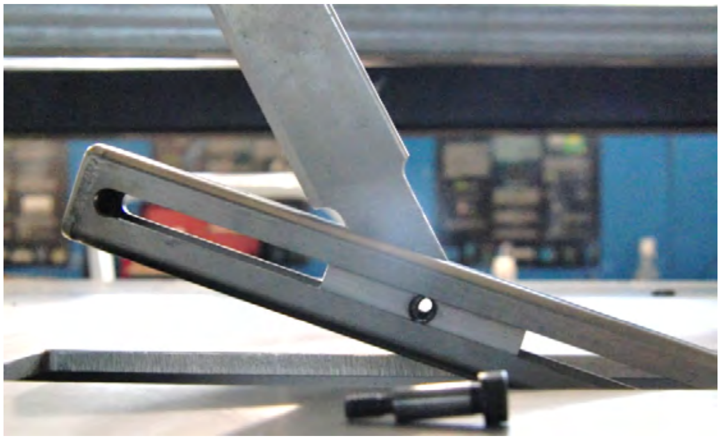


Figure 21: AOA control arm installation

2. On the back side of the test section, attach the control arm to the force balance using a 1/8"-24 shoulder bolt and finger tighten

FOUR COMPONENT FORCE BALANCE

Platform/Parallelogram Balance Overview

The platform balance is used to measure the lift, pitching moment and rolling moment produced on a model in the wind tunnel. It consists of three FUTEK Force Transducers located under the top balance plate. These are labeled F1, F2, and F3. The fourth transducer, located outside the parallelogram balance, measures the drag produced, and is labeled F0. All transducers are connected to the National Instruments Channel Amplifiers. A schematic of the setup is shown below.

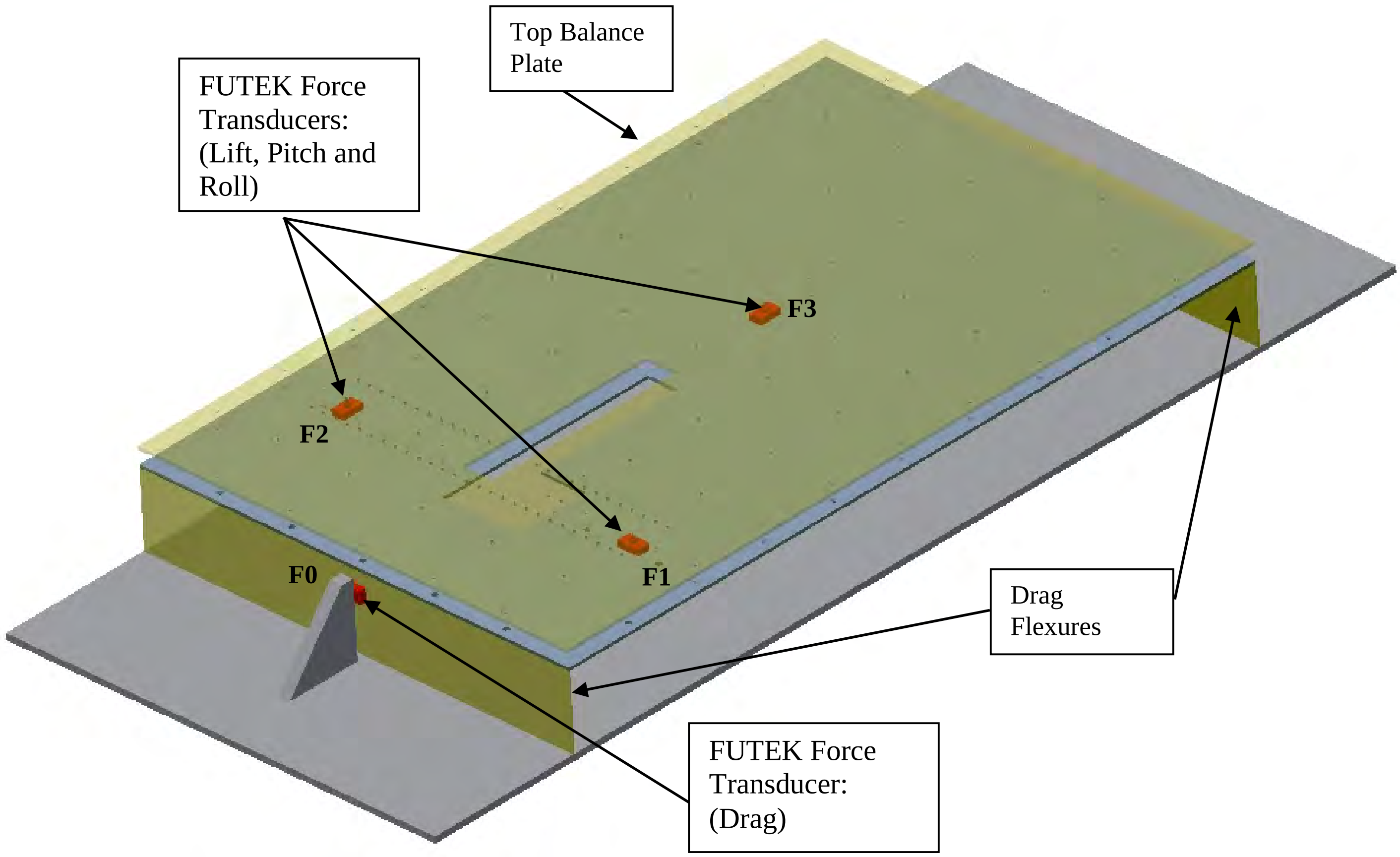


Figure 22: Platform balance setup

The balance works by taking the readings from the different transducers and manipulating them with the proper equations to output the lift, drag and pitching moment respectively.

- **The Drag** – is measured by the F0 transducer reading inside the parallelogram. It measures the force induced between the top plate and the bottom plate.

$$D = F0$$

- **The Lift** – is measured by the F1, F2, and F3 transducers located beneath the top plate. When the airfoil is placed in the wind tunnel, the lift force pulls up on the balance. This lift force is the sum of the transducers.

$$L = F1 + F2 + F3;$$

- **The Pitching Moment** – is measured by the F3 and F0 transducers. It is measured from the moments created by the lift and drag forces on the airfoil.

$$P = -Lp * F3 + h * F0;$$

(where Lp is the distance from the airfoil base on the top plate (30.0 inches), to the F3 transducer, and h is the distance from the top plate to the airfoil 32 inches).

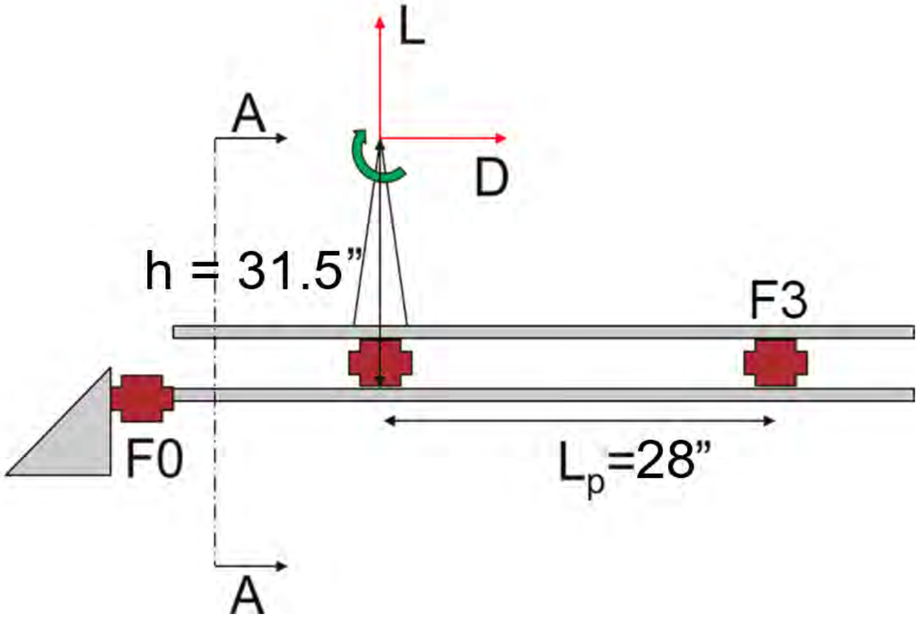


Figure 23: Free body diagram for lift, drag and pitch

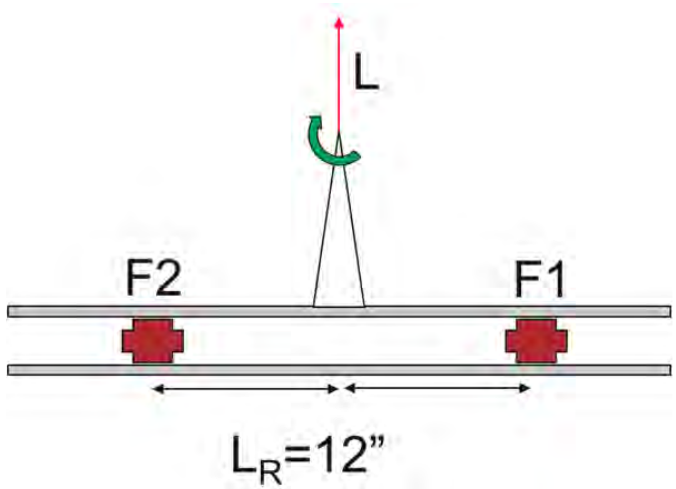


Figure 24: Free body diagram for roll (Section A-A)

- **The Rolling Moment** – is measured by the F1 and F2 transducers.

$$R = Lr * (F1 - F2)$$

(where Lr is the distance from the airfoil base on the top plate (12.0 inches), to the F2 and F1 transducer).

LabVIEW Implementation

When implementing the free body diagram equations above into LabVIEW, the units for the values of h, Lr and Lp are in feet.

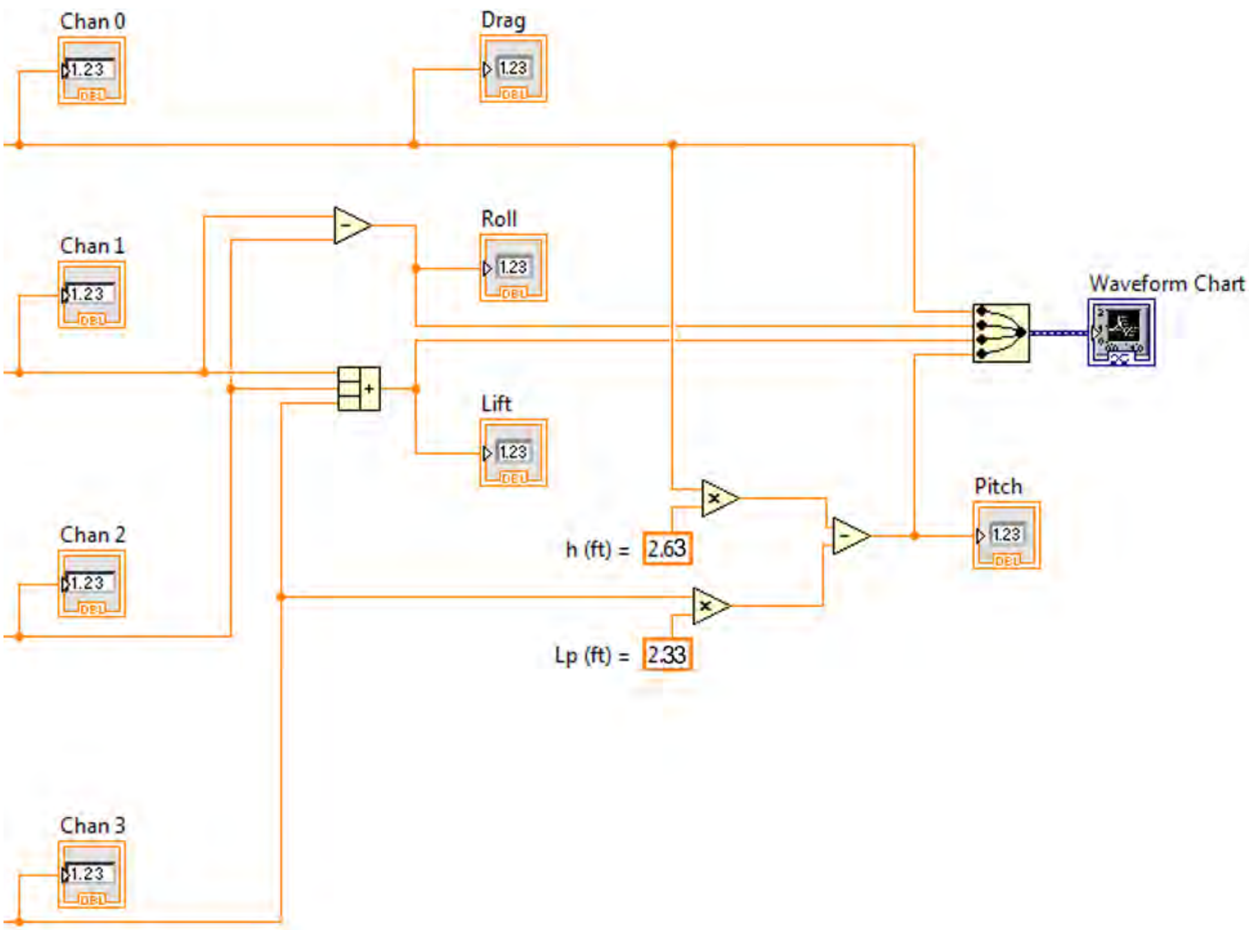


Figure 25: Free body diagram LabVIEW implementation

Calibration

To calibrate the four transducers on the platform balance, it is necessary to apply a known load at three different locations on the balance to measure lift, dag and pitching moment respectively.

To Calibrate the Lift

1. Open the ***Wind Tunnel Balance*** LabVIEW program located in the ***C:\Temp\AAE 334l-Fall2017*** folder. Once opened, select a folder and text file where you would like the output readings to be saved. (You only need to create one text file for the calibrations, the program sets a separate time stamp for each reading you take)
2. Run the balance program and click the tare values button
3. Apply one of the known weights from the weight box to the middle of the Top Balance Plate and let the balance even out before recording data. A circle is marked on the top balance plate with L written on it; place weights on this circle for lift
4. The transducer lift measurements are located in the text file to which you created the path. The text file includes 11 columns of data which are: Pitot pressure, wind speed, temperature, AoA,

drag, lift, pitch, F0 (force from 0 transducer), F1, F2, and F3 respectively. The lift is calculated using the equation shown in the introduction.

5. Use 1-10lb weights to get 10-point calibration
6. In Excel or MATLAB, compare this value to the actual value of the weight you used, and scale appropriately.

To Calibrate the Drag

1. Remove the weight used to calibrate the lift.
2. Place a known weight on the pulley platform located just behind the F2 transducer and let the balance even out before writing data.
3. The transducer drag measurements are located in the text file to which you created the path. The drag measured is the fifth column of data.
4. Use 1-10lb weights to get 10 point calibration
5. In Excel or MATLAB, compare this value to the actual value of the weight you used, and scale appropriately.

To Calibrate the Pitching Moment

1. Remove the weight used to calibrate the drag
2. Place a known weight on the same circle where you placed the lift weight.
3. The transducer data is located in the same text file with new timestamp. The pitching moment is the seventh column of data.
4. Use 1-10lb weights to get 10 point calibration
5. The pitching moment is calculated using the equation shown in the introduction. In Excel or MATLAB, compare this value to the actual value of the weight you used and scale appropriately.

FORCE TRANSDUCERS

Instrumentation

FUTEK Low Profile Tension & Compression Load Cell (F0 Transducer)

- Model No. LRF325
- 75 lb. capacity
- 1/4-28 thread connector

FUTEK Low Profile Tension & Compression Load Cell (F1-F3 Transducers)

- Model No. LRF350
- 150 lb. capacity
- 3/8-24 thread connector

LabVIEW Implementation

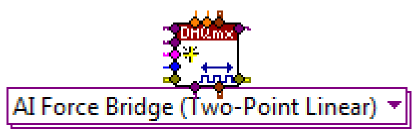


Figure 26: Force transducer virtual channel block

Table 2: Temperature probe channel configuration

Channel	Value		Units
	F0	F1-F3	
Physical Channels	cDAQ2Mod2/ai0	cDAQ2Mod2/ai1:3	
Bridge Configuration	Full bridge (10182)		
Voltage excitation source	Internal (10200)		
Voltage excitation value	3.3		V
Nominal bridge resistance	350		Ohms
Minimum value	-75	-150	lbs.
Maximum value	75	150	lbs.
Units	Pounds (15876)		
First electrical value	0	0	
Second electrical value	2	1.65	
Electrical units	mVolts/Volt (15897)		
First physical value	0	0	
Second physical value	75	150	
Physical units	Pounds (15876)		

Location and Installation

At the DAQ platform

Connect the black BNC connector from the force transducers to the corresponding MOD2 ports (i.e. F1 to Ch1) on the input module (NI-9237)

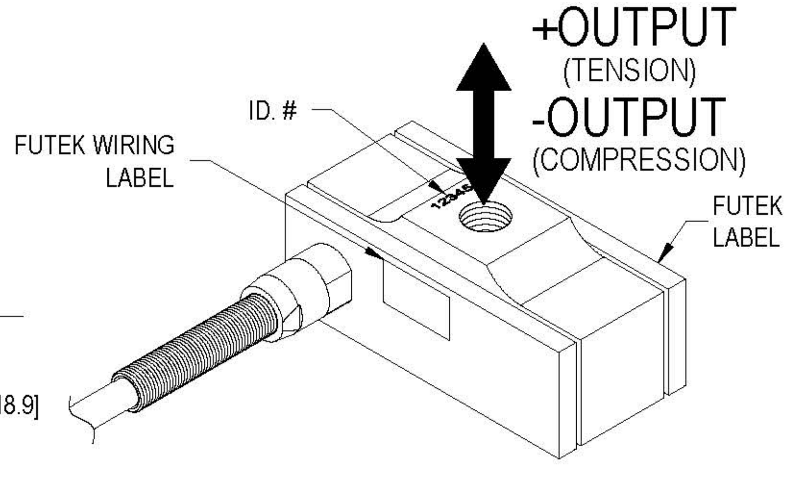
FUTEK MODEL LRF325 (L2320) *LOW PROFILE TENSION AND COMPRESSION LOAD CELL*

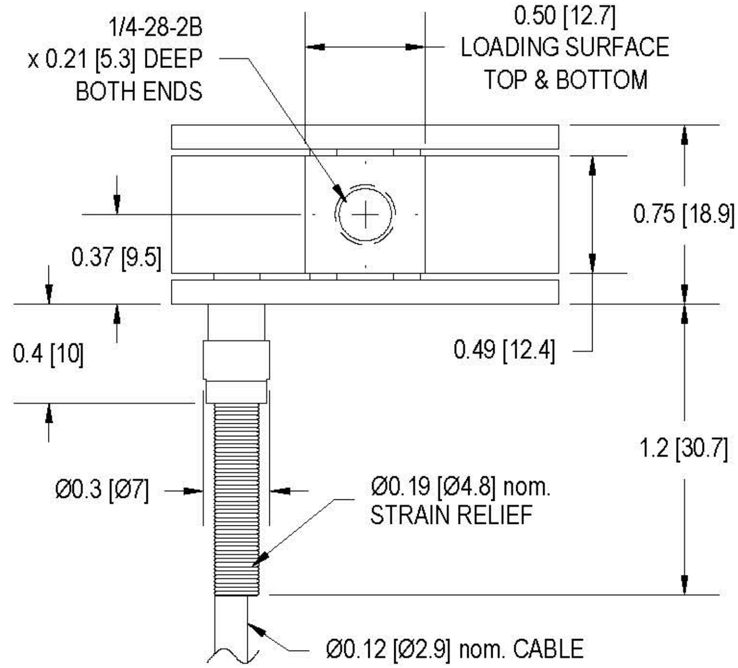
Drawing Number: FI1069-A

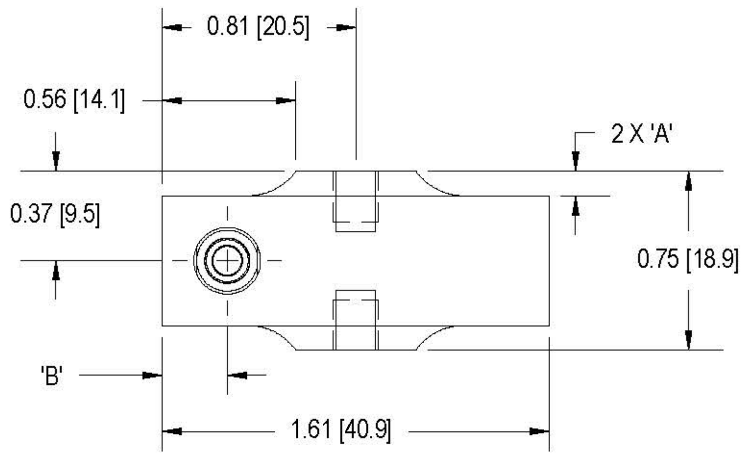
INCH [mm]	R.O.= Rated Output

WIRING CODE (WC1)			
+Excitation	-Excitation	+Signal	-Signal
RED	BLACK	GREEN	WHITE

Shield
FLOATING







STK#	CAPACITY lb	CAPACITY N	A	B
FSH00073	25	111	0.10 [2.5]	0.27 [6.9]
FSH00074	50	222		0.29 [7.4]
FSH00075	75	334	0.09 [2.3]	0.30 [7.6]
FSH00076	100	445	0.07 [1.8]	0.31 [7.9]

SPECIFICATIONS:

RATED OUTPUT	2 mV/V nom.
SAFE OVERLOAD	150% of R.O.
ZERO BALANCE	±1% of R.O.
EXCITATION (VDC OR VAC)	15 MAX
BRIDGE RESISTANCE	350 Ω nom.
NONLINEARITY	±0.1% of R.O.
HYSTERESIS	±0.1% of R.O.
NONREPEATABILITY	±0.05% of R.O.
CREEP	±0.05% of LOAD
TEMP. SHIFT ZERO	±0.005% of R.O./°F[0.01% of R.O./°C]
TEMP. SHIFT SPAN	±0.005% of LOAD/°F[0.01% of LOAD/°C]

COMPENSATED TEMP.	60 to 160°F [15 to 72°C]
OPERATING TEMP.	-60 to 200°F [-50 to 93°C]
WEIGHT	1.8oz [51g]
MATERIAL	ALUMINUM
DEFLECTION	0.002 [0.05] nom.

CABLE: #28 AWG, 4 Conductor, Spiral Shielded Clear PVC Cable 10 ft [3 m] Long

ACCESSORIES AND RELATED INSTRUMENTS AVAILABLE

CERTIFICATE OF CONFORMANCE (STD)	TENSION
CALIBRATION (AVAILABLE)	5 pt. TENSION/COMPRESSION 60.4 K Ω SHUNT CAL. VALUE
CALIBRATION TEST EXCITATION	10 VDC

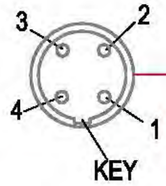
10 THOMAS
IRVINE, CA 92618 USA
1-800-23-FUTEK (38835)

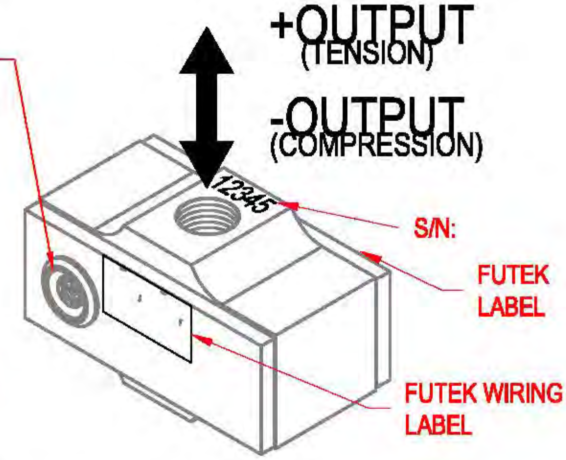
INTERNET:
http://www.futek.com

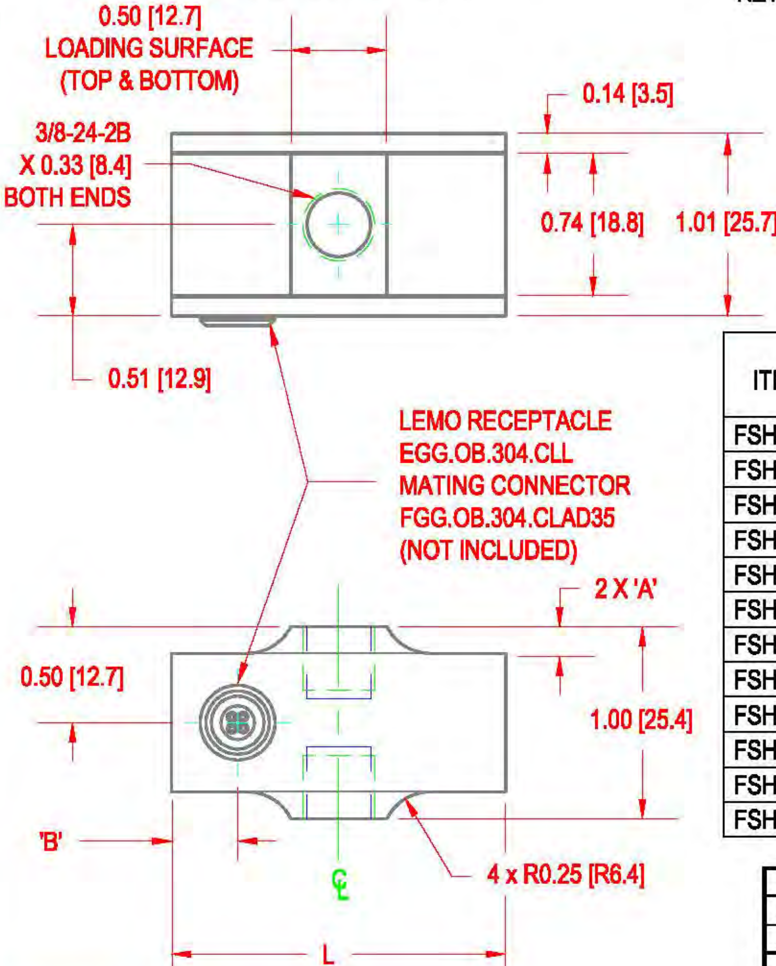
FUTEK MODEL LRF350 (L2320) *LOW PROFILE TENSION AND COMPRESSION LOAD CELL*

Drawing Number: FI1070-C	
INCH [mm]	R.O.= Rated Output

CONNECTOR CODE (CC4)			
+Excitation	-Excitation	+Signal	-Signal
1 RED	4 BLACK	2 GREEN	3 WHITE

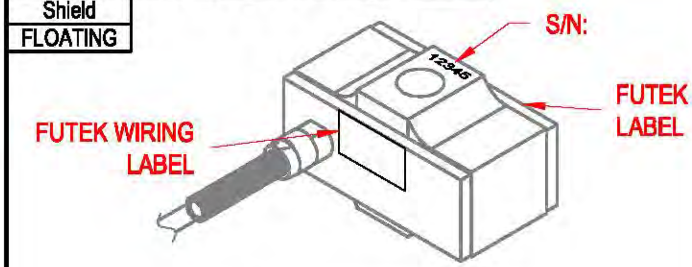


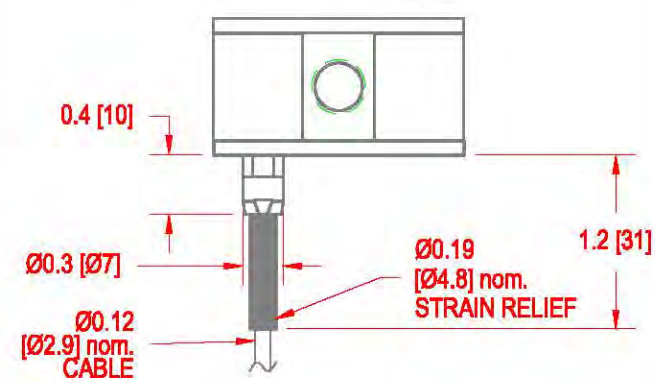




ITEM#	CAPACITY lb	CAPACITY N	A	B	L	MATERIAL	CABLE OPTION
FSH00083	150	667	0.16 [4.1]	0.35 [8.9]	1.74 [44.2]	ALUMINUM 2 oz [57 g]	
FSH00077							X
FSH00084	200	890	0.14 [3.6]	0.36 [9.1]			
FSH00078							X
FSH00085	300	1334	0.12 [3.0]	0.39 [9.9]			
FSH00079							X
FSH00086	500	2224	0.16 [4.1]	0.34 [8.6]	1.70 [43.2]	17-4PH S.S. 5 oz [142 g]	
FSH00080							X
FSH00087	750	3336	0.14 [3.6]	0.36 [9.1]			
FSH00081							X
FSH00088	1000	4450	0.11 [2.8]	0.39 [9.9]	1.74 [44.2]		
FSH00082							X

CABLE OPTION (WC1)			
+Excitation	-Excitation	+Signal	-Signal
RED	BLACK	GREEN	WHITE
Shield			
FLOATING			





SPECIFICATIONS:

RATED OUTPUT	*2 mV/V nom.*
SAFE OVERLOAD	*150% of R.O.*
ZERO BALANCE	*±1% of R.O.*
EXCITATION (VDC OR VAC)	*18 MAX*
BRIDGE RESISTANCE	*350 Ω nom.*
NONLINEARITY	*±0.1% of R.O.*
HYSTERESIS	*±0.1% of R.O.*
NONREPEATABILITY	*±0.05% of R.O.*
CREEP	*±0.05% of LOAD*
TEMP. SHIFT ZERO	*±0.005% of R.O./°F[0.01% of R.O./°C]*
TEMP. SHIFT SPAN	*±0.005% of LOAD/°F[0.01% of LOAD/°C]*
COMPENSATED TEMP.	*60 to 160°F [15 to 72°C]*
OPERATING TEMP.	*-60 to 200°F [-50 to 93°C]*
MATERIAL(FLEXURE)	*SEE CHART*
MATERIAL(COVER)	*ALUMINUM, Red Anodized After S/N:400511*
DEFLECTION	*0.002[0.05] nom.*

CONNECTOR: LEMO 4 Pin Receptacle (EGG.OB.304.CLL)
CABLE: #28 AWG, 4 Conductor, Spiral Shielded Clear PVC Cable 10 ft [3 m] Long
ACCESSORIES AND RELATED INSTRUMENTS AVAILABLE

CALIBRATION (STD)	*5 pt. TENSION; 60.4 KΩ SHUNT CAL. VALUE*
CALIBRATION (AVAILABLE)	*COMPRESSION*
CALIBRATION TEST EXCITATION	*10 VDC*

10 THOMAS
IRVINE, CA 92618 USA
1-800-23-FUTEK (38835)
INTERNET:
http://www.futek.com

TEMPERATURE MEASUREMENTS

Instrumentation

Omega quick disconnect RTD probe

- Model No. PR-13-2-100-3/16-12-E
- 12” sheath length
- 3/16” probe diameter
- -200 to 500ºC range

LabVIEW Implementation

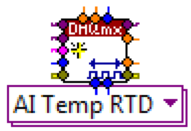


Figure 27: Temperature probe virtual channel block

Table 3: Temperature probe channel configuration

Channel	Value	Units
Physical Channels	cDAQ2Mod4/ai0	
Current excitation value	5.00e-4	V
r0	100	Ohm
Resistance configuration	3-Wire (3)	
Minimum value*	15	°C
Maximum value*	50	°C
Current excitation source	Internal (10200)	
RTD type	Pt3851 (10071)	
Output units	°C	

*Can be changed to better match the bounds of the expected temperature measurements

Location and Installation

The RTD probe is located directly upstream of the contraction section on the north side of the wind tunnel.

At the probe hole

1. Insert the probe all the way through the plastic hole in the side of the wind tunnel
2. Tighten the set screw onto the probe just enough so the probe doesn’t slide out
    - NOTE: do not over-tighten the setscrew

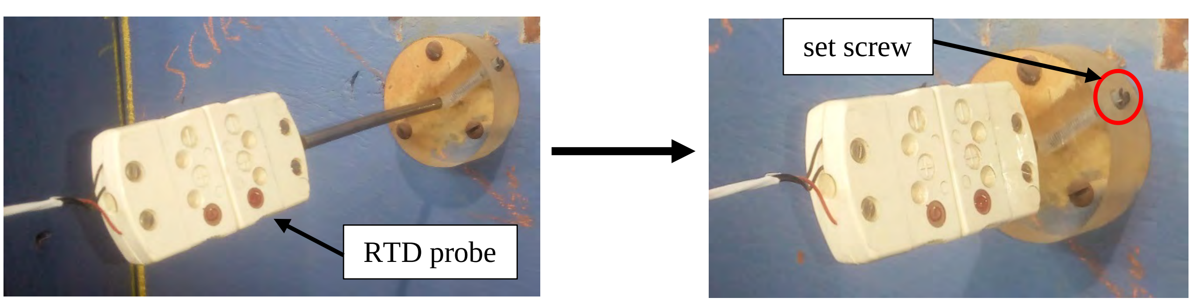


Figure 28: Temperature probe installation

At the DAQ platform

1. Connect the three wires coming from the white wire to the analog input module (NI-9219)
2. Connect the red wire to CH0-3
3. Connect one of the black wires to CH0-6
4. Connect the other black wire to CH0-5

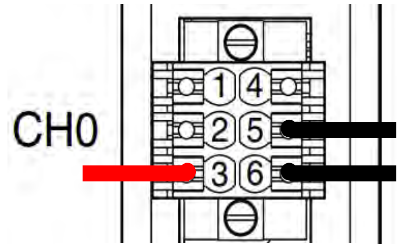


Figure 29: Temperature probe DAQ wiring

Platinum RTD Probes

ACCURACY IEC CLASS A

Standard Dimension PR-13 Series Quick Disconnect Probes

Type PR-13 Mating Female Connector Included.

Shown actual size.

Red lead attaches to this pin for Style 2.

Also Available with PFA Coating

A general purpose probe with electrical connections made via a standard size OTP 3-prong connector. Each unit is supplied with mating connector. Available in 1/16", 1/8", 3/16", or 1/4" diameters, with standard probe lengths from 6" to 24". Custom lengths available on request.

To Order

Model Number	Lead Style†	Ω at 0°C	Sheath Length**
PR-13-2-100-(*)-6-E	2	100	6"
PR-13-2-100-(*)-9-E	2	100	9"
PR-13-2-100-(*)-12-E	2	100	12"
PR-13-2-100-(*)-18-E	2	100	18"
PR-13-2-100-(*)-24-E	2	100	24"

** Specify: **1/16**, **1/8**, **3/16** or **1/4** for probe diameter in inches.*
*** Add additional cost per inch for lengths over 24" (1/16" diameter 24" max).*
† 3-wire lead configuration standard, contact sales for other configurations.
RTD Probes cannot be bent in the field. OMEGA offers custom bending; consult our Sales Department.
***Ordering Example: PR-13-2-100-1/4-6-E**, quick disconnect PR-13 probe with mating connector, style 2 wiring, 100 Ω @ 0°C, 1/4" diameter, 6" long, European curve (α = 0.00385).*

- ✔ **Includes a Precision 100 Ω, Class "A" DIN Platinum Wire Wound RTD Element**
- ✔ **Easily Connect to Your Meter or Measurement System via Our Standard 3-Prong OTP Connector and Extension Cords or Cables**
- ✔ **Variable Diameters and Lengths Available**
- ✔ **Temperature Range is -200 to 500°C (220°C Max at Connector)**

Metric Dimension PR-13 Series Quick Disconnect RTD Probes

A general purpose probe with electrical connections made via a standard size OTP 3-prong connector. Each unit is supplied with mating connector. Available from 1.5 to 6 mm diameters, with standard probe lengths from 150 to 600 mm. Other lengths available on request.

Model Number	Lead Style†	Ω at 0°C	Sheath Length**
PR-13-2-100-(*)-150-E	2	100	150 mm
PR-13-2-100-(*)-225-E	2	100	225 mm
PR-13-2-100-(*)-300-E	2	100	300 mm
PR-13-2-100-(*)-450-E	2	100	450 mm
PR-13-2-100-(*)-600-E	2	100	600 mm

** Specify: **M15** for 1.5 mm, **M30** for 3 mm, **M45** for 4.5 mm or **M60** for 6 mm, for probe diameter in mm.*
*** Add additional cost per 25 mm for lengths over 600 mm (1.5 mm diameter 600 mm max).*
† 3-wire lead configuration standard; others available, contact sales for other configurations.
RTD Probes cannot be bent in the field. OMEGA offers custom bending; consult our Sales Department.
***Ordering Example: PR-13-2-100-M60-150-E**, quick disconnect PR-13 probe with mating connector, style 2 wiring, 100 Ω @ 0°C, 6 mm diameter, 150 mm long, European curve (α = 0.00385).*

Options

HH804U meter.

BRLK fitting.

RECU1-OTP-TAF extension coil cable.

AIR VELOCITY TRANSDUCER

Instrumentation

TSI air velocity transducer

- 8455 series
- 12” probe length
- 1/4” probe diameter
- 25–10,000 ft./min (0.125–50 m/s) range

Transducer Configuration

Current settings for the transducer (can be changed by opening the box)

Units = m/s
Full scale = 50.0 m/s
Output = 0 – 5 V
Time Constant = 1 s
Adjust Zero = 0
Span = +0.05 (+5%)

LabVIEW Implementation

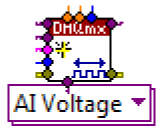


Figure 30: Analog voltage virtual channel block

Table 4: Air velocity transducer channel configuration

Channel	Value	Units
Physical Channels	cDAQ2Mod3/ai1	
Input Terminal Configuration	Differential (10106)	
Minimum value	0	V
Maximum value	5	V
Output Units	0.1 m/s	

Location and Installation

The air velocity transducer is located on the top of the upstream end of the test section.

Before Installation

1. Make sure that the probe is covered with heat shrink tubing longer than the metal sheath

Figure 31: Air velocity transducer protection

2. The heat shrink should cover the black plastic part of the probe

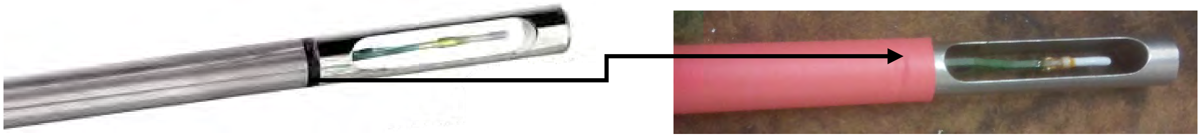


Figure 32: Hot-wire anemometer rubber sheath

At the probe hole – on top of the wind tunnel

3. Install the cord grip fitting into the 3/8-NPT hole in the top of the wind tunnel
    - The bottom of the fitting should be flush with the inner roof of the wind tunnel.

4. Slide the hot-wire probe through the top of the fitting, and into the tunnel
5. Tighten the top of the fitting just enough that the probe doesn't fall through

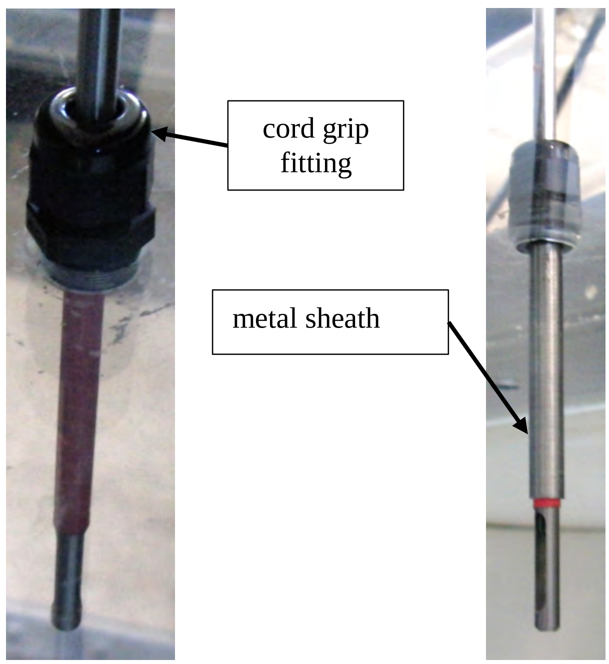


Figure 33: Air velocity transducer probe installation

In the wind tunnel

6. Slide the metal protective sheath over the probe and fully into the cord grip fitting
    - The end of the sheath will butt against the fitting when fully in
7. Slide the probe up or down so that end of the heat shrink just peeks out of the metal sheath.
    - **The metal sheath is used to protect the plastic part of the probe from snapping and thus must fully encase this section**
8. Carefully turn the probe so that the opening of the probe tip is aligned with the direction of flow

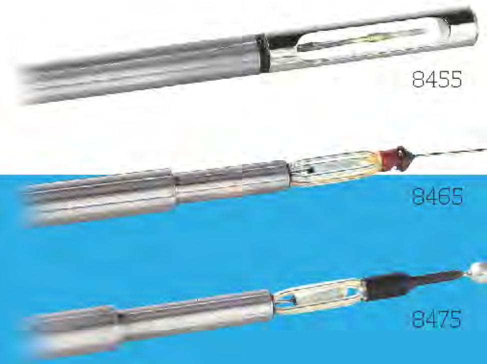
At the probe hole – on top of the wind tunnel

9. Tighten the top of the fitting so that probe has very little wiggle room

At the DAQ platform

10. Connect the black BNC connector from the air velocity transducer box to MOD3-CH1 of the voltage input module (NI-9215)

AIR VELOCITY TRANSDUCERS MODELS 8455, 8465, AND 8475



The 8455, 8465, and 8475 Air Velocity Transducers are ideal for both temporary and permanent installations for air velocity measurements in research and development labs, manufacturing processes, and other applications. The full-scale range, signal output, and time constant are user selectable and can be easily changed to meet the needs of your application.

Applications

+ Comfort and draft studies
+ Critical environment installations (e.g., clean rooms and hospitals)
+ Diffuser design analysis
+ Monitoring drying processes
+ Monitoring air flows in tunnels and subways
+ Used as a standard in wind tunnels and calibration facilities
+ Environmental monitoring in greenhouses and IAQ applications
+ General engineering applications

General Purpose (8455)

+ Protected probe tip
+ Rugged ceramic sensor
+ Wide range of measurement applications
+ Fast response time

Windowless (8465)

+ Less flow blockage
+ Ideal for measuring in confined spaces
+ Fast response time

Omnidirectional (8475)

+ Omnidirectional probe tip
+ Accurate at low velocities from 10 to 100 ft/min (0.05 to 0.5 m/s)
+ Ideal for unknown or varying flow direction

UNDERSTANDING, ACCELERATED

SPECIFICATIONS

AIR VELOCITY TRANSDUCERS
MODELS 8455, 8465, AND 8475

Accuracy

8455	±2.0% of reading[1], ±0.5% of full scale of selected range
8465	±2.0% of reading[1], ±0.5% of full scale of selected range
8475	±3.0% of reading[2], ±1.0% of full scale of selected range

Field Selectable Range

8455 and 8465	25 ft/min to 200, 250, 300, 400, 500, 750, 1,000, 1,250, 1,500, 2,000, 2,500, 3,000, 4,000, 5,000, 7,500, 10,000 ft/min (0.125 m/s to 1.0, 1.25, 1.50, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0, 12.5, 15.0, 20.0, 25.0, 30.0, 40.0, 50.0 m/s)
8475	10 ft/min to 100, 125, 150, 200, 250, 300, 400, 500 ft/min (0.05 m/s to 0.5, 0.75, 1.0, 1.25, 1.50, 2.0, 2.5 m/s)

Repeatability

8455 and 8465	<±1.0% of reading[3]
8475	N/A

Response to Flow

8455 and 8465	0.2 sec[4]
8475	5 sec[5]

Temperature Range

Compensation	32 to 140°F (0 to 60°C)
Operating (electronics)	32 to 200°F (0 to 93°C)
Operating (sensor)	32 to 200°F (0 to 93°C)
Storage	32 to 200°F (0 to 93°C)

Resolution (minimum)
0.07% of selected full scale

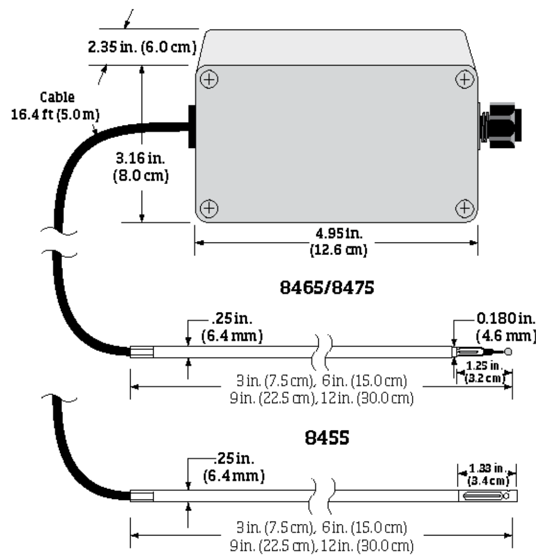
Input Power
11 to 30 VDC or 18 to 38 VAC, 350 mA max[6]

Output

Impedance	Voltage mode: less than 1 ohm, 20 mA max source current
Resistance	Current mode: 500 ohms maximum load
Signal	Field selectable 0 to 5V, 0 to 10V, 0 to 20, 2 to 10V, mA, 4 to 20 mA
Time Constant	Field selectable 0.05 to 10 seconds

Probe length
3 in., 6 in., 9 in., 12 in. (7.5 cm, 15 cm, 22.5 cm, or 30 cm)

All models contain on-board electronics and calibration curves that provide a linear signal output. This linear signal is sent out as either a current (mA) or a voltage (V) signal, allowing output to a variety of data loggers or data acquisition systems. In addition, the current and voltage output ranges are user-selectable for your convenience.



	8455/8465	8475
Range	25 to 10,000 fpm (0.127 to 50.8 m/s), selectable	10 to 500 fpm (0.05 to 2.54 m/s), selectable
Accuracy	±(2% of reading at 64.4 to 82.4°F (18-28°C) +0.5% of full scale of selected range)	±(3% of reading at 68.0-78.8°F (20 to 26°C) +1% of full scale of selected range)
Response time	0.2 seconds	5.0 seconds
Input power	11 to 30 VDC or 18 to 28 VAC, 350 mA maximum	

[1]From 64.4 to 82.4°F (18 to 28°C), outside this range and within temperature compensation range add 0.11% per °F (0.2% per °C).
[2]From 68 to 78.8°F (20 to 26°C), outside this range and within temperature compensation range add 0.28% per °F (0.5% per °C). Directional sensitivity of the Model 8475 is +5%/-20% of reading +0/-10 ft/min (+0/-0.05 m/s) over 270° solid angle regardless of flow direction.
[3]Standard deviation based on one minute average from 100 to 1,000 fpm (0.5 to 5.0 m/s).
[4]For 63% of final value, tested at 1,500 fpm (7.5 m/s).
[5]For 63% of final value, tested at 500 fpm (2.5 m/s).
[6]Input voltage must be maintained within specifications at the transducer.

Specifications are subject to change without notice.

UNDERSTANDING, ACCELERATED

TSI Incorporated - Visit our website **www.tsi.com** for more information.

USA	**Tel:** +1 800 874 2811	**India**	**Tel:** +91 80 67877200
UK	**Tel:** +44 149 4 459200	**China**	**Tel:** +86 10 8251 6588
France	**Tel:** +33 4 91 11 87 64	**Singapore**	**Tel:** +65 6595 6388
Germany	**Tel:** +49 241 523030		

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CONTRACTION PRESSURE DROP

Instrumentation

Omega differential pressure transducer

- Model No. PX653-10D5V
- 0 – 10 in.H_2O (0 – 2.49 kPa) range
- DP41-E-S4 meter

LabVIEW Implementation

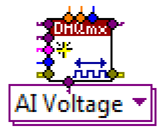


Figure 34: Analog voltage virtual channel block

Table 5: Air velocity transducer channel configuration

Channel	Value	Units
Physical Channels	cDAQ2Mod3/ai0	
Input Terminal Configuration	Differential (10106)	
Minimum value	1	V
Maximum value	5	V
Output Units	in.H_2O	

Location and Installation

Two lengths of tubing connect the pressure transmitter to pressure taps at stations 1 and 2.

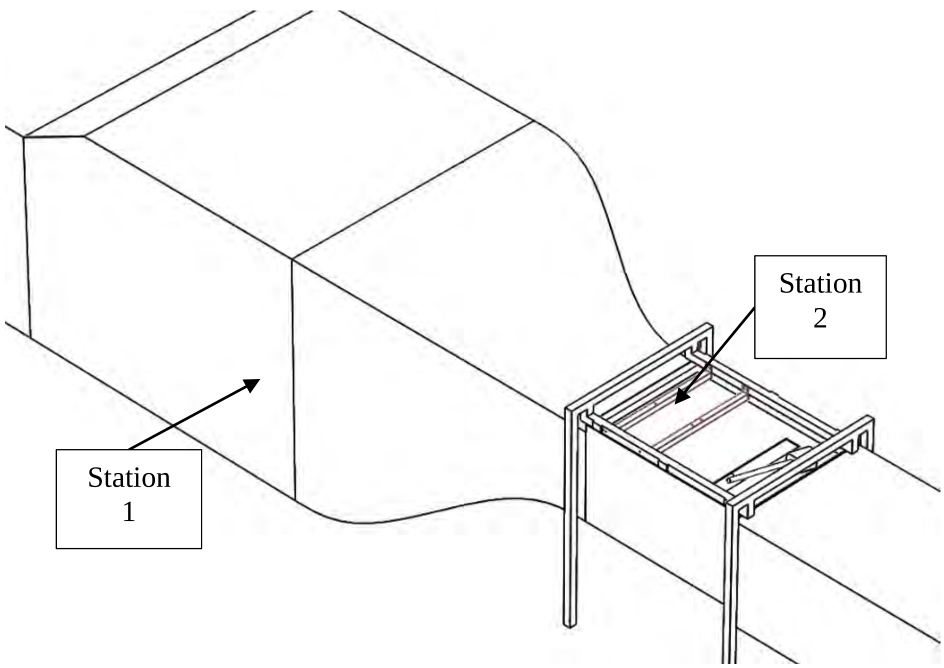


Figure 35: Contraction pressure tap locations

At the pressure taps

1. Connect the long length of tubing to the brass fitting at Station 1.
2. Connect the short length of tubing to the brass fitting at Station 2.
    - If this fitting is loose, reseal it into the wind tunnel with RTV

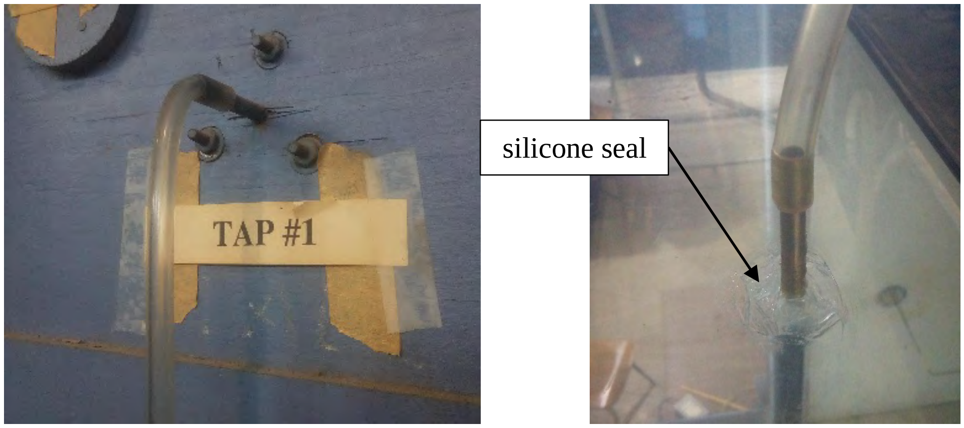


Figure 36: Pressure tap installation

At the pressure transmitter

3. Connect the tubing from Station 1 to the high pressure fitting
4. Connect the tubing from Station 2 to the low pressure fitting

At the DAQ platform

5. Connect the black BNC connector from the pressure transmitter to MOD3-CH0 of the voltage input module (NI-9215)

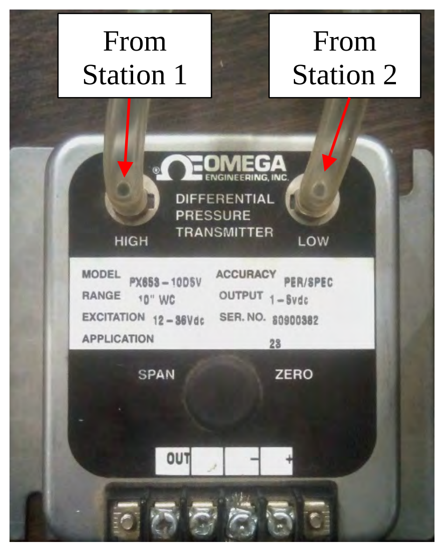


Figure 37: Pressure transducer connection

HIGHLY ACCURATE, LOW-PRESSURE LABORATORY TRANSDUCER

0-0.1 to 0-50 inH_2O
0-25 Pa to 0-12.5 kPa

PX653 Series

1 YEAR WARRANTY
NIST Standard

PX653-10D5V, with **DP3002-E** meter, shown smaller than actual size.

Ideal Applications:

- Clean Rooms
- HVAC
- Laboratory Fume Hoods

SPECIFICATIONS

Excitation: 12 to 36 Vdc
Output: 1 to 5 Vdc (3 wire)
Linearity: 0.3% FS (BFSL)
Hysteresis: 0.02% FS
Repeatability: 0.05% FS
Operating Temperature: -29 to 72°C (-20 to 160°F)
Compensated Temperature: 2 to 57°C (35 to 135°F)
Thermal Effects:
  Zero: 0.015% FS/°F
  Span: 0.015% rdg/°F
Proof Pressure: 15 psi
Burst Pressure: 20 psi
Static Pressure: 25 psi
Gage Type: Capacitance
Supply Current: <5 mA
Calibration Report: NIST cal at 25, 50, 75 and 100% FS; upscale and downscale provided
Response Time: 250 ms
Wetted Parts: Dry, clean, non-corrosive gases only
Enclosure: NEMA 2 (IP62)
Dimensions: 107 H x 117 W x 53 mm D (4.2 x 4.6 x 2.1")
Pressure Port: ¼ barbed fittings (tubing TY-316-100)
Electrical Connections: Screw terminal
Weight: 368 g (13 oz)

To Order

RANGE inH_2O	Pa/kPa	MODEL NO.	COMPATIBLE METERS
0 to 0.1	0 to 25	**PX653-0.1D5V**	DP25B-E, DP41-E, DP460-E
0 to 0.25	0 to 62	**PX653-0.25D5V**	DP25B-E, DP41-E, DP460-E
0 to 0.50	0 to 125	**PX653-0.5D5V**	DP25B-E, DP41-E, DP460-E
0 to 0.75	0 to 187	**PX653-0.75D5V**	DP25B-E, DP41-E, DP460-E
0 to 1	0 to 249	**PX653-01D5V**	DP25B-E, DP41-E, DP3002-E
0 to 2	0 to 498	**PX653-02D5V**	DP25B-E, DP41-E, DP460-E
0 to 3	0 to 748	**PX653-03D5V**	DP25B-E, DP41-E, DP460-E
0 to 5	0 to 1.25	**PX653-05D5V**	DP25B-E, DP41-E, DP460-E
0 to 10	0 to 2.49	**PX653-10D5V**	DP25B-E, DP41-E, DP3002-E
0 to 25	0 to 6.23	**PX653-25D5V**	DP25B-E, DP41-E, DP460-E
0 to 50	0 to 12.5	**PX653-50D5V**	DP25B-E, DP41-E, DP460-E
BI-DIRECTIONAL RANGES			
±0.1	25	**PX653-0.1BD5V**	DP25B-E, DP41-E, DP460-E
±0.25	62	**PX653-0.25BD5V**	DP25B-E, DP41-E, DP460-E
±0.50	125	**PX653-0.5BD5V**	DP25B-E, DP41-E, DP460-E
±1	249	**PX653-01BD5V**	DP25B-E, DP41-E, DP460-E
±2.5	623	**PX653-2.5BD5V**	DP25B-E, DP41-E, DP460-E
±5	1.25	**PX653-05BD5V**	DP25B-E, DP41-E, DP460-E
±10	2.49	**PX653-10BD5V**	DP25B-E, DP41-E, DP460-E
±25	6.23	**PX653-25BD5V**	DP25B-E, DP41-E, DP460-E
±50	12.5	**PX653-50BD5V**	DP25B-E, DP41-E, DP460-E

Comes complete with NIST traceble calibration certificate and operator's manual.
***Ordering Examples: PX653-01D5V**, 0 to 1 inH_2O range with 1 to 5 Vdc output.*
***PX653-01BD5V**, ±1 inH_2O range. 1 to 5 Vdc output with 0 = 3 Vdc.*

omega.com™
OMEGA®

PX653, PX654, PX655, PX656
Pressure Transducer
M1436/0902

PX654, PX656

PX653, PX655*

CE*

COMMON SPECIFICATIONS FOR ALL UNITS

Accuracy:	±0.25% FS (BFSL)		
(Based on best fit straight line, although NIST cal. sheet is based on terminal point, therefore NIST cal. sheet could report a max. accuracy of 0.5% TP.)			
Linearity:	±0.25% FS (BFSL)		
Hysteresis:	±0.02% FS		
Repeatability:	±0.05% FS		
Operating Temp.:			
PX653, PX655:	−20° to 160°F (−29° to 72°C)		
PX654, PX656:	−20° to 185°F (−29° to 85°C)		
Compensated Temp.:			
PX653, PX655:	35° to 135°F (2° to 57°C)		
PX654, PX656:	0° to 160°F (−18° to 72°C)		
Storage Temp.:			
PX653, PX655:	−40 to 180°F		
PX654, PX656:	−40 to 210°F		
Proof Pressure:	PX653 / PX655	15 PSI	PX654 / PX656: 20 PSI
Burst Pressure:	PX653 / PX655	25 PSID	PX654 / PX656: 50 PSID

Static Pressure:	
PX653, PX655:	15 PSI
PX654, PX656:	100 PSI
Procss Media:	Clean, dry clean non-corrosive gases
Thermal Effects:	
Zero:	0.02% FS/°F
Span:	0.02% FS/°F
Sensor Type:	Capacitance
Response Time:	250 ms
Enclosure:	
PX653, PX655:	NEMA 2
PX654, PX656:	NEMA 4X
Pressure Port:	
PX653, PX655:	⅛ and ¼ barbed fittings
PX654, PX656:	¼ NPTF
Electrical Connection:	Screw terminal
PX654, PX656:	Two 1/2 NPTF conduit

PX653 & PX654 (VOLTAGE OUTPUT)

EXCITATION:	12-36Vdc
OUTPUT:	1-5Vdc
SUPPLY CURRENT:	<5mA
WEIGHT:	
PX653:	13 oz. (368 g)
PX654:	2.1 lb. (955 g)

PX655 & PX656 (ANALOG OUTPUT)

EXCITATION:	12-36Vdc
OUTPUT:	4-20mA (2 wire)
MAX. LOOP RES.:	(supply voltage - 10) x 50 ohms
WEIGHT:	
PX655:	13 oz. (368 g)
PX656:	2.1 lb. (955 g)

HANDLING PRECAUTIONS

This sensor has a high insulation resistance. It can be damaged when exposed to high static discharges. Good instrumentation grounding practices should be used during handling, testing and installation.

*CE Approval is only available on PX655 and valid if connected per the wiring diagram see reverse.

CALIBRATION REPORT

All models are tested to meet or exceed the published specifications. Calibration testing was performed using NIST traceable instrumentation, all sensors come calibrated. **DO NOT ATTEMPT TO RECALIBRATE SENSOR, UNLESS YOU HAVE A KNOWN PRESSURE SOURCE THAT IS AT LEAST 5 TIMES MORE ACCURATE THAN THE SENSOR.**

TWO-AXIS TRAVERSE

The two-axis traverse system, consists of two Velmex BiSlides controlled by a Velmex VXM stepper-motor controller.

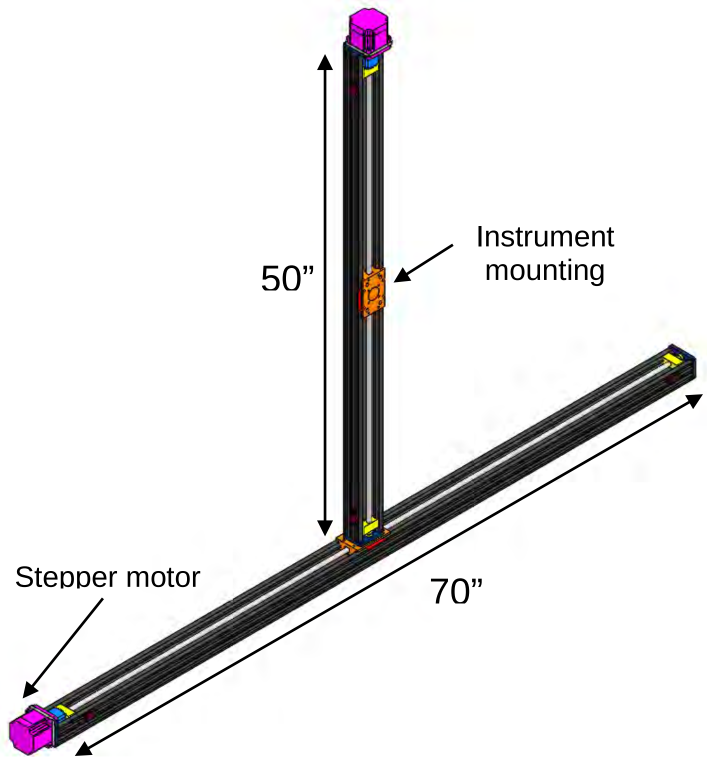


Figure 38: Two-axis traverse layout

Instrumentation

Two Velmex Precision Lead Screw BiSlides

- Model No. MN10-0700-E04-31 (70 inch travel)
- Model No. MN10-0500-E04-31 (50 inch travel)
- 0.4 in/rev travel
- Limit switches
- Fail safe brake on vertical slide
- 4 in/sec speed
- 0.001 inch resolution

Two Vexta Type 34T1 stepper motors

- Model No. PK296-03AA-A6-3/8
  - Single shaft
  - Controls horizontal slide
- Model No. PK296-03BA-A3-3/8
  - Double shaft
  - With fail safe brake
  - Controls vertical slide
- Two-phase
- accuracy of ± 3 arc minutes (0.05°)
  - This error does not accumulate from step to step

Probe Mounting

The probe mounting arm is attached to the vertical axis plate on the traverse, and extends down into the flow through a slot in the top of the tunnel. The probe arm is enclosed in an aluminum aerodynamic strut, and probes can be mounted at the end of the arm. The hole in the top of the tunnel is only 24” long, so to allow for positioning of the probe outside of this region, a probe arm extension (80/20 beam) can be used.

The aerodynamic strut is hollow which allows routing of any probe cabling/tubes up through the center, to the top of the tunnel. With the mounting arm extended into the tunnel, the two hole covers must be secured around the strut to cover the hole in the top of the tunnel.

For dimensioned drawings of the probe mounting parts, see “Selected Part Drawings” at the end of this manual.

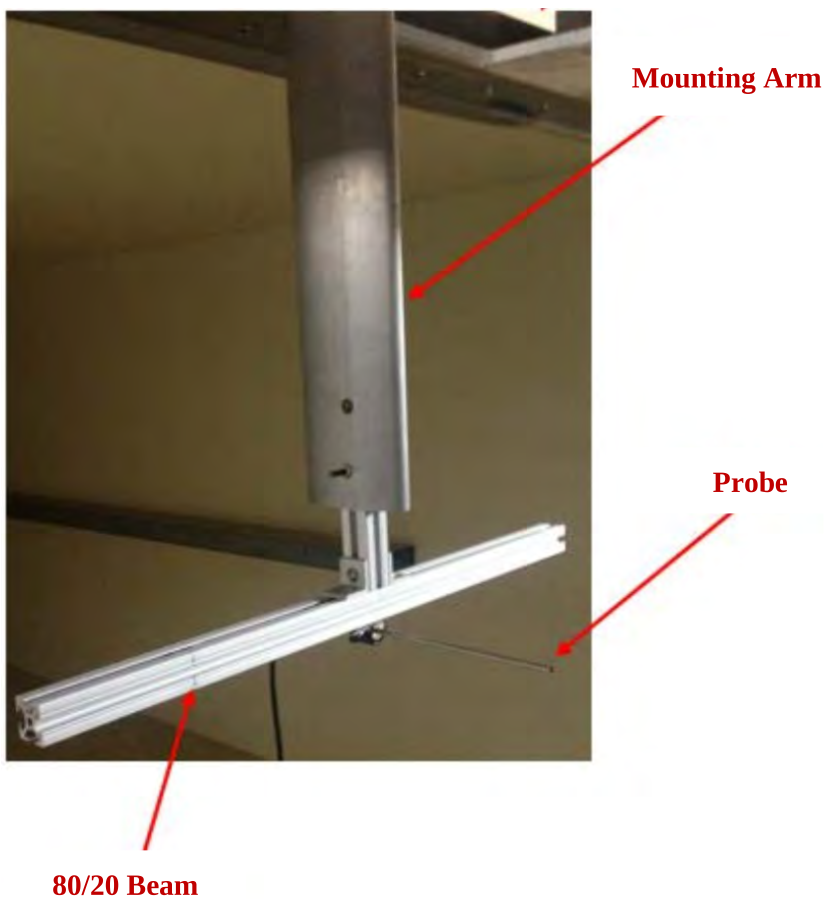


Figure 39: Traverse probe mounting configuration

Running the Traverse

Setup

If the traverse has not been used for some time or the lead screw and ways appear dry of lubricant, lubricate with Velmex BL-1 oil.

- Continuous use applications with heavy loads may necessitate daily lubrication.
- To lubricate, traverse carriage near center of travel and apply 3 to 4 drops of oil to the end of carriage at the way surfaces and on the lead screw threads.
- Apply oil to both ends of carriage

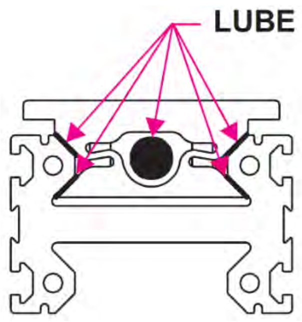


Figure 40: Traverse lubrication points

Moving the Traverse

If the traverse needs to be stopped immediately press red STOP button

1. Switch on the traverse using the switch mounted above the computer desk
2. Open the "Move Traverse.vi" code which runs the traverse.
3. Ensure that the hole on top of the tunnel for the mounting arm is open
4. Run the vi code but do not move the traverse yet
5. Center the mounting arm over the hole
   - Use the horizontal movement value selector and *move* button to do this
   - **DO NOT press "center" button while arm is above the tunnel**
6. Once the arm is centered it can be lowered into the tunnel
   - Use the vertical movement value selector and *move* button to do this

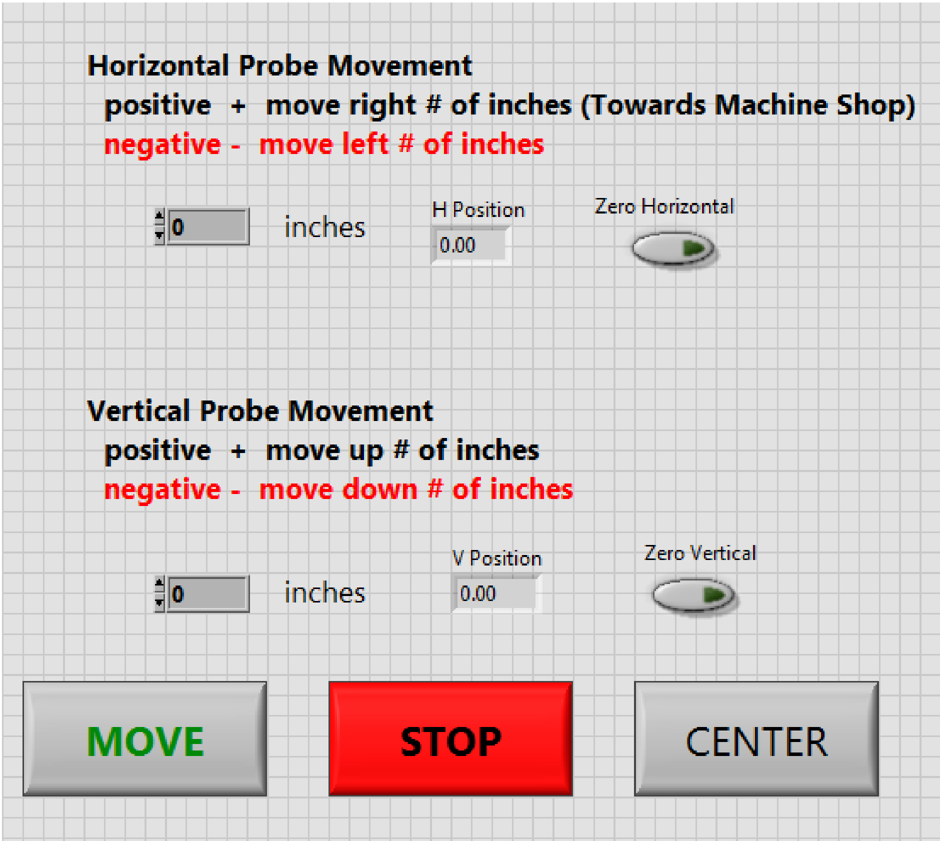


Figure 41: Traverse movement LabVIEW Interface

7. Secure the hole cover around the mounting arm
8. When using the hole cover
   - Ensure the strings holding the ends of the cover are not worn or broken
   - If broken or worn replace the strings
     - The ends of the cover must lift up when the traverse is at the ends of its travel and must stay down when over the hole in the tunnel
     - This may take some adjustment in string length.

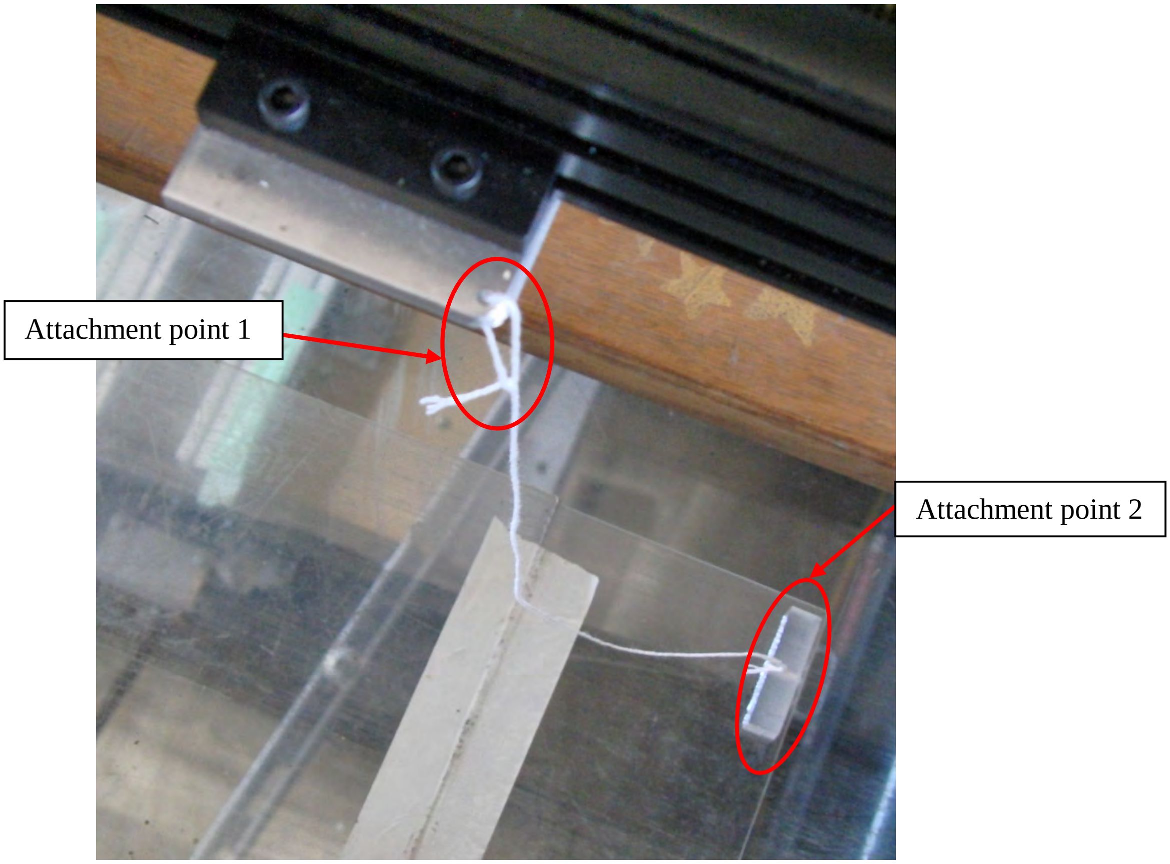


Figure 42: Hole cover lifting points

LabVIEW Implementation

The following information outlines a basic LabVIEW implementation of manually inputted traverse movements. The structures within this simple program can be extrapolated for programs that are more complex.

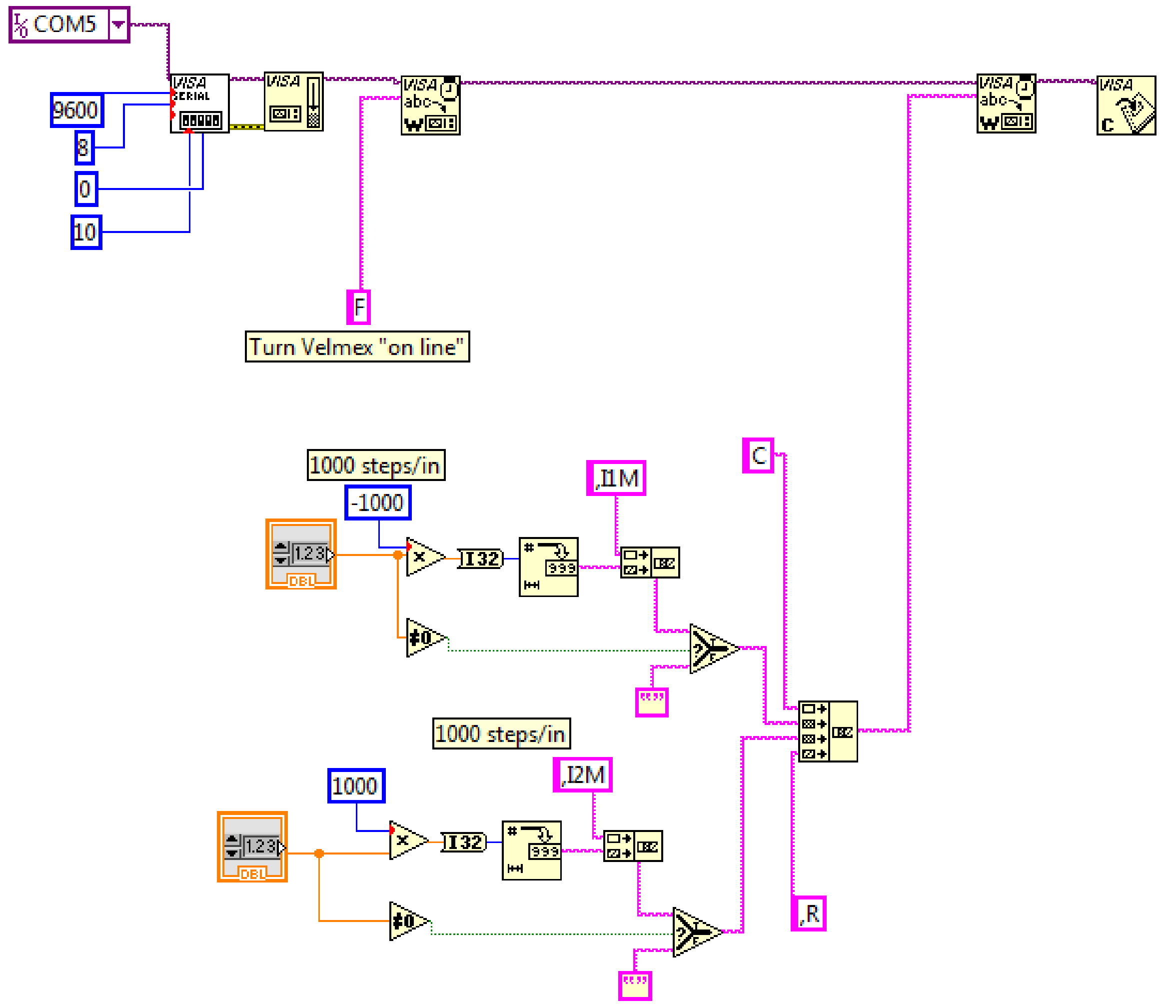


Figure 43: LabVIEW program - manually inputted traverse movement

The upper half of the program is where the traverse is configured. Currently the traverse system is connected to COM5, which controls both axis of the traverse.

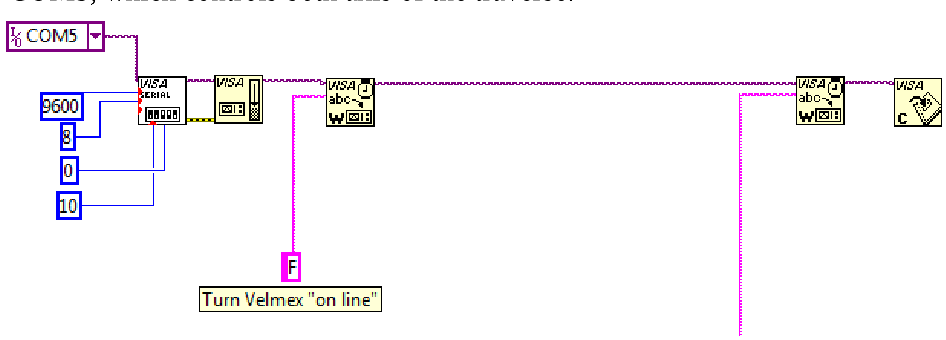


Figure 44: Traverse configuration setup

The lower half of the program controls the movement of the traverse. The program takes in two values, in inches, from the front panel and moves the horizontal and vertical axis by their respective amounts. Both user inputs have to be multiplied by 1000 because the Velmex control works in motor steps rather than absolute distances (1 step = 0.001 inch).

I1M controls the vertical axis movement, and the input distance is multiplied by -1000, which allows a positive input to correspond to an upward movement of the traverse. I2M controls the horizontal axis movement, where a positive input moves the traverse towards the north side of the test section.

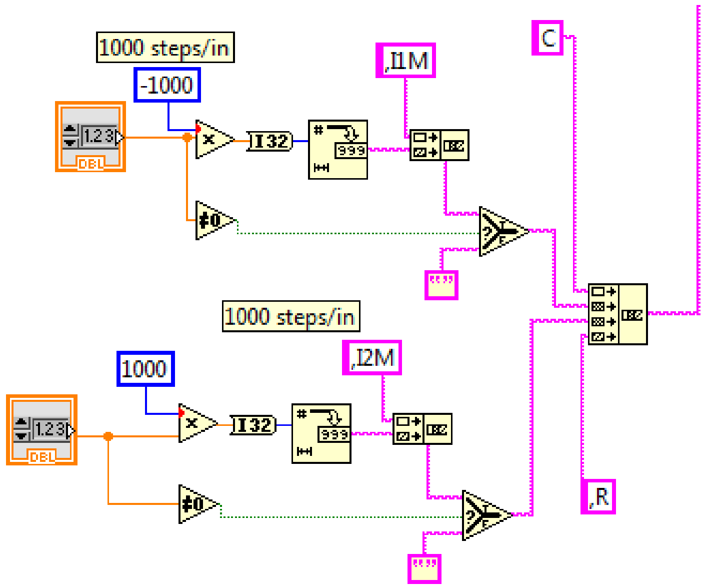


Figure 45: Traverse movement configuration

If the Velmex controller were to receive a value of zero for the distance, the traverse would move continuously in one direction until it hit the limit switches rather than not moving at all. The true/false block is critical in mitigating this, and allows for a true zero distance input at the front panel.

BiSlide Construction Delivers High Precision and Long Life

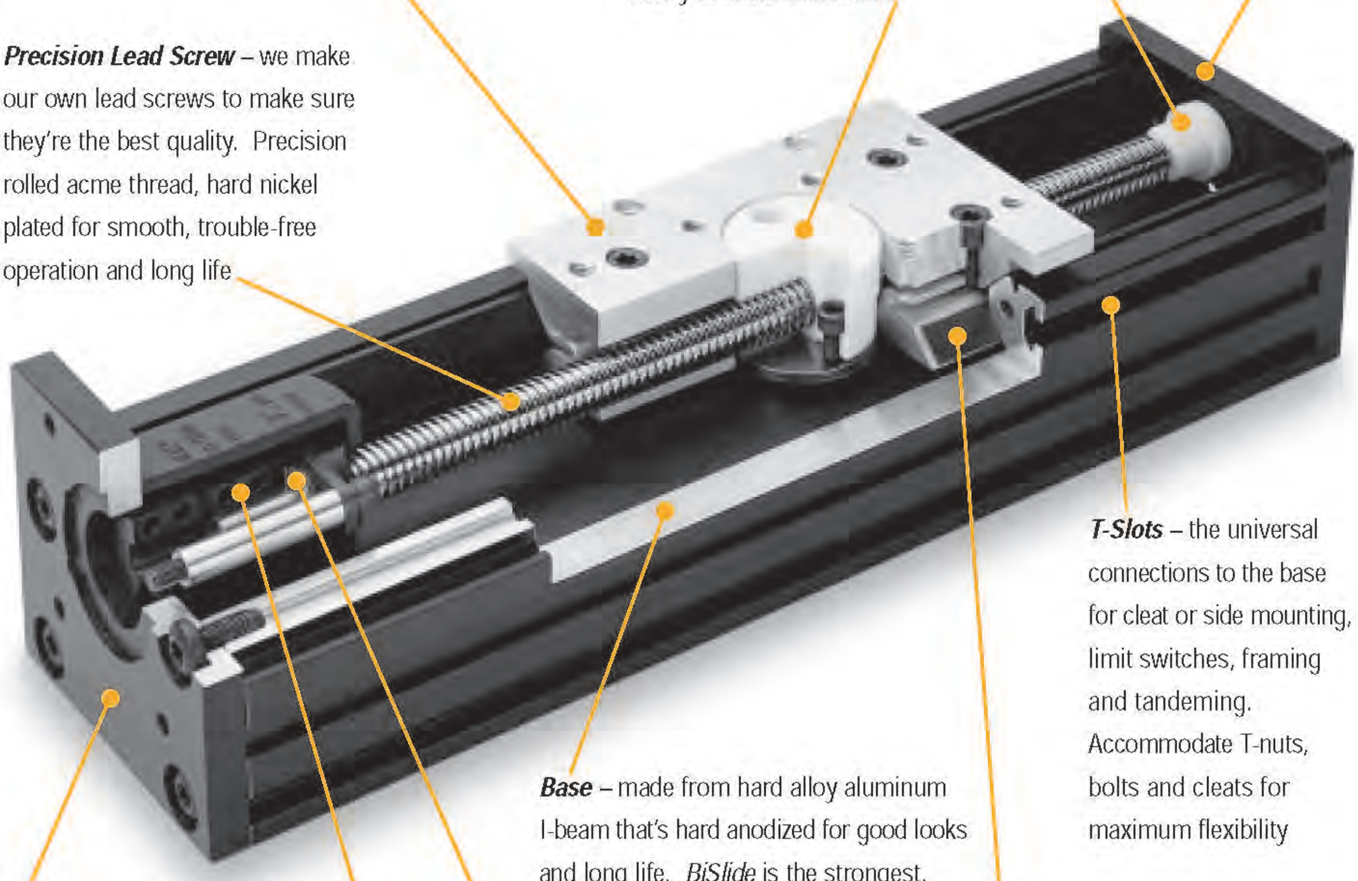
Support Bearing – delivers just the right combination of constraint and anti-vibration qualities for the lead screw

Large, Versatile Carriage – provides a 4.6" x 3.1" mounting surface suitable for carrying anything from assembly fixture to a measuring probe – eight threaded attachment holes let you securely fasten any kind of payload. Also, there's four accessory holes for limit switch cam or other sensors. Carriage has fit and wear compensation adjustments

StabilNut™ – a Velmex exclusive, is the "solid", low friction connection between the lead screw and carriage. It has an antibacklash design with fine mesh adjustment for responsive rotary to linear translation

End Plate – provides a convenient way to directly mount a *BiSlide* assembly on end. Four hole pattern mates with other BiSlide carriages and T-slots

Precision Lead Screw – we make our own lead screws to make sure they're the best quality. Precision rolled acme thread, hard nickel plated for smooth, trouble-free operation and long life



T-Slots – the universal connections to the base for cleat or side mounting, limit switches, framing and tandeming. Accommodate T-nuts, bolts and cleats for maximum flexibility

Base – made from hard alloy aluminum I-beam that's hard anodized for good looks and long life. *BiSlide* is the strongest, lightest, and most durable slide actuator available

Motor Plate – the four bolt design securely attaches the motor

Bearing Pads – super slick PTFE compound for lowest friction, smooth linear motion, and long life

Coupling – precision-honed to provide a rigid motor to lead screw mating

Roller Bearings – preloaded to provide axial constraint for the lead screw. Designed for high capacity, for impact resistance and long life

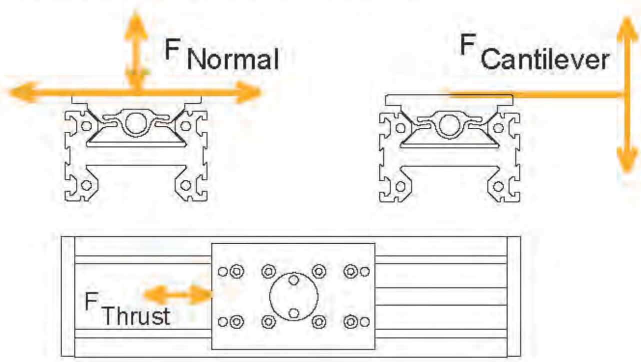
A Versatile, Durable Design

BiSlide Delivers the Accuracy and Load-Carrying Capacity You Need

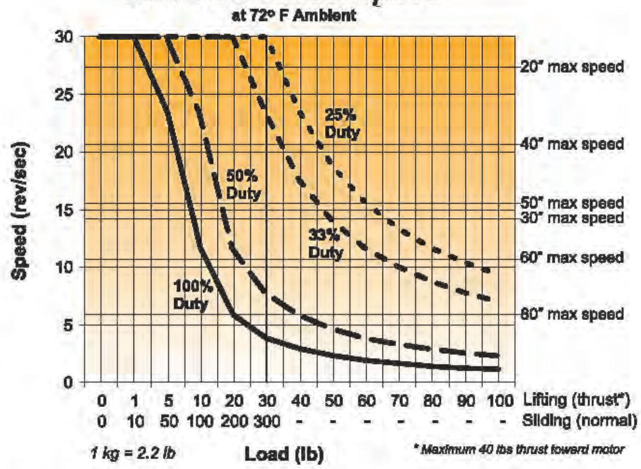
Coefficient of friction: 0.09 typical
Coefficient range: 0.04 (Heavy Load Dynamic) to 0.15-0.3 (Lubricated Heavy Load Static>1 hour)
Minimum motor torque required: 55 oz-in
Repeatability: 0.0002" over short term, long term dependant on wear
Straight line accuracy: 0.003" over entire travel distance
Screw lead accuracy: 0.003"/10" (0.076 mm/25 cm)
Operating temperature: 0 to180° F (-18 to 82° C)

Finish

Lead screw: hard nickel plated
Carriage: machined aluminum
Other surfaces: black anodized aluminum



Maximum Load/Speed**



**In other environments contact our technical sales department for recommendations

Maximum Load Carrying Capacity

Load	Dynamic	Static	Momentary
Normal Centered	300 lb.	300 lb.	1000 lb.
Thrust	100 lb*	200 lb.	300 lb.
Cantilevered	500 inch-lb. (See formula below)		

For cantilevered loads: equivalent center load = (d x L/2) + L where d= distance load is from center in inches, L= Load (lbs.)

How to Specify Your BiSlide Model

M N 1 0 - 0 2 0 0 - E 0 1 - 2 1

Cross Section M

Design
10=Inch
11=Inch & Way Cover

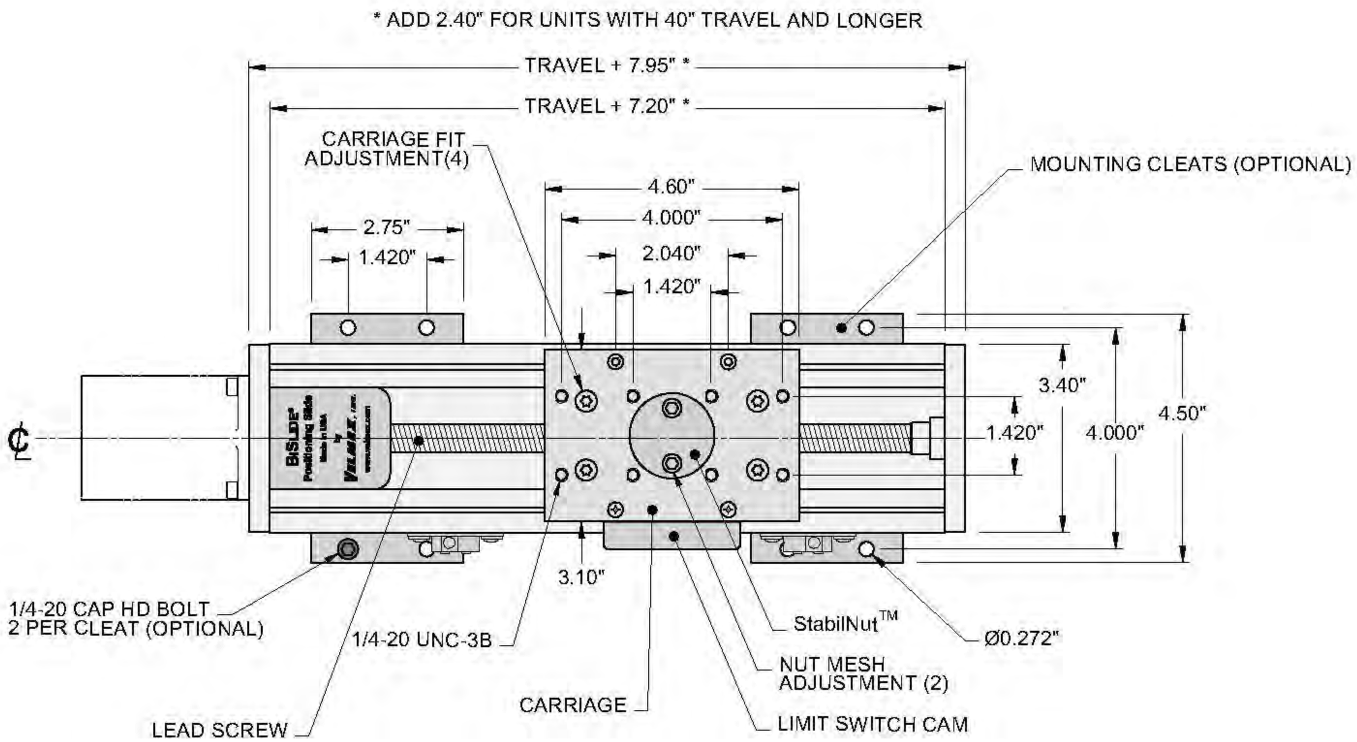
Drive Scheme
N=Nut/Screw Drive
F=Free Sliding

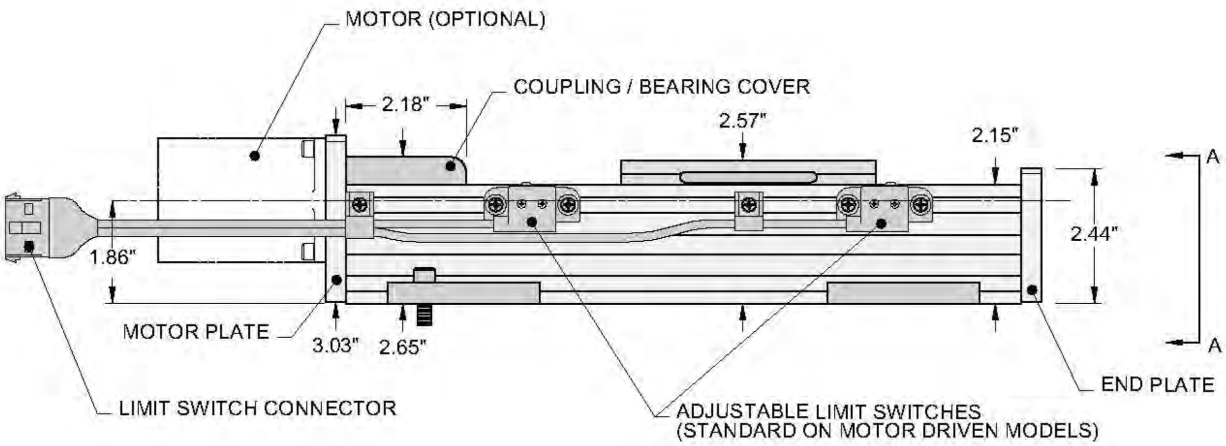
Design Travel* (Tenth of Inch)
Standard Travel Lengths (Inches):
5, 10, 15, 20, 30, 40, 50, 60, 80
** Free sliding models have 2.4" longer travel, way cover models under 40" travel have 1.0" less*

Lead Screw	Advance/Turn
Blank	None
M02	2.00 mm
E01	0.10 inches
E04	0.40 inches

Mounting
Blank=None
11=Basic Knob
12=Knob/Counter, Horizontal, Increment + from Knob
13=Knob/Counter, Vertical, Increment + from Knob**
14=Knob/Counter, Horizontal, Increment - from Knob
15=Knob/Counter, Vertical, Increment - from Knob**
20=NEMA 23 Motor Mount
21=NEMA 23 Mount & Limit Switch
30=NEMA 34 Motor Mount
31=NEMA 34 Mount & Limit Switch
*** For BiSlides oriented vertically with the knob up. Use the horizontal reading (-12 or -14) for applications with knob down.*

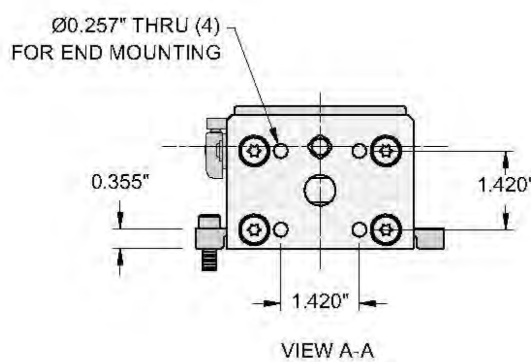
BiSlide Assembly Series M Dimensions



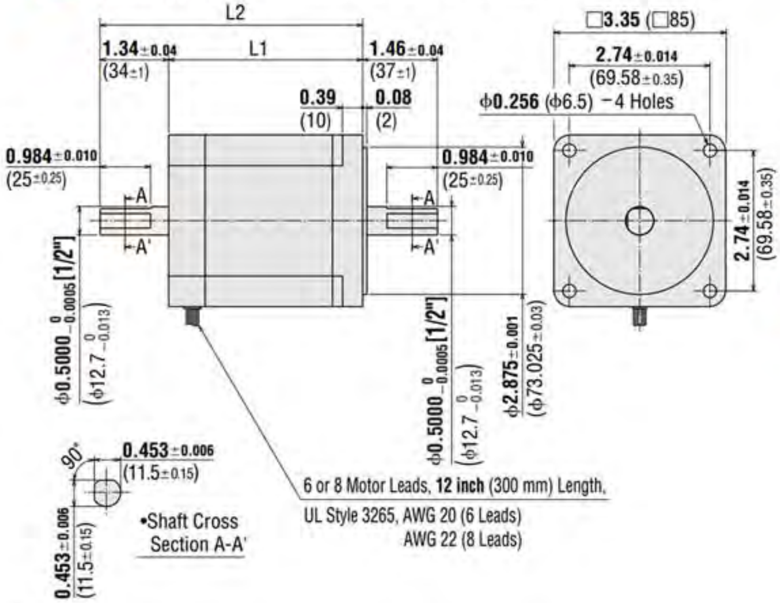


Travel Length (Inches)	Cleats Recommended**
5	4
10	4-6
15	4-8
20	6-10
30	8-12
40	10-14
50	12-16
60	14-18
80	16-20

***Use higher number for heavy loads*



Dimensions Scale 1/4, Unit = **inch** (mm)

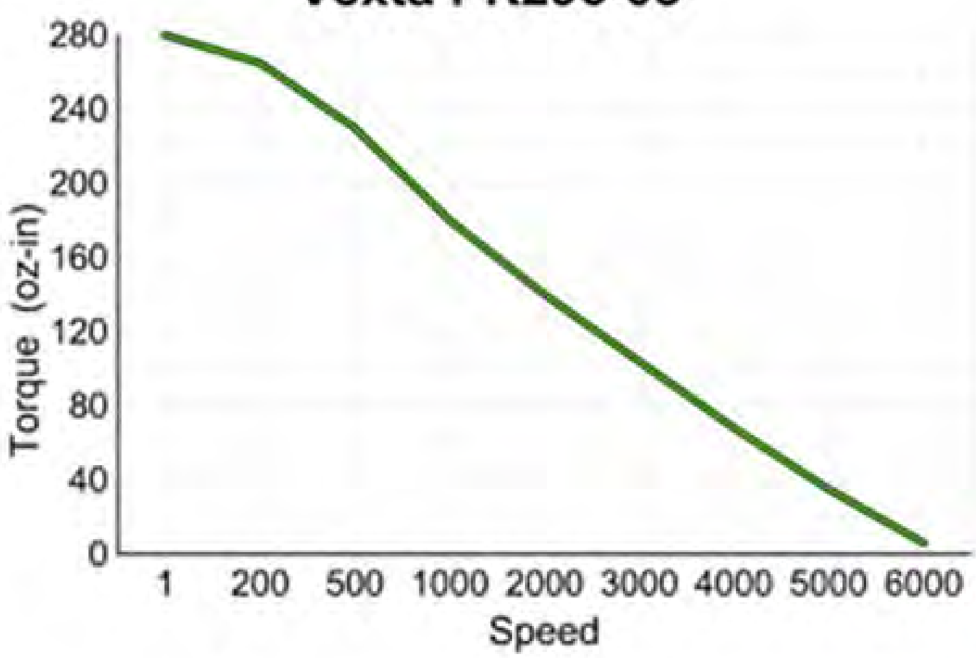


Model	L1 inch (mm)	L2 inch (mm)	Weight lb. (kg)	DXF
PK296-0□AA **PK296-F4.5A**	2.60 (66)	—	3.7 (1.7)	B122U
PK296-0□BA **PK296-F4.5B**		3.94 (100)		

- Enter the winding specification in the box (□) within the model name.

- These dimensions are for double shaft models. For single shaft models, ignore the shaded area.

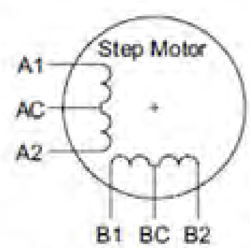
Vexta PK296-03

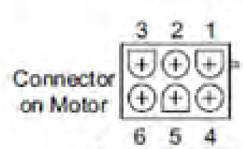


Motor Wiring (for Velmex installed step motors)

Pin	Motor	Cable (6 wire)	Slo-Syn	Vexta	Pacific Scientific*
1	BC	W	W	W	W/Y & W/R
2	B2	Gn	Gn	Bu	R
3	AC	Bk	Bk	Y	W/Bk & W/O
4	A2	Or	W/R	Bk	O
5	A1	R	R	Gn	Bk
6	B1	Bu	W/Gn	R	Y

* 8 lead motor with wires combined at AC and BC for 6 lead configuration





Amp 1-480705-0
(mates with: 1-480704-0 on Cable)

SMOKE WAND

Instrumentation

AEROLAB electric-powered Smoke Generator

- **White mineral oil fluid**
    - KAYDOL® White Mineral Oil
    - Drakeol® 19 MIN OIL USP
    - Or similar
- 18” long smoke wand
- Compressed air supply: 20 – 150 psig
- Automatic temperature setting
- Electrical power: 110VAC ONLY
- 45 minutes of runtime (full reservoir)
- 1 gallon reservoir

Figure 46: AEROLAB smoke generator

Location and Installation

The access hole for putting the smoke wand into the tunnel is located on the right side of the test section door.

Instruction Manual

The following instruction manual is from AEROLAB; use the instructions from this manual instead of the ones on the side of the smoke generator.

MAKE SURE YOU HAVE THE BUCKET OF GRAVEL TO CATCH ANY DRIPPING OIL

AEROLAB

AEROLAB Complete Smoke Generator System
Owner's Manual / Operating Instructions

V11.1

Specifications

The AEROLAB Complete Smoke Generator System is supplied with the following items:

- Base/Power Unit
- Corded Smoke Wand (short or long)
- Smoke Wand Protective Cap
- One Gallon (3.70 liter) Smoke Fluid (Propylene Glycol or White Mineral Oil)
- Airline Fitting
- Funnel and Heat-resistant Collector Can
- Owner's / Operator's Manual (this document)

Base/Power Unit

- 14.5 inches (36.8cm) long, 5 inches (12.7cm) deep, 7.25 inches (18.4) tall inclusive of all knobs and fittings
- 9.8 pounds (4.4kg) excluding smoke fluid

Short Smoke Wand

- 18 inches (46cm) long
- 1.8 pounds (0.8kg) including cabling

Long Smoke Wand

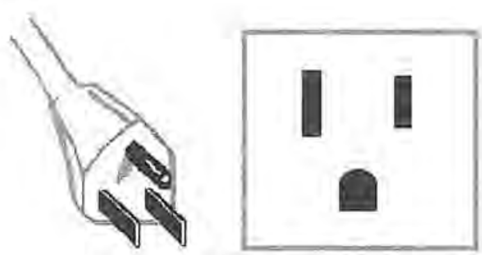
- 45 inches (114cm) long
- 2.2 pounds (1kg) including cabling

Electrical Requirements

- The Smoke Wand must <u>never</u> be plugged directly into domestic power. This is dangerous and permanent damage to the wand will result.
- 110VAC **<u>ONLY</u>**
- 375 Watts
- Type B Extension Cord (Not included)

Compressed Air Requirements

- 150 psig (1,034 KPa) maximum
- 1 pint (475cc) per hour



Type B Extension Cord

System Warnings

****** NOTE ******

The AEROLAB Smoke Generator can be used with 110-120VAC 50/60Hz ONLY!
The system draws 375 Watts.

1. Read and understand this manual before operating the unit.

2. NEVER plug the smoke wand directly into a wall outlet. It should ONLY be plugged into the base/power unit.

3. Make sure the unit is sitting in an upright position at all times! It should NEVER be positioned or stored on its side!!

4. Use the recommended smoke fluid only. Failure to do so may cause injury and/or permanent damage to the system. The system is designed for propylene glycol or white mineral oil, only. These fluids are available directly from Aerolab (301)-776-6585.

5. During operation and cool-down, do not touch the wand near the tip. Severe burns may result.

6. If the smoke fluid reservoir runs empty, immediately turn **POWER** OFF. Allow air to pass through the system for at least 10 minutes. Failure to do this may clog the tip and result in costly repairs.

7. To shut down the unit: First, turn Power OFF. Then, allow smoke fluid to drip from the wand for least 7 minutes or until cool.

8. Failure to follow proper shut-down procedure will likely clog the tip and result in costly repairs.

9. Systems Using White Mineral Oil: Never position the wand tip less than 5 inches (13cm) to an object. Vapor combustion could result.

Introduction

The AEROLAB Smoke Generator vaporizes a fluid (white mineral oil or propylene glycol) as it flows through an electronically-heated, small-diameter stainless steel tube. Although the system is referred to as a smoke generator, it does not burn the fluid or produce smoke.

The base/power unit (black) consists of a compressed air pressure regulator, a fluid reservoir, a wand tip temperature controller and a fluid flow valve. The system requires compressed air (supplied by your existing compressed air system), a standard electric extension cord and 110-120VAC. The internal regulator ensures the system will not be over pressurized. The regulated compressed air drives the smoke fluid from the reservoir to the wand tip. In the tip, the smoke fluid is vaporized as it passes by a heating element.

Controls and Connections

Top View of the Base/Power Unit

PRESSURE REGULATOR – Allows the Operator to adjust the compressed air pressure in the smoke fluid reservoir.

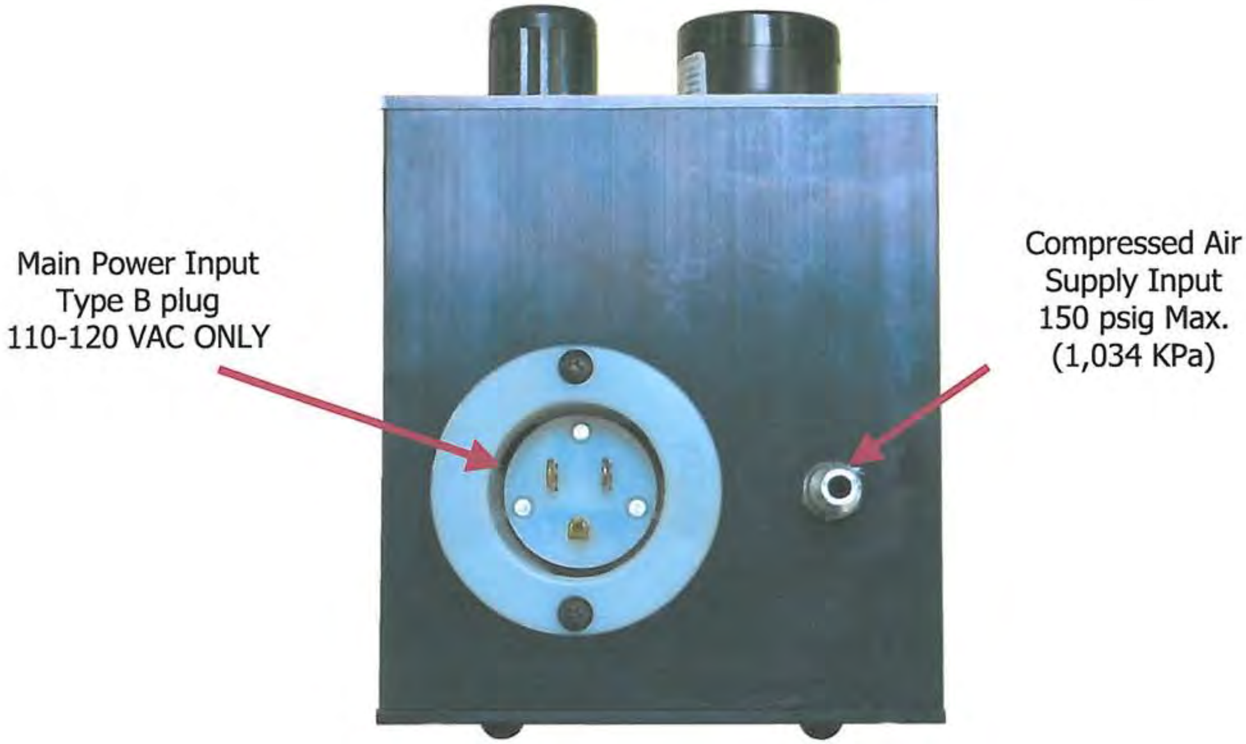
Pressure Gauge – Indicates the current air pressure within the smoke fluid reservoir.

FLUID FILLER PLUG – A screw-in cap for the smoke fluid reservoir.

TEMPERATURE CONTROLLER – Calibrated and set at AEROLAB, this component maintains correct smoke wand temperature.

FLUID FLOW – This knob controls smoke fluid flow from the reservoir to the smoke wand.

POWER – This switch powers the base/power unit and the smoke wand.



Input Side of Base/Power Unit

Output Side of Base/Power Unit

Operation

Startup

Note: All Smoke Generator Systems are thoroughly tested at AEROLAB prior to shipment. As such, some residual fluid will be present in the smoke wand tubing and fluid reservoir. This is normal.

1. Ensure:
   - compressed air is ***not*** connected to the base/power unit
   - electrical power is ***not*** connected to the base/power unit
   - the **POWER** switch is **OFF**

2. Connect the wand fluid tube to the base/power unit.

3. Connect the wand power cord to the base/power unit.

4. Connect the temperature sensor plug to the base/power unit. Note: The plug is polarized – it can be inserted only one way. Do not force the plug.

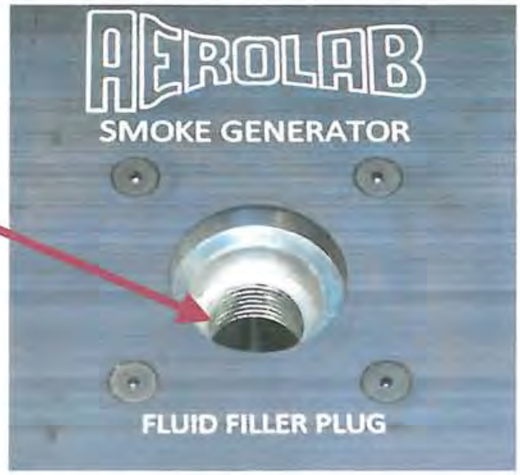
All Wand Connections Complete

5. To remove the smoke wand tip protector cap, pull it off the wand. The protector cap is clearly labeled with a red cloth flag reading, "REMOVE BEFORE FLIGHT". Do not proceed to the next step until the protector cap has been removed. Never attempt to operate the system with the cap installed – permanent damage will result.

6. Remove the **FLUID FILLER PLUG** (turn the filler plug anticlockwise). Note: If pressure exists in the reservoir, a slight hissing sound will be heard as the filler plug is loosened. There is no danger.

7. Using the supplied funnel, fill the fluid reservoir with an approved fluid. The fluid can be filled up to the bottom of the filler plug threads.

Maximum Fluid Fill Height



8. Reinstall the **FLUID FILLER PLUG** (turn the filler plug clockwise).

9. Close the **FLUID FLOW** valve. To do so, turn the knob clockwise.

10. Connect electrical power to the base/power unit.

11. Connect compressed air to the base/power unit. Note: Compressed air supply must not exceed 150 psig (1,034 KPa).

All Input Connections Complete

12. Pull up on the **PRESSURE REGULATOR** knob to unlock it for adjustment.

13. While watching the air pressure gauge, turn the **PRESSURE REGULATOR** knob clockwise or anticlockwise to adjust the reservoir pressure to 20 psig.

14. Press down on the Pressure Regulator knob to lock the setting

Should be fill with small rocks

15. Position the smoke wand tip over the supplied heat-resistant metal can. Smoke fluid will be discharged in the following steps.

16. Turn the **FLUID FLOW** knob anticlockwise ⅛ to ¼ of a turn. This will begin fluid flow to the smoke wand. (Turning FLUID FLOW knob more than ¼ turn will keep unit from heating up fully)

17. Watch the smoke wand tip. Do not proceed to the next step until there is a steady drip of fluid.

18. Turn **POWER** ON. Soon, the steady drip of fluid will become a steady stream and then white vapor.

    Notes:
    - Upon turning **POWER** ON, the **TEMPERATURE CONTROLLER** will indicate **YCA** and then **rLY**. This is normal.

The system is now ready for use.

Notes:

- The smoke wand tip becomes very hot. Do not touch the wand tip to skin or combustible materials – burns or fire will likely result.
- The wand temperature was adjusted and set at AEROLAB during pre-delivery testing. Temperature adjustment is possible, but not recommended (see Temperature Adjustment – Not Recommended)

Normal Shutdown

1. Position the smoke wand tip over a heat-resistant vessel such as a metal can. Smoke fluid will be discharged in the following steps.

2. Turn **POWER** OFF. Soon, the white vapor will become a steady stream and then a steady drip.

3. Allow the wand to drip for at least 7 minutes. After this time, the wand should be cool to the touch.

4. Turn the **FLUID FLOW** knob clockwise until it stops. This will stop the fluid flow to the smoke wand.

5. Disconnect electrical power from the base/power unit.

6. Disconnect compressed air supply from the base/power unit.

7. Reinstall the smoke wand tip protector cap.

The system is now completely shutdown.

Notes:

- Do not reinstall the smoke wand tip protector cap until you are certain the wand is cool. Otherwise, burns could result.
- Following normal shutdown, fluid will remain in the smoke wand and delivery tube. This is normal.
- Pressure will remain in the fluid reservoir. It is not necessary to remove this pressure.

Loss of Smoke Fluid / Abnormal Shutdown

If the reservoir becomes empty during use, follow these steps.

1. Turn **POWER** OFF.

2. Allow air to pass through the wand for at least 10 minutes. After this time, the wand should be cool to the touch.

3. Disconnect compressed air supply from the base/power unit.

4. To prepare the system for use, proceed to Startup, step #1.

System Storage

Ensure:

- the **POWER** switch is **OFF**
- the smoke wand is cool
- the smoke wand protector cap is installed
- compressed air is ***not*** connected to the base/power unit
- electrical power is ***not*** connected to the base/power unit
- the wand is not connected to the base/power unit
- the **FLUID FLOW** knob is turned clockwise until it stops

Notes:

- Never position the base/power unit on its side or ends. It must be stored upright.
- It is OK to store the system with fluid in the reservoir.
- It is okay to store the system with pressure in the reservoir.
- To avoid spilled smoke fluid, it is best to hang the smoke wand and cabling above a collector vessel for a period of 1 to 2 days. After this time, store the wand and cabling on a flat surface away from sunlight and heat.

Troubleshooting

If the **TEMPERATURE CONTROLLER** does not become active upon **POWER** ON:

- Ensure power is properly connected to the base/power unit.
- Check the power fuse located on the output side of the base/power unit. If open, replace with similar 4 Amp fuse – never use a larger fuse.
- If these measures do not correct the problem, contact AEROLAB.

If white vapor turns to liquid fluid during use:

- Position the wand tip over a non-combustible collector vessel.
- Ensure the wand temperature sensor plug is properly inserted.
- Ensure the wand power plug is properly inserted.
- Ensure the base/power unit is properly connected to power.
- Ensure the fuse is not open.
- If these measures do not correct the problem, perform a Normal Shutdown and contact AEROLAB.

Temperature Adjustment – Not Recommended

During pre-delivery testing at AEROLAB, every Smoke Generator System is thoroughly tested. Additionally, the **TEMPERATURE CONTROLLER** is set for optimal smoke density. Adjustments to the wand temperature should be completely unnecessary for the majority of the system's service life. Improper adjustment of the wand temperature will result in diminished smoke density and substandard operation.

Over time, a slight increase in wand temperature may be necessary to ensure complete vaporization of the smoke fluid. The following steps are offered for this adjustment.

Note: The thickest smoke density is obtained at a wand temperature just above vaporization. Beyond this temperature, the vapor will become thin and translucent.

1. Startup the system as described in Startup.

2. Quickly touch and release the **MD** button on the **TEMPERATURE CONTROLLER**. Do not hold the button. The display will change to **Su**. Then, it will display the current temperature setting.

3. To increase or decrease the temperature setting, press the arrow buttons.

4. To accept the new temperature setting and save it to memory, quickly press and release the **MD** button.

Notes:

- During pre-delivery testing at AEROLAB, a temperature range was determined and programmed into the **TEMPERATURE CONTROLLER**. Do not attempt to increase this range or permanent damage to the wand will result. Attempts to change the original temperature range will void the warranty.
- Temperature settings will not effective until the **MD** button is pressed a second time (exiting the adjustment routine).
- Make SMALL temperature changes and then test.
- High wand temperatures do not increase smoke flow or density.

Wand Temperature Too Cool

Wand Temperature Too HOT

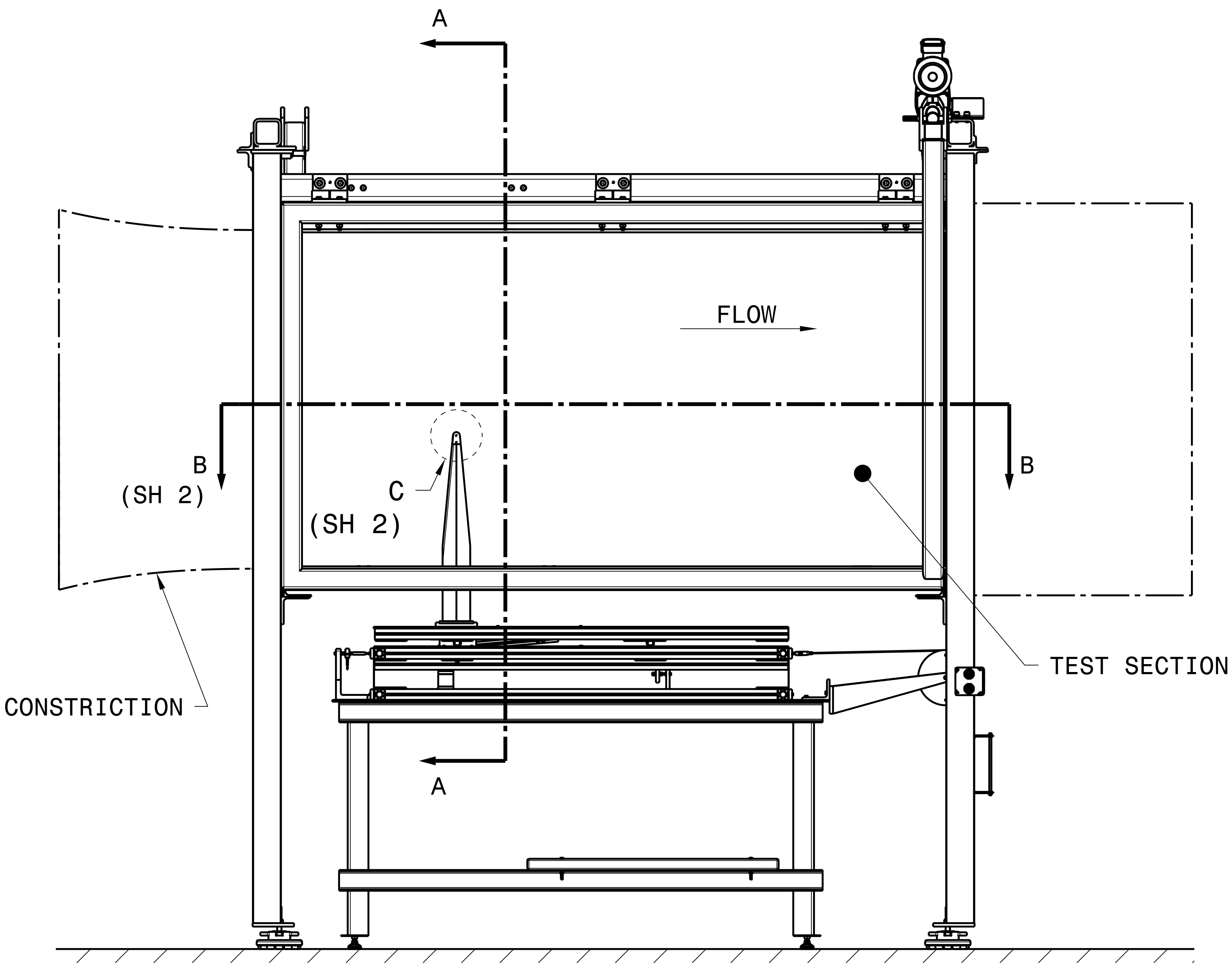
Perfect Wand Temperature

Contact AEROLAB

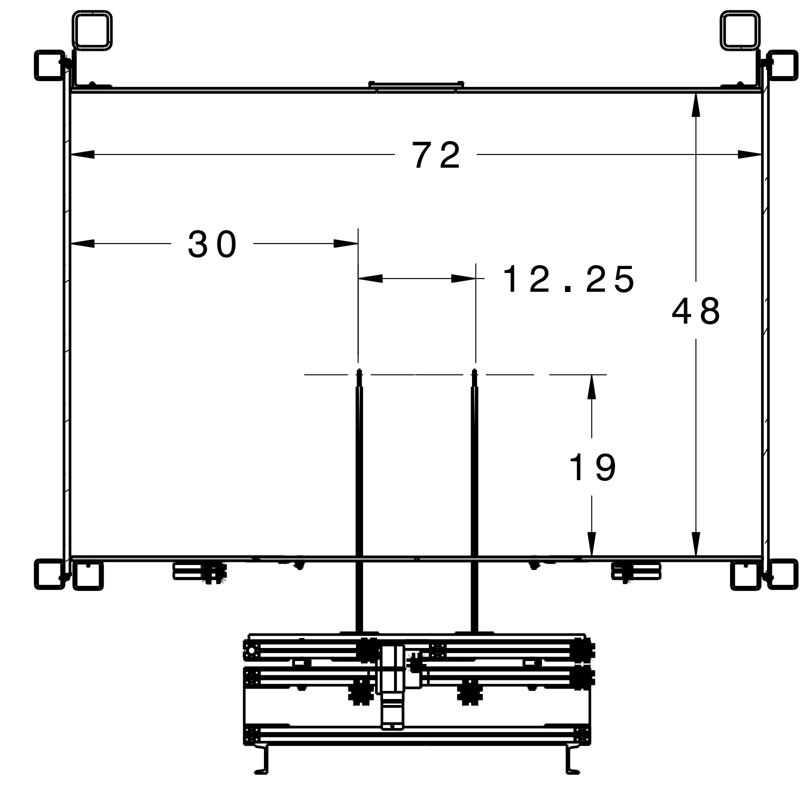
AEROLAB LLC
9580 Washington Boulevard
Laurel, Maryland 20723
(P) 301-776-6585
(F) 301-776-2892

www.aerolab.com
aerolab@aerolab.com

SELECTED PART DRAWINGS



Front view
Scale: 1:20



Section view A-A

NOTES:

1. IT IS RECOMMENDED TO LEAVE SPACE BETWEEN THE MODEL AND THE TUNNEL DOORS.

2. ANGLE OF ATTACK ARM IS ADJUSTABLE. GENERAL SETUP USES ONE ∅0.25 HOLE TO SECURE ARM TO MODEL.

UNLESS OTHERWISE SPECIFIED

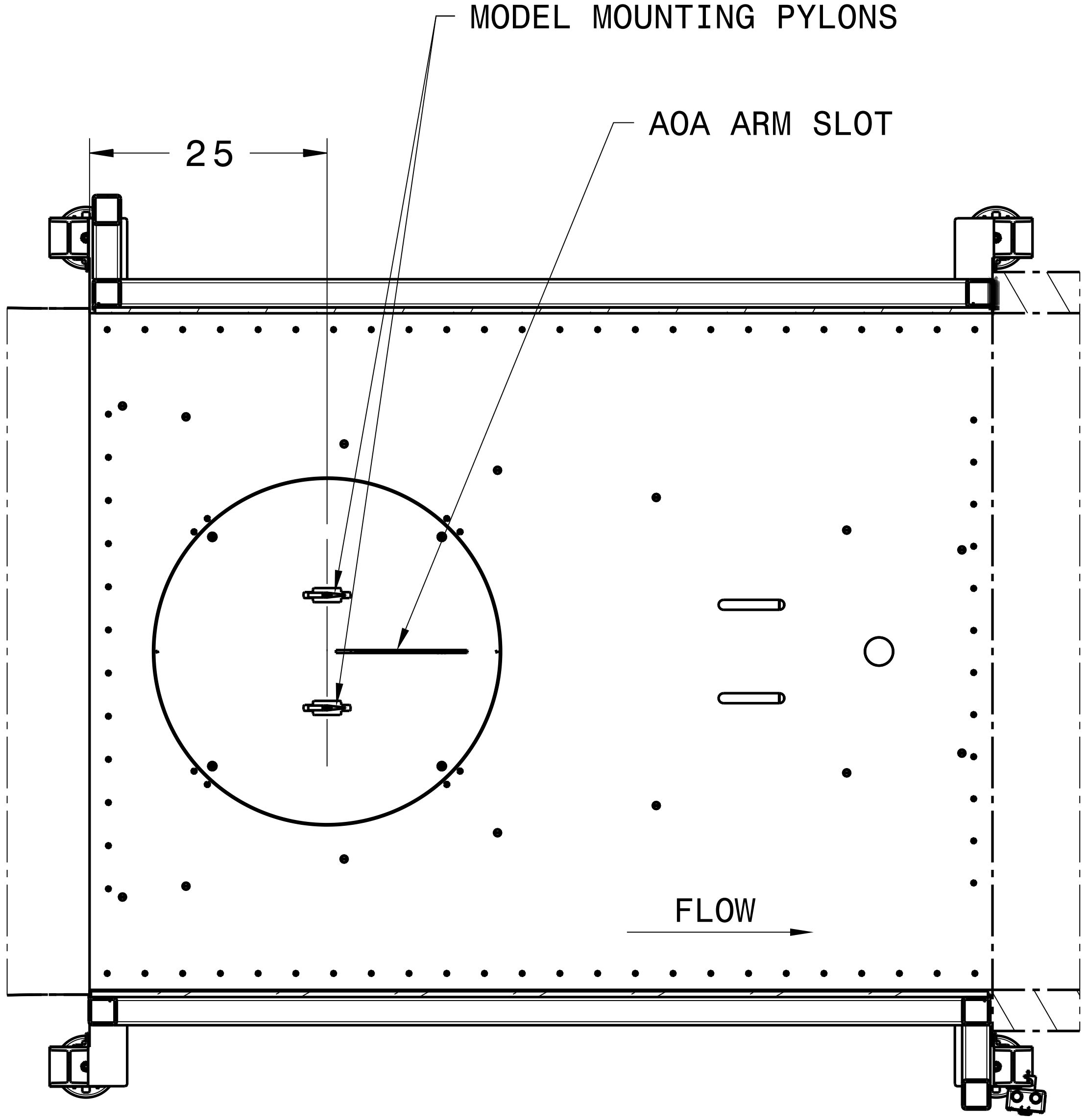
- TOLERANCES
  X.X = ±.05
  X.XX = ±.01
  X.XXX = ±.005
- DEBURR HOLES AND BREAK SHARP EDGES.
- GEOMETRY IS DEFINED BY 3D SOLID MODELS.

DRAWN BY: 7/1/2019
P. BALDWIN

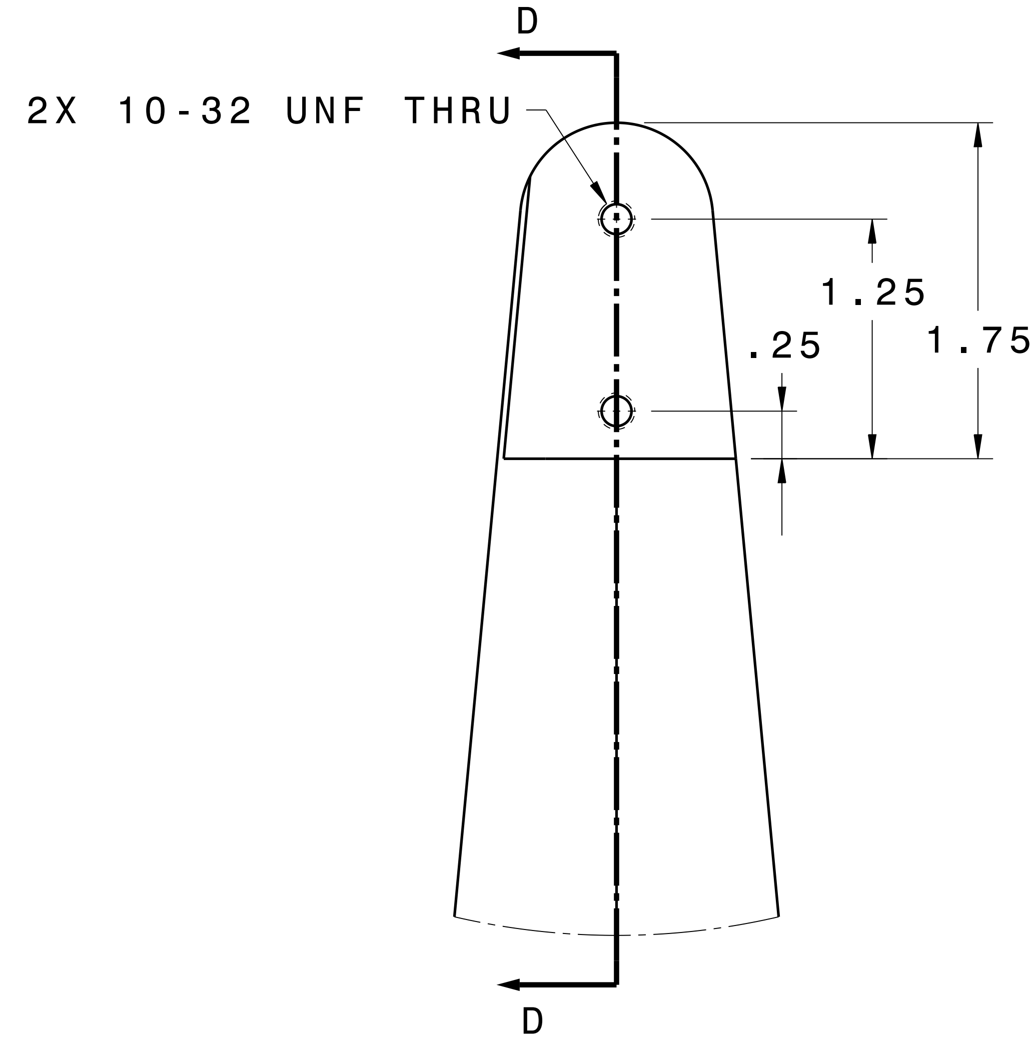
PURDUE UNIVERSITY
AERONAUTICS
& ASTRONAUTICS

SHEET SIZE	DRAWING NAME	REVISION
B	BOEING WIND TUNNEL- MODEL INTERFACE CONTROL	-A
SCALE	DRAWING NUMBER	SHEET
1:20 & NOTED	XXXXXXXXXXXXXXXXX	1/2

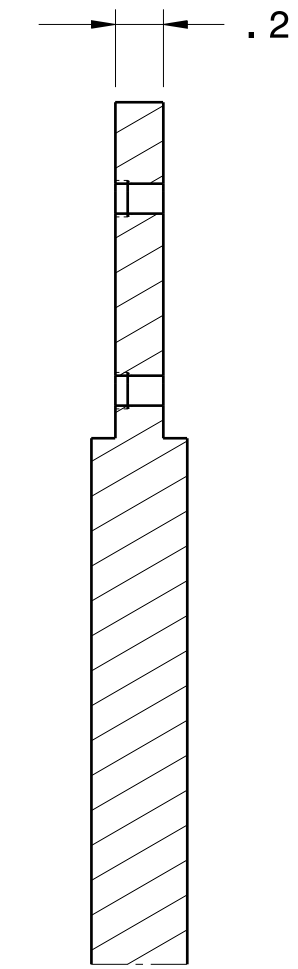
ALL DIMENSIONS IN INCHES



Section view B-B
(SH 1)



Detail C
(SH 1)
TYP 2 PL
Scale: 1:1



Section view D-D
Scale: 1:1

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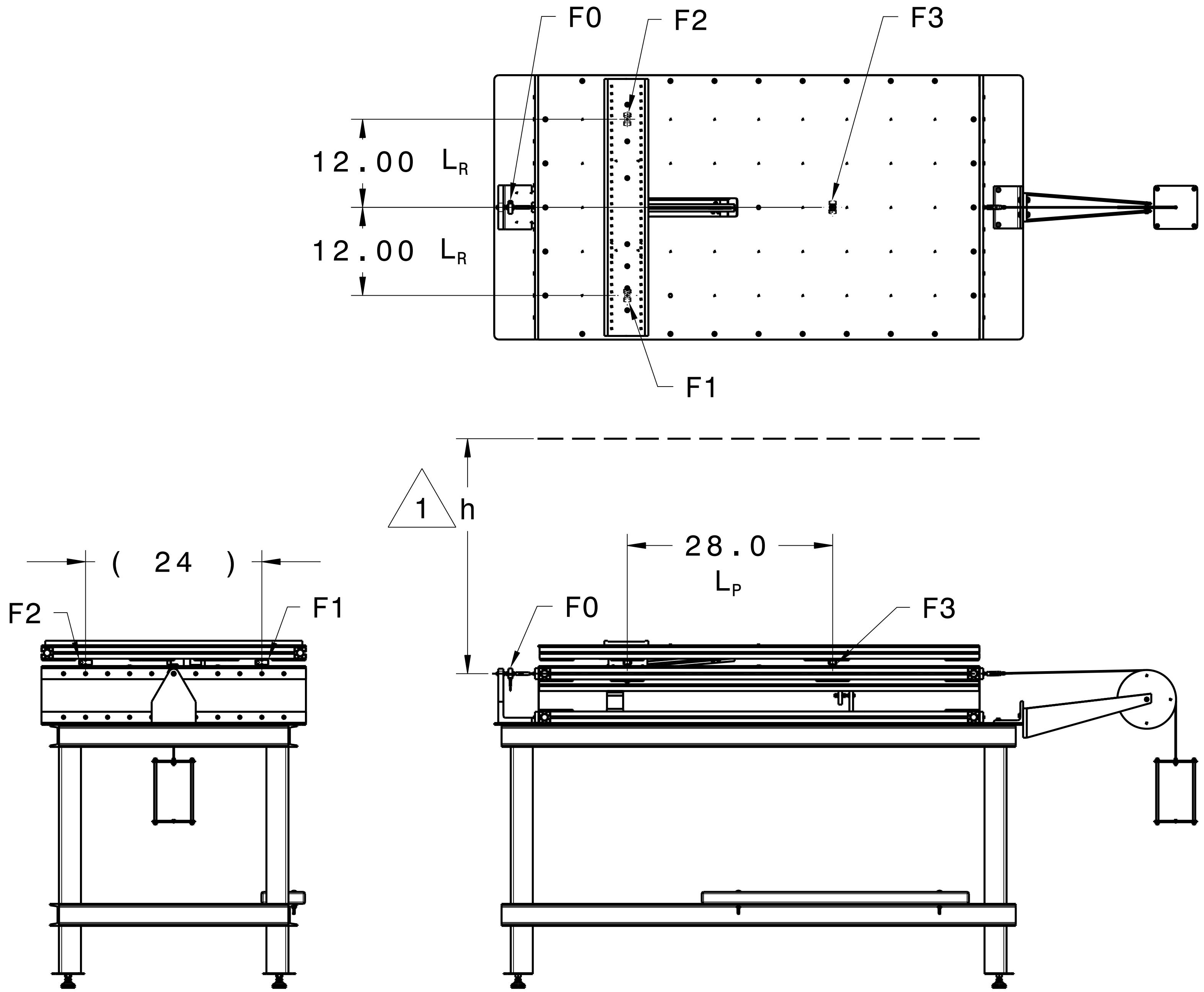
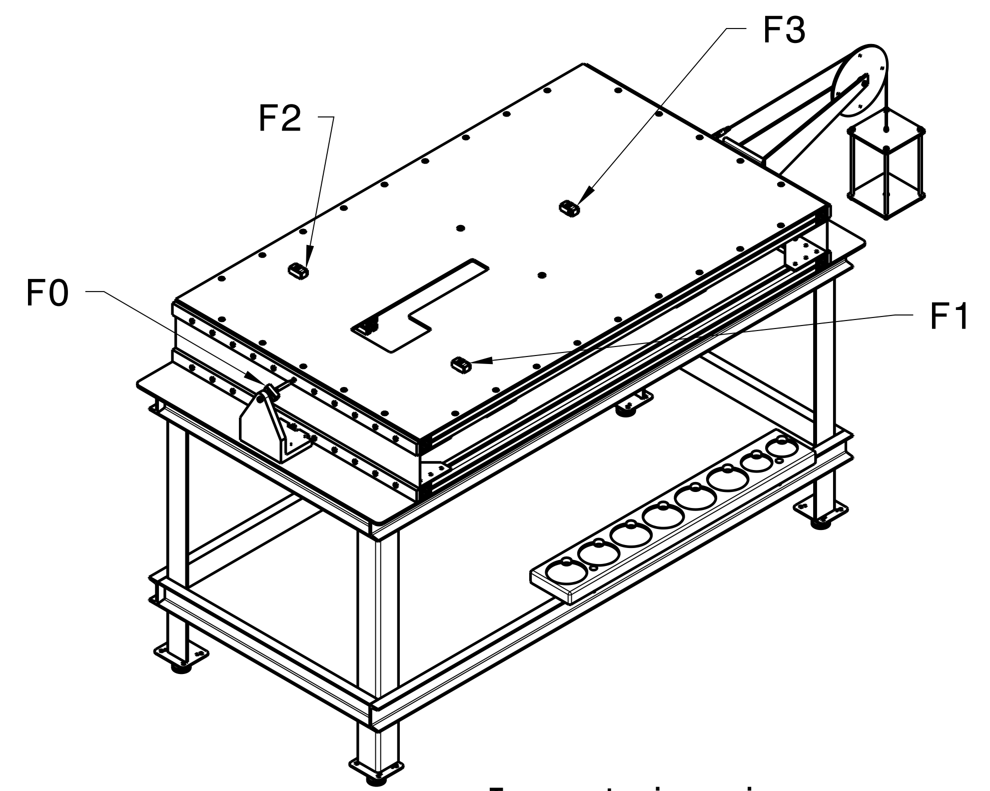
SHEET SIZE	DRAWING NAME	REVISION
B	BOEING WIND TUNNEL- MODEL INTERFACE CONTROL	-A
SCALE 1:20 & NOTED ALL DIMENSIONS IN INCHES	DRAWING NUMBER XXXXXXXXXXXXXXXXX	SHEET 2/2





Isometric view
TOP LEVEL NOT SHOWN FOR CLARITY

NOTES:

1. "h" IS THE HEIGHT FROM THE DRAG AXIS TO THE MODEL ROTATION AXIS. FOR THE STANDARD PYLONS, h = 31.5 INCHES.

2. FORCES AND MOMENTS ARE CALCULATED AS FOLLOWS:

DRAG FORCE: D = F0

LIFT FORCE: L = F1 + F2 + F3

PITCHING MOMENT: $P = -L_P*F3 + h*F0$

ROLLING MOMENT: $R = L_R*(F1 - F2)$

LABEL	MODEL	CAPACITY
F0	FUTEK LRF325	75 LB
F1	FUTEK LRF350	150 LB
F2		
F3		

UNLESS OTHERWISE SPECIFIED

- TOLERANCES
  X.X = ±.05
  X.XX = ±.01
  X.XXX = ±.005
- DEBURR HOLES AND BREAK SHARP EDGES.
- GEOMETRY IS DEFINED BY 3D SOLID MODELS.

DESIGNED BY:

DRAWN BY: 7/3/2019
P. BALDWIN

SHEET SIZE
B

SCALE
1:20

ALL DIMENSIONS IN INCHES

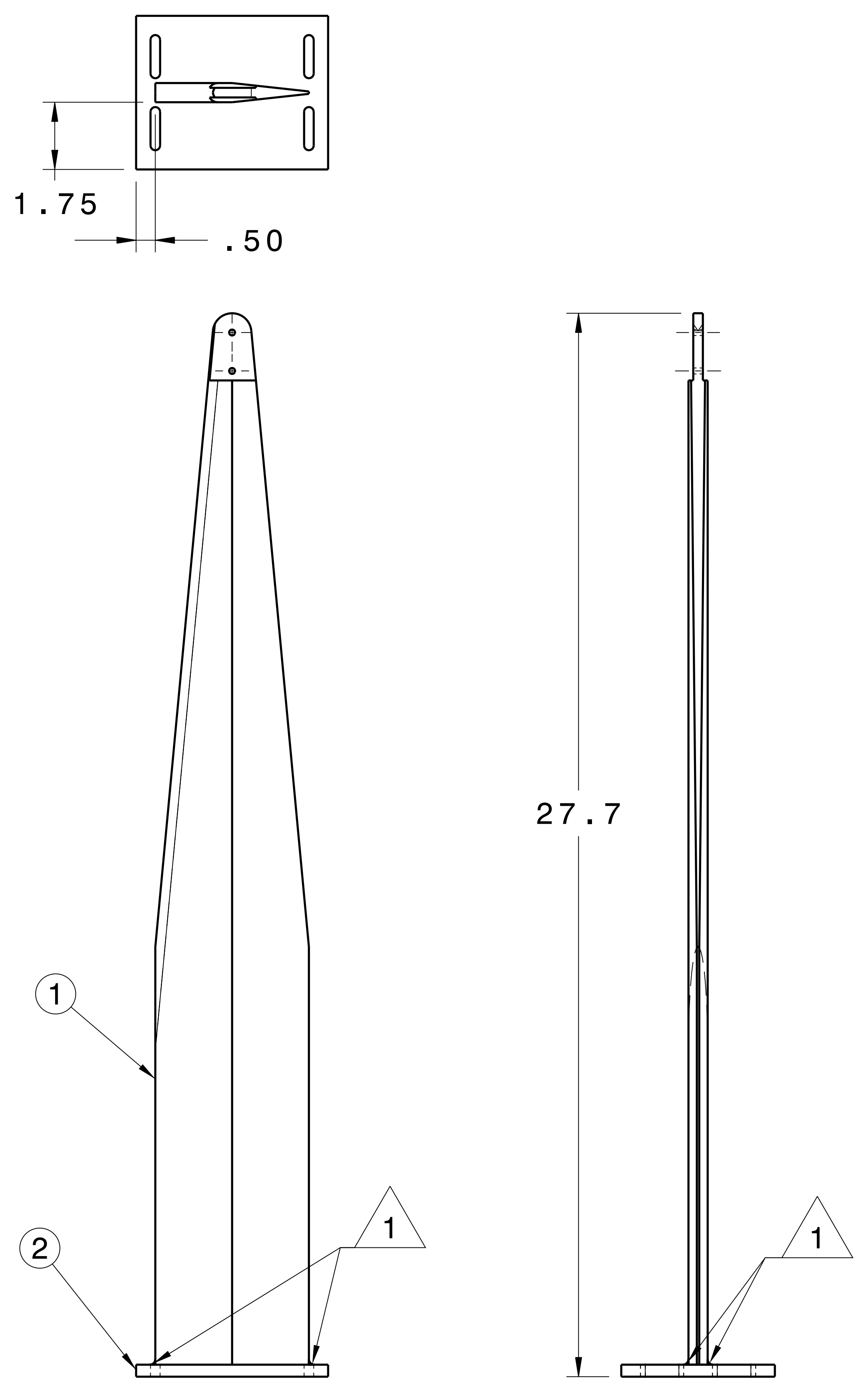
PURDUE UNIVERSITY
AERONAUTICS & ASTRONAUTICS

DRAWING NAME
BOEING WIND TUNNEL FORCE BALANCE INSTRUMENTATION

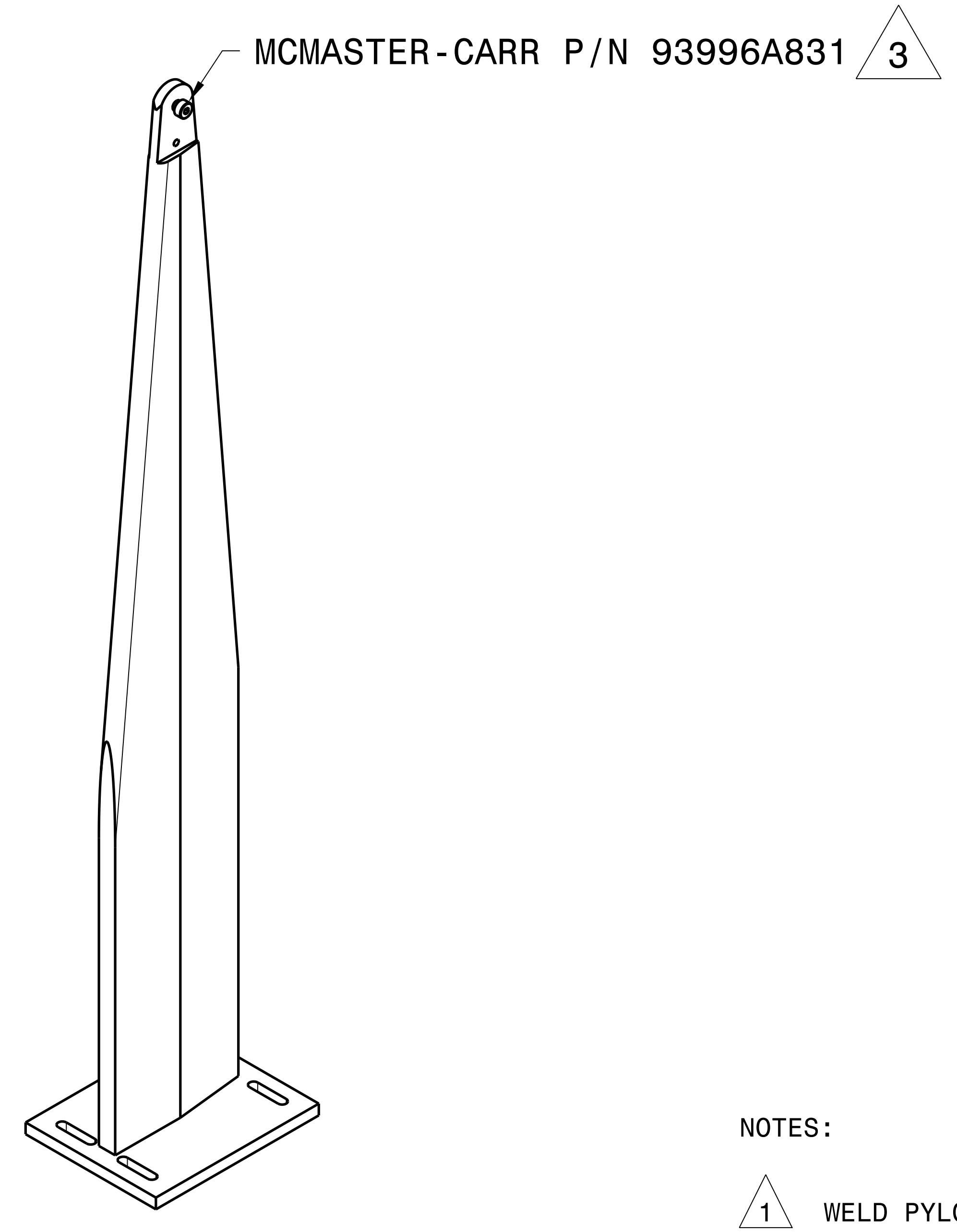
REVISION
--

DRAWING NUMBER

SHEET
1/X



STRUT ASSEMBLY



NOTES:

1. WELD PYLON TO BASE AT MACHINIST'S DISCRETION.
2. TO BE DONE IN THE STYLE OF THE EXISTING PYLONS.
3. SHOULDER SCREW FOR MODEL MOUNITNG IS TENTATIVE.

UNLESS OTHERWISE SPECIFIED

- TOLERANCES
  X.X = ±.05
  X.XX = ±.01
  X.XXX = ±.005
- DEBURR HOLES AND BREAK SHARP EDGES.
- GEOMETRY IS DEFINED BY 3D SOLID MODELS.

DESIGNED BY: P. BALDWIN	2/21/2018
DRAWN BY: P. BALDWIN	3/7/2018
SHEET SIZE: B	
SCALE: 1:4	
ALL DIMENSIONS IN INCHES	

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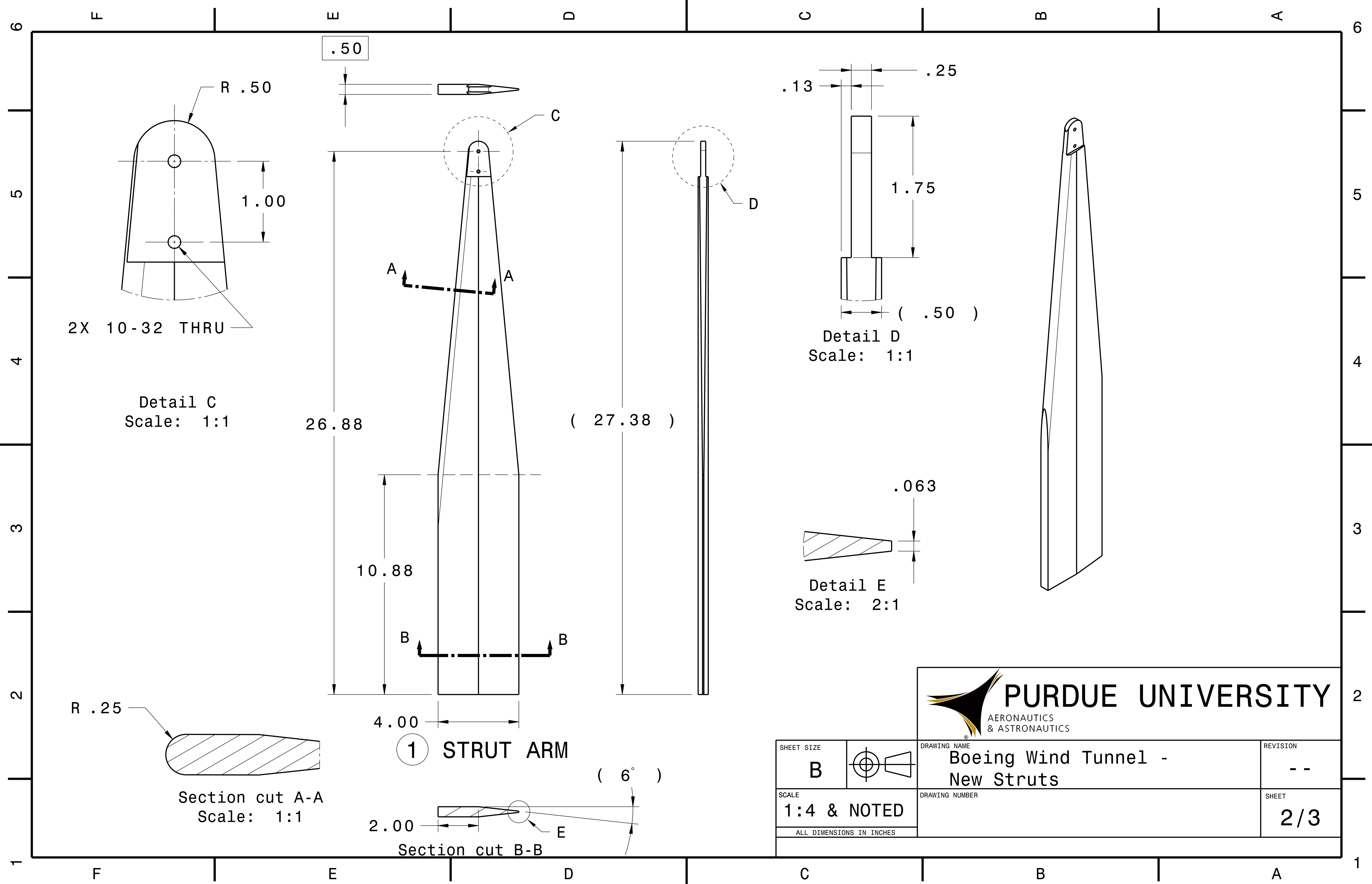
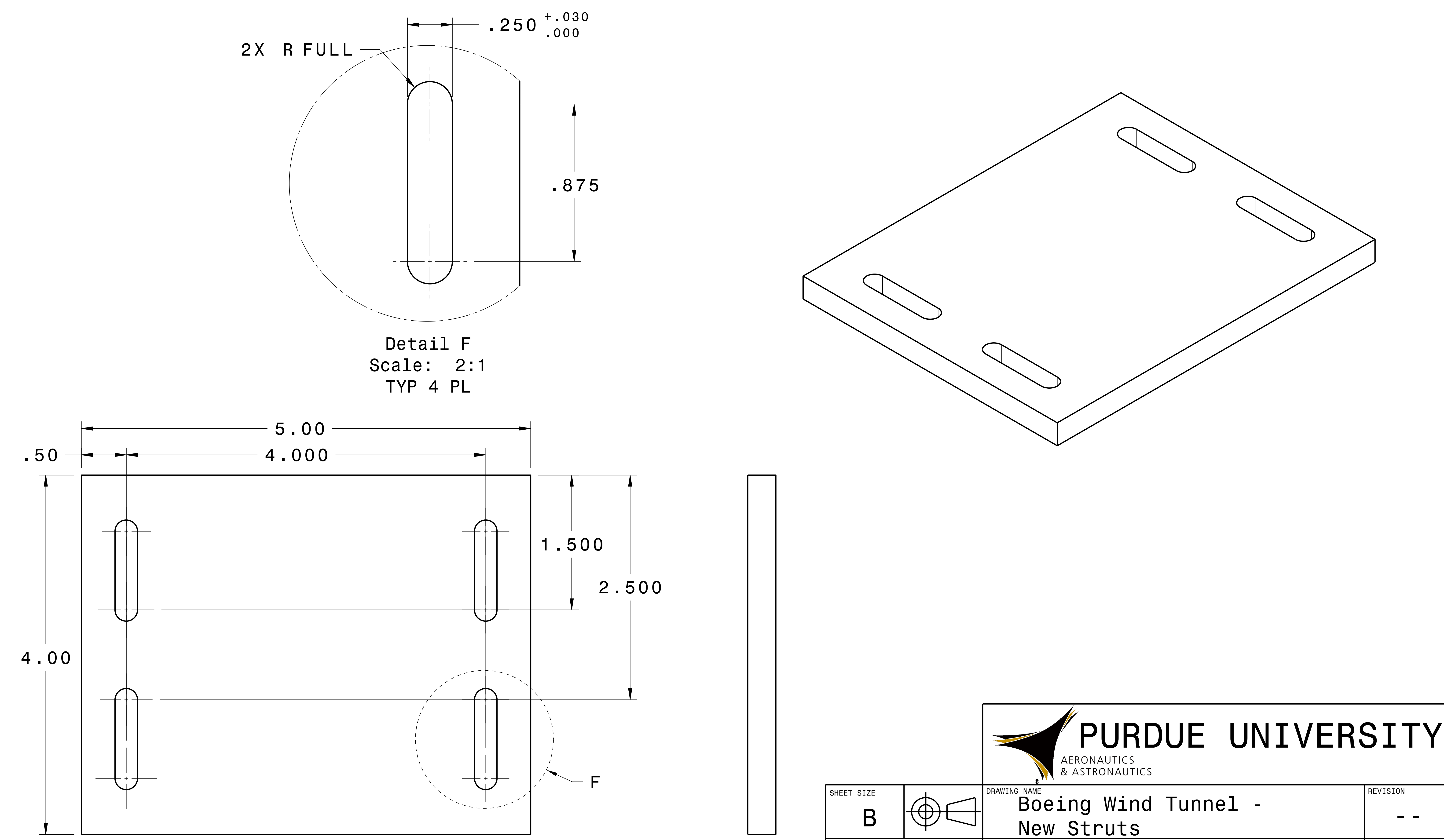
DRAWING NAME	REVISION
Boeing Wind Tunnel - New Struts	--
DRAWING NUMBER	SHEET
	1/3



R .50
1.00
2X 10-32 THRU
Detail C
Scale: 1:1
.50
C
A
A
26.88
10.88
B
B
4.00
1 STRUT ARM
(27.38)
D
.25
.13
1.75
(.50)
Detail D
Scale: 1:1
.063
Detail E
Scale: 2:1
R .25
Section cut A-A
Scale: 1:1
(6°)
2.00
E
Section cut B-B
PURDUE UNIVERSITY
AERONAUTICS
& ASTRONAUTICS
SHEET SIZE
B
DRAWING NAME
Boeing Wind Tunnel -
New Struts
REVISION
--
SCALE
1:4 & NOTED
ALL DIMENSIONS IN INCHES
DRAWING NUMBER
SHEET
2/3



② STRUT PLATE

SHEET SIZE: B		DRAWING NAME: Boeing Wind Tunnel - New Struts	REVISION: --
SCALE: 1:1 & NOTED		DRAWING NUMBER:	SHEET: 3/3
ALL DIMENSIONS IN INCHES			

PURDUE UNIVERSITY
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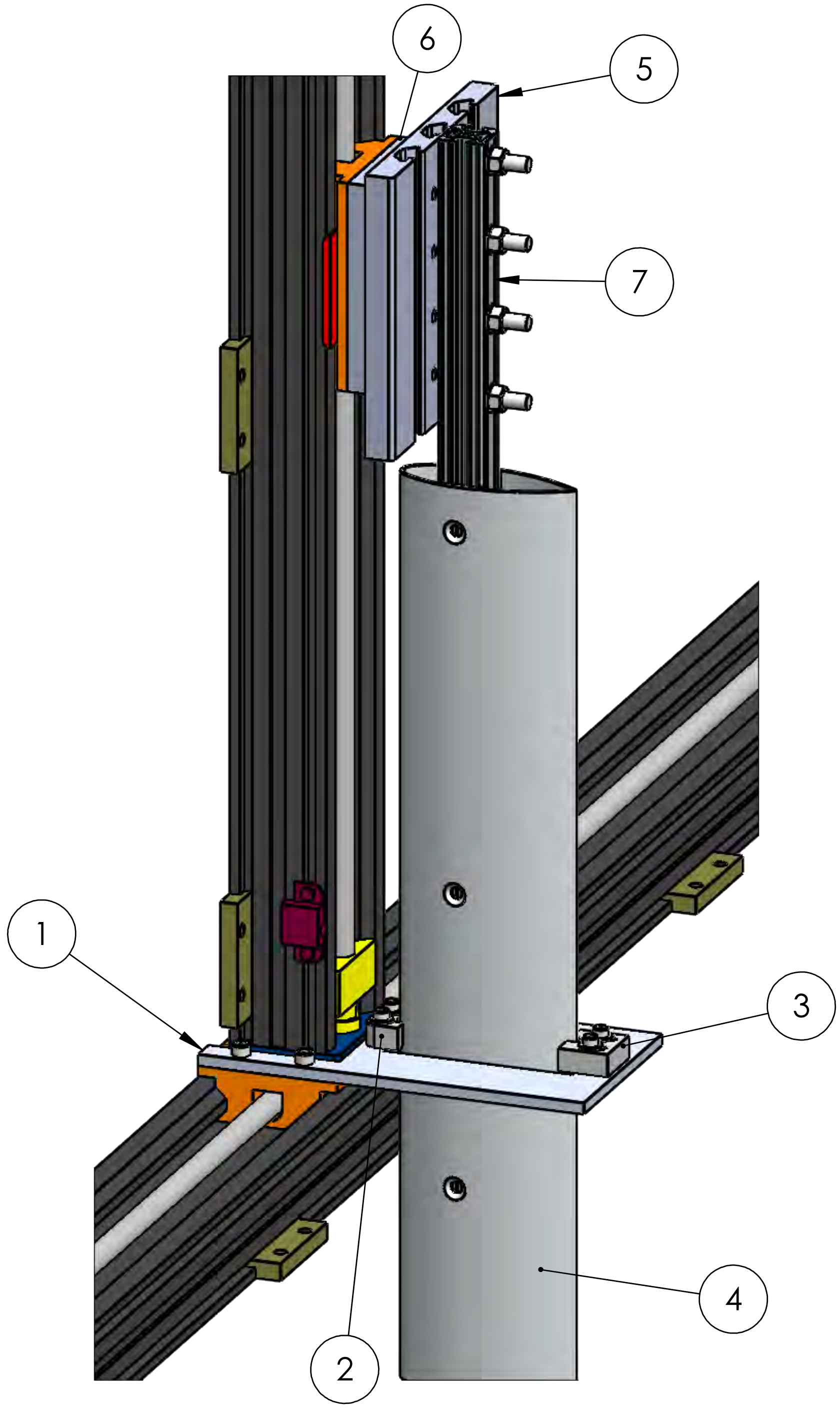
2 | 1

B | B

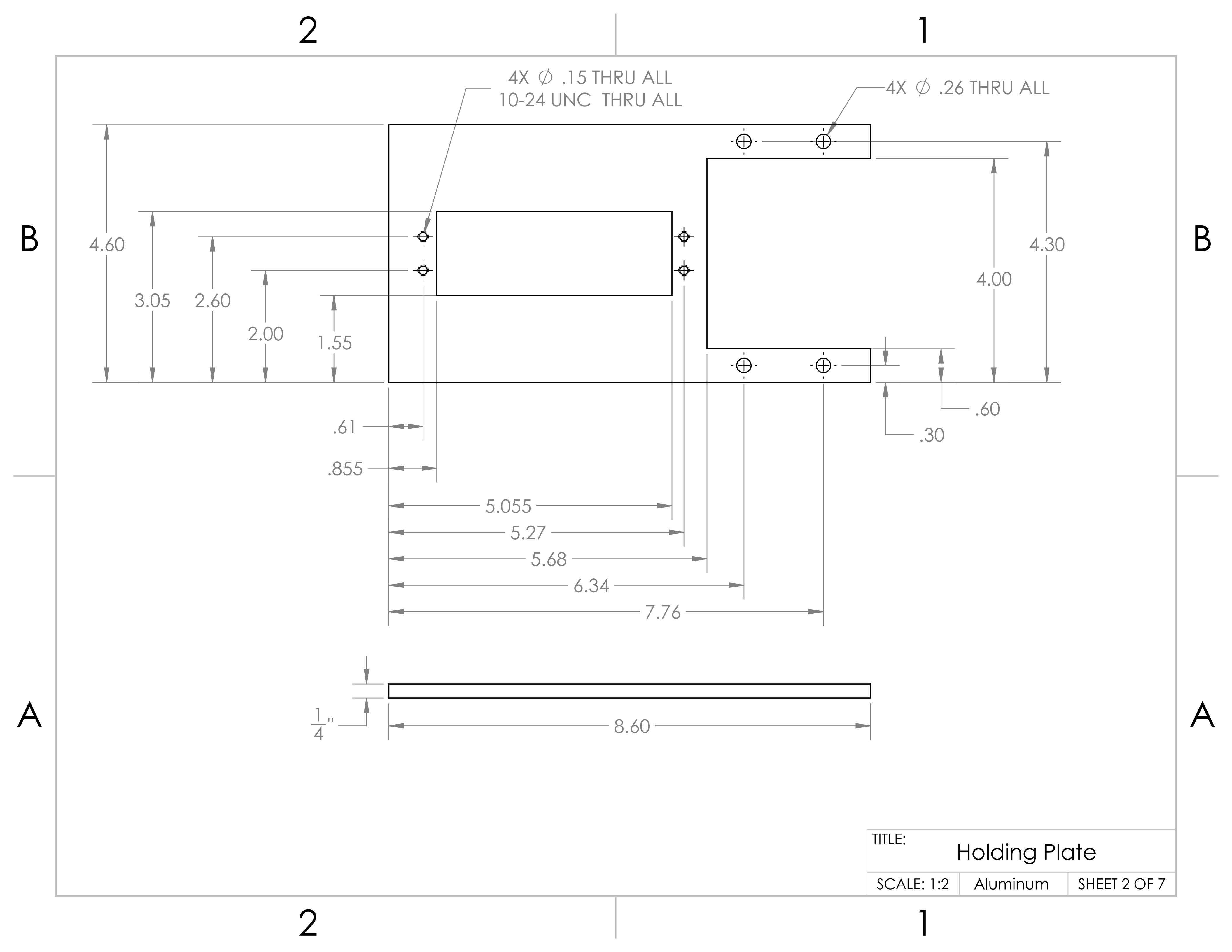


ITEM NO.	PART NUMBER
1	Holding Plate
2	Nose Support
3	Tail Support
4	Hollow Airfoil
5	Mounting Plate
6	Mounting Spacer
7	Support Rod

A | A

	NAME	DATE	TITLE: Traverse Probe Mounting		
DRAWN	C. Diffey	7/2/2019			
COMMENTS:			SIZE A	DWG. NO.	REV --
MATERIAL			SCALE: 1:4	WEIGHT:	SHEET 1 OF 7

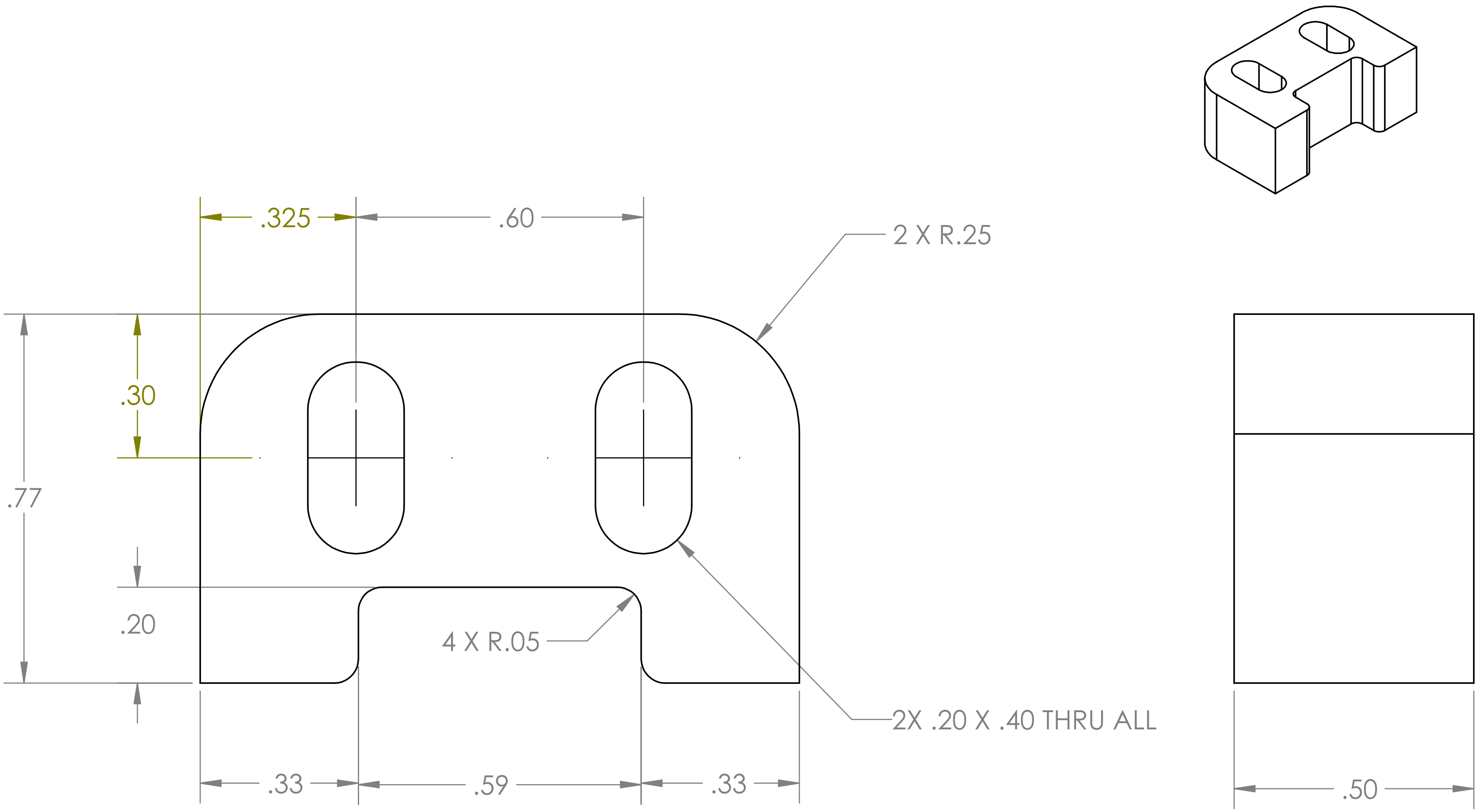
2 | 1



TITLE: Holding Plate		
SCALE: 1:2	Aluminum	SHEET 2 OF 7

2 | 1

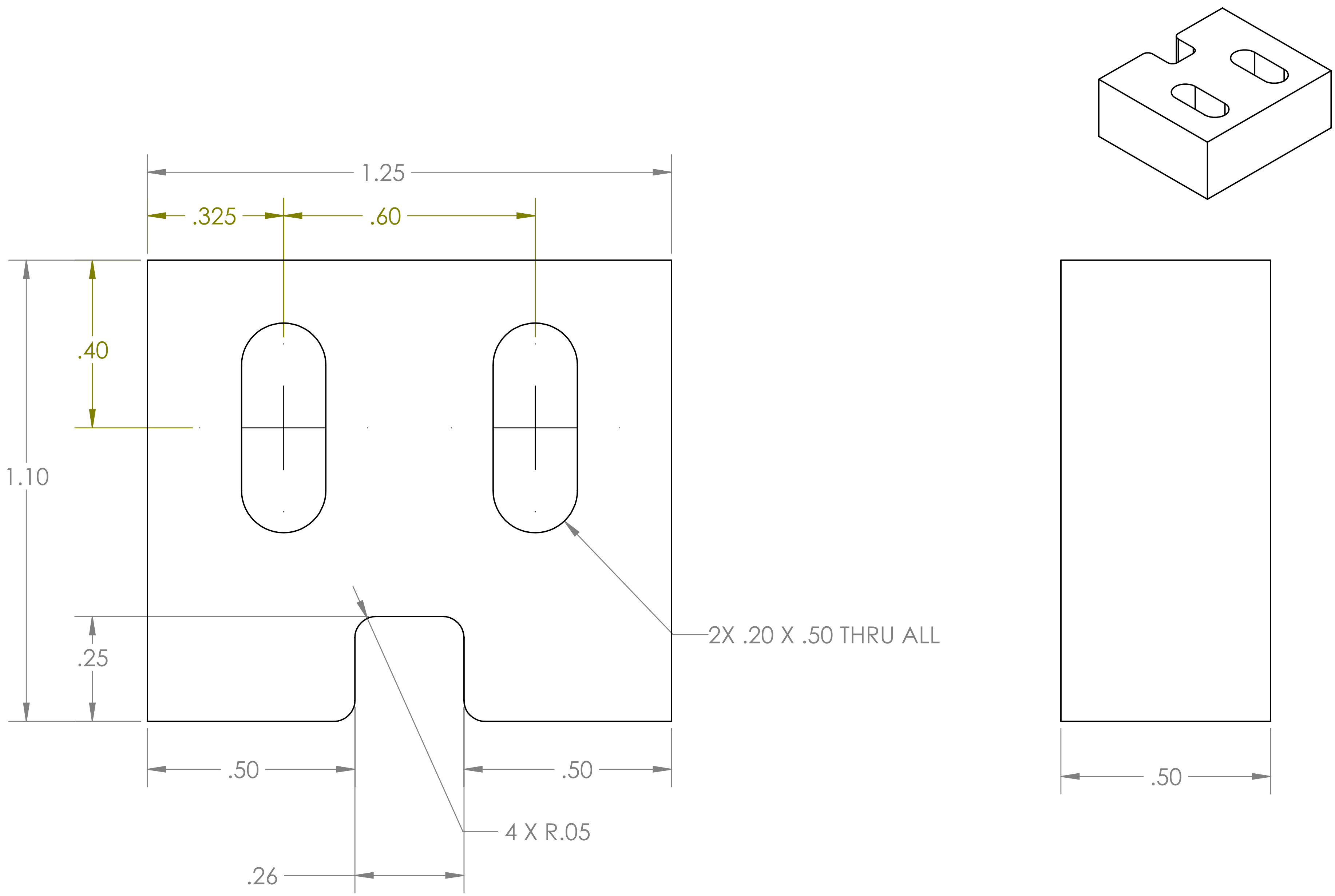
B | B



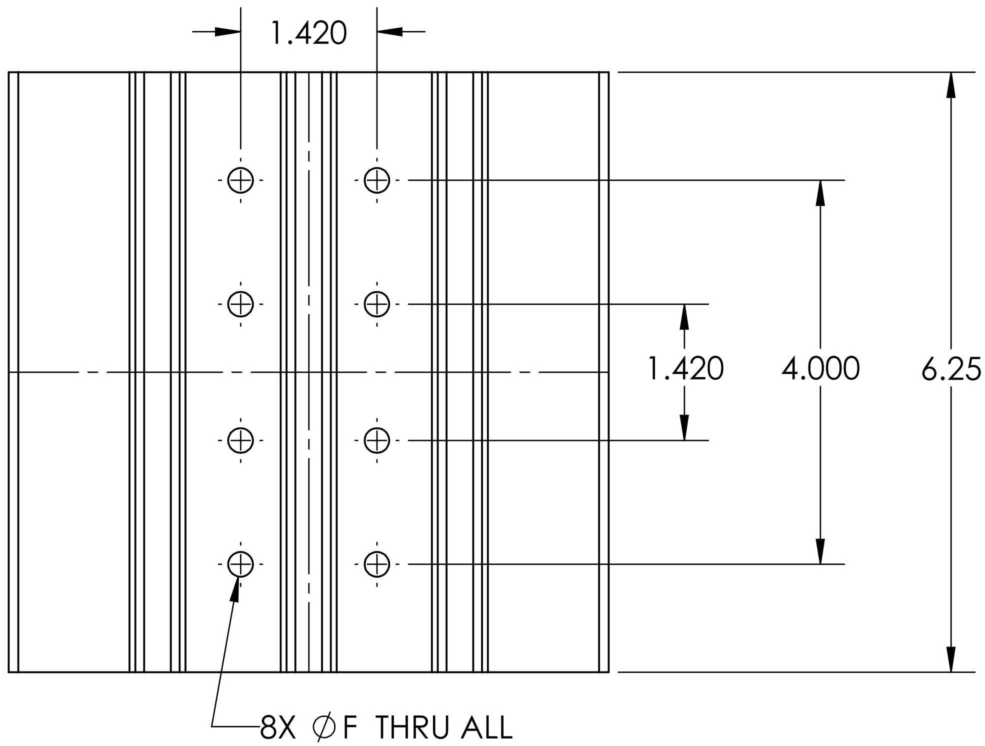
A | A

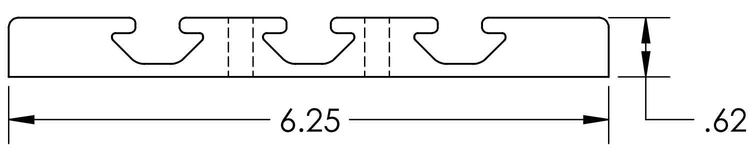
TITLE: Nose Support		
SCALE: 3:1	Plastic	SHEET 3 OF 7

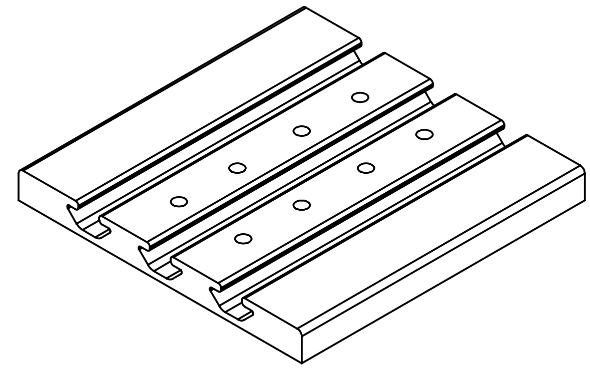
2 | 1



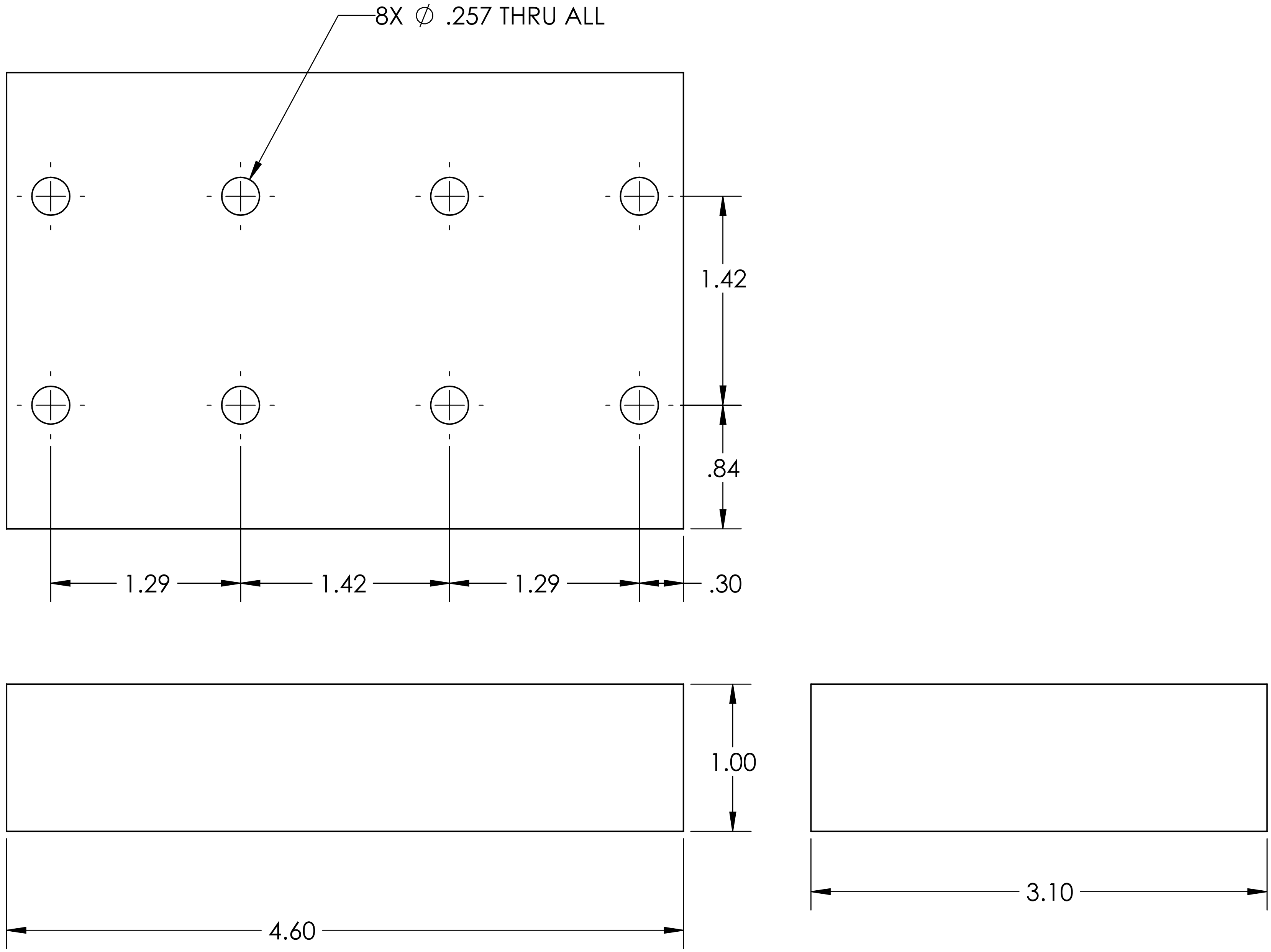
TITLE: Tail Support		
SCALE: 2:1	Plastic	SHEET 4 OF 7



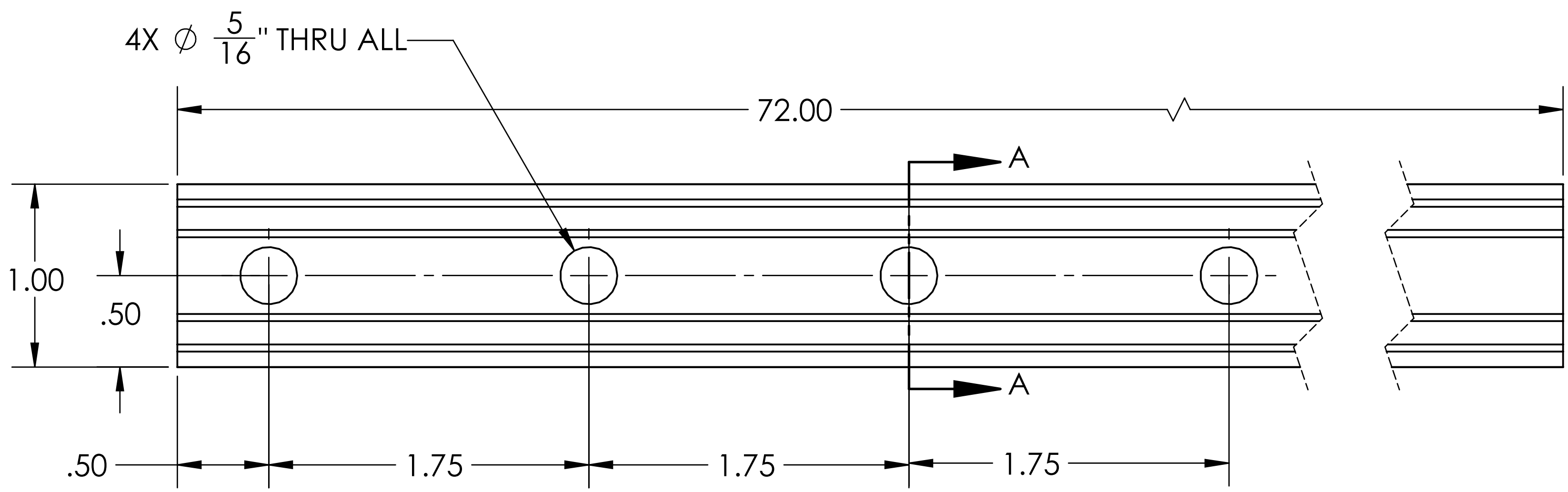


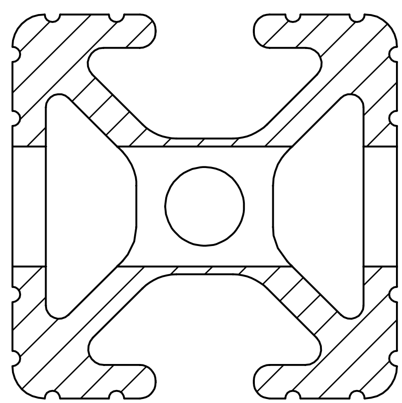


TITLE: Mounting Plate		
SCALE: 1:2	Aluminum	SHEET 5 OF 7



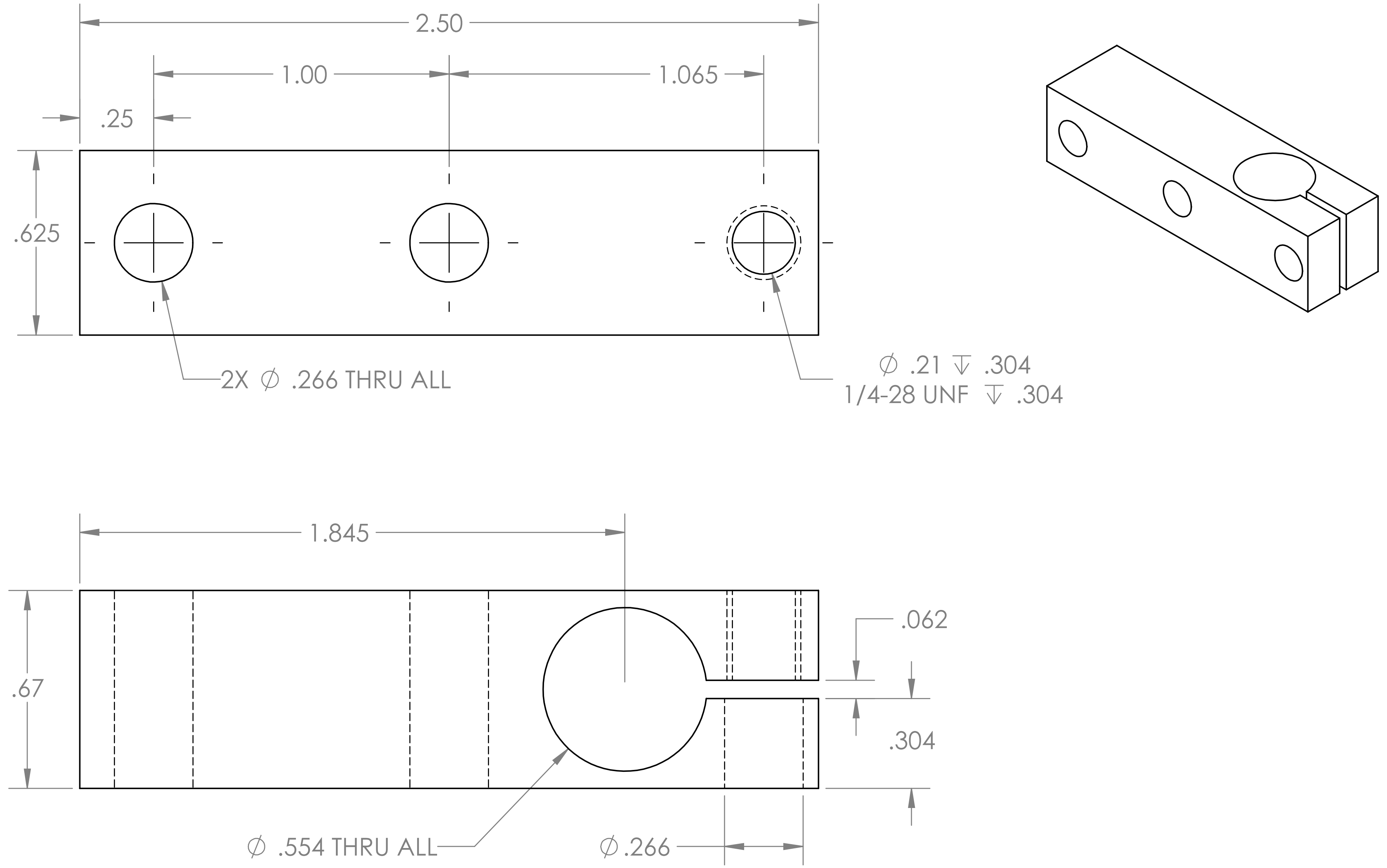
TITLE: Mounting Spacer		
SCALE: 1:1	Aluminum	SHEET 6 OF 7



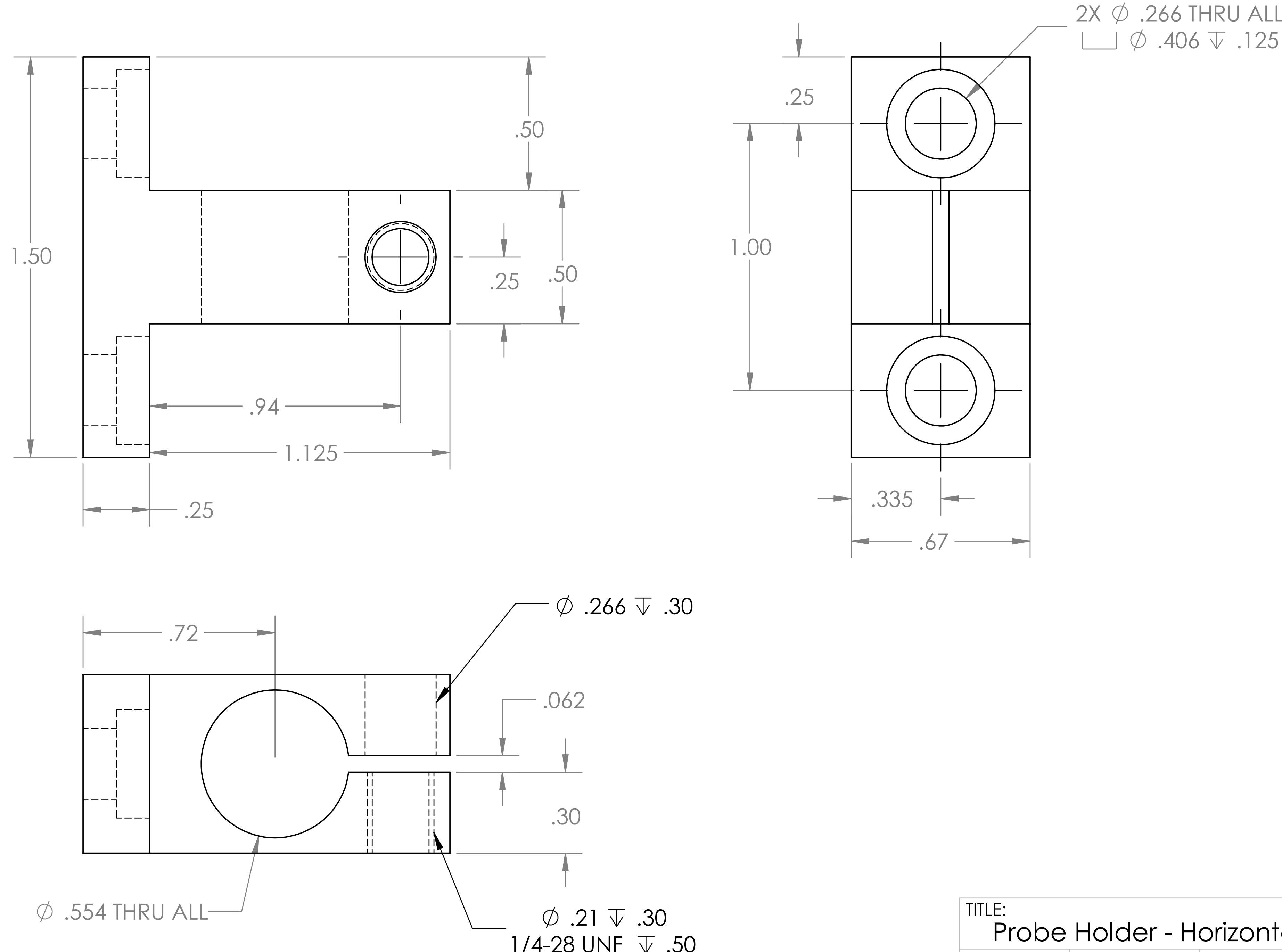


SECTION A-A
SCALE 2 : 1

TITLE: Support Rod		
SCALE: 1:1	Aluminum	SHEET 7 OF 7



TITLE: Probe Holder		
SCALE: 2:1	Aluminum	SHEET 1 OF 1



TITLE: Probe Holder - Horizontal		
SCALE: 2:1	Aluminum	SHEET 1 OF 1