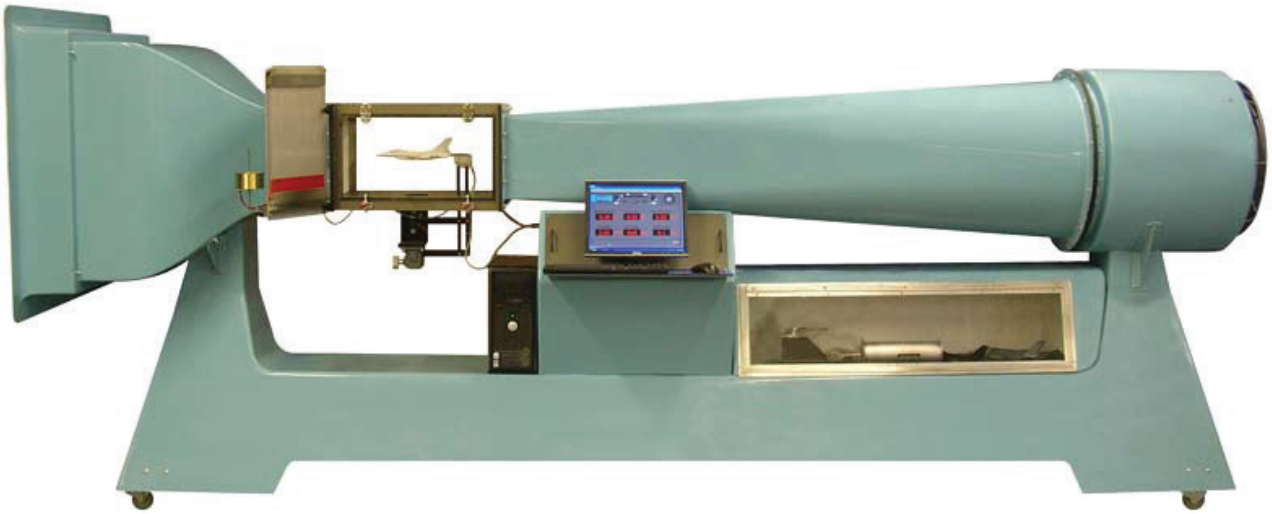
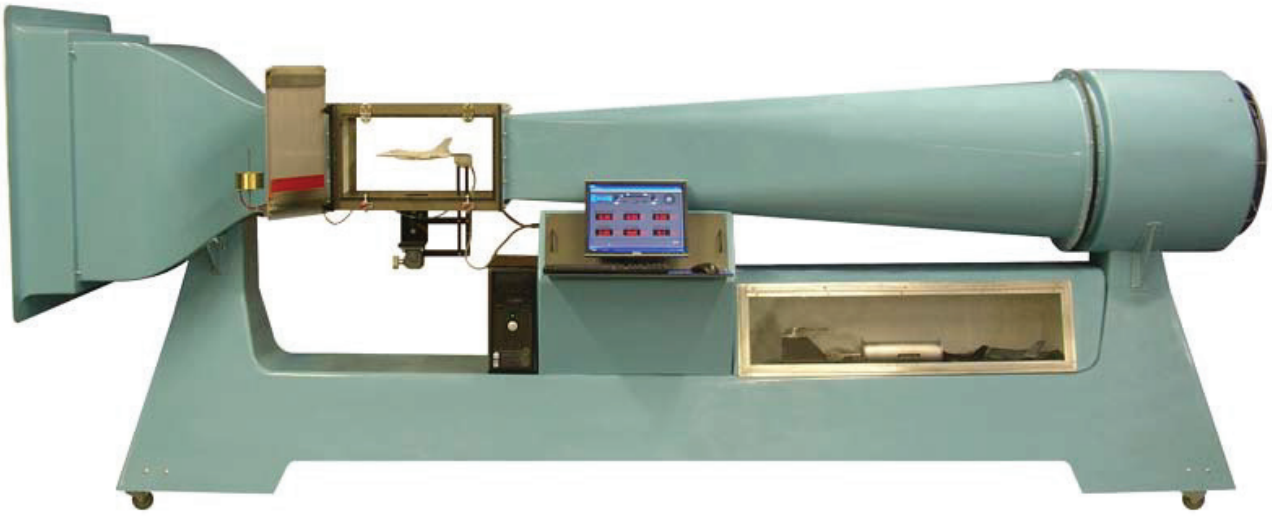


EDUCATIONAL WIND TUNNEL

V1

AEROLAB LLC
8291 Patuxent Range Road
Suite 1200
Jessup, MD 20794

Phone: 301.776.6585
Fax: 301.776.2892
contact@aerolab.com
www.aerolab.com



EDUCATIONAL WIND TUNNEL

Conceived in 1947 by AEROLAB founder A. Wiley Sherwood, the EWT is a wind tunnel system designed to meet the needs of educators and researchers alike.

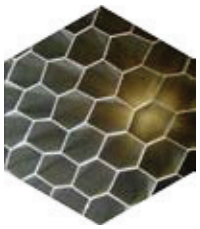
Lending itself well to budget-conscious users, the EWT can be configured to meet your specific requirements. For increased capability, features can be added as needed.

Flexibility and adaptability are essential qualities in our rapidly-changing, technologycentered world. The AERO-LAB Educational Wind Tunnel (EWT) System posseses both of these qualities. Aerodynamic principals do not change, but the tools we use to study and record them do. Although production of the first EWT started in 1947, the system has evolved in stride with advances in measurement and data technology. Because the EWT is based on a proven air duct design (from the proprietary inlet design through the user friendly test section and out the noise-attenuated exhaust) the current instrumentation and data acquisition system can easily update older existing EWT systems.

BASIC SPECIFICATIONS

- Test Section Dimensions: 12”x12”x24” (30.5cm x 30.5cm x 61cm)
- Airspeed Range: 10 mph (4.5 m/s) to 145 + mph (65 + m/s)
- Turbulence Level: less than 0.2%
- Length: 15 feet (4.6m)
- Width: 42 inches (1.1m)
- Height: 6 feet (1.8m)
- Weight: approximately 600 pounds (272 kg)
- Power: 10 hp (7.5 KW) electric motor
- Mobility: four industrial-grade steel casters w/ polyurethane wheels
- 230 or 460 VAC option

BUILD YOUR OWN SYSTEM STARTING WITH THE BASICS



Standard Features

Fiberglass Construction
- Accurately-formed
- Rugged and strong

Honeycomb Flow Straightener
- Aluminum
- 4-inch deep hexagonal cells
- Removable for cleaning

Turbulence-reducing Screens
- Two 20 x 20 (mesh) screens made of 0.009" (0.23mm) diameter stainless steel wire

Contraction (bell mouth) Contour
- Proprietary design used on all AEROLAB wind tunnels
- 9.5:1 contraction ratio

Static Pressure Ring
- Access to test section static pressure for non-intrusive q/V measurements
- Consists of four pressure ports – one on each wall just prior to test section entrance w/ manifold

Test Section
- Hard anodized aluminum structure
- Two top-hinged Acrylic side windows and one top window
- Integrated yaw table w/ engraved scale and prepared for optional model positioning system

Diffuser Design
- Increases wind tunnel efficiency and overall flow quality

Motor
- High-efficiency 10 hp (7.5 KW) electric motor

Fan/Propeller
- High-efficiency
- 9-blade
- Balanced

Noise Attenuator
- Reduces noise w/ 2 layers of acoustic insulation

Speed Controller
- Solid state Variable Frequency Drive (VFD)
- Accepts analog or digital remote control signals
- Built-in display is selectable for Hz, RPM, % power and Amps
- Adaptable to 208-240VAC, 380-480VAC and 50/60Hz

Excellent Flow Quality
- Less than 0.2% turbulence

Functionality
- Easy to use

Mobility
- Four high-quality steel casters with polyurethane wheels

OPTIONS

Complete EWT Systems include all of the following options. Budget-conscious users can select components as needed.

Data Acquisition, Display and Control System:

- National Instruments hardware and LabVIEW software
- Configurable to meet any need
- Capable of measuring, displaying and recording force/moment balance output and angle of attack
- Capable of controlling wind tunnel airspeed
- Dell desktop computer
- Contact AEROLAB for more details

3-Component "Sting" Force/Momentum Balance:

- Normal Force, Axial Force and Pitching Moment (easily reconfigurable for Side Force, Axial
- Force and Yawing Moment)
- 3/8" outside-diameter sting
- Designed specspecifically for the EWT Model Positioning System
- Adaptable to other model positioning systems
- Completely instrumented w/ strain gages, wired and ready

Model Positioning System:

- Designed specifically for the EWT to keep models centered regardless of pitch angle
- Manual pitch adjustment to +/- 30°
- Parallelogram vertical arms keep model centered regardless of pitch angle
- 3/8" "sting" to mount models
- Mounts to EWT test section yaw table for combined yaw/pitch capability

Drag Model Set:

- Five model set: teardrop, backward cup, sphere, forward cup and circular flat plate.
- Mounts to any 3/8" sting balance using one set screw
- Great for flow visualization and force measurements

Suggested Experiments (Sophomore)

- Compare effect of shape on Drag Force for objects with similar cross sectional area (teardrop excluded)
- Use smoke to visualize flow phenomenon

1:48th Scale F-16 Model:

- Mounts to any 3/8" sting balance using one set screw
- Strong, stiff and durable
- 11.5 inches (29.2cm) long with 7.5 inch (19cm) span

Suggested Experiments (Sophomore)

- Generate C_L, C_D, and C_M curves as a function of angle of attack (Aerolab Sting Balance and Model Positioning System required)
- Provide Visualization of flow using the Aerolab smoke generator or apply tufts for a low-cost
- Alternative observation

Suggested Experiments (Junior)

- Explore various flight characteristics including Vstall and Stability derivatives
- Learn the basics of tunnel corrections as applied to flight vehicles

Pressure Cylinder:

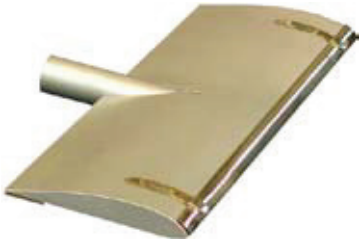
- Mounts vertically and spans the test section of the EWT
- 24 flush-mounted pressure taps along its circumference
- Manually-set angular position read from turntable scale
- Outside diameter of 4 inches (10.2cm)
- Supplied with all necessary tubing

Suggested Experiments (Sophomore)

- Demonstrate the pressure distribution over a cylinder
- Compare experimental results with theoretical prediction
- Investigate the loss of pressure in the separated region

Suggested Experiments (Junior)

- Explore the effects of trip-strip application



Wing with Slat and Flap:

- Clark Y-14 airfoil
- Adjustable slat and flaps
- Mounts to any 3/8" sting balance using one set screw
- Great for both flow visualization and force measurements
- 9.875 inch (25cm) span and 3.5 inch (9cm) chord
- Other NACA airfoil choices are optional – contact AEROLAB

Suggested Experiments (Sophomore)

- Observe the effects of slats and flaps on the "clean" Clark Y-14 C_l, C_d, and C_m curves

Suggested Experiments (Junior)

- Study the effects of slats and flaps on stability derivatives

Pressure Wing:

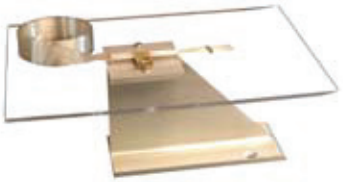
- Mounts vertically and spans the test section of the EWT
- 18 flush-mounted pressure taps around the Clark Y-14 airfoil
- Manually set angle of attack is read from turntable scale
- 3.5 inch (9cm) chord
- Supplied with all necessary tubing
- Other airfoil choices are optional – contact AEROLAB for more details

Suggested Experiments (Sophomore)

- Demonstrate the pressure distribution over an airfoil
- Investigate the loss of pressure in a stalled region
- Illustrate the effect of camber on lift

Suggested Experiments (Junior)

- Generate C_L, C_D, and C_M curves using C_P measurements (offers a practical introduction to numerical integration techniques)
- Predict performance parameters such as $C_{l=0}$, $C_{m=0}$ location, and $C_{l,max}$
- Explore the effect of trip strip application



Boundary Layer Plate and "Mouse":

- Convenient way to demonstrate and study boundary layers and boundary layer growth
- 10-tap total pressure probe ("mouse")
- Three Mouse locations along the length of the flat plate
- Pressure taps ascend at an angle to span the boundary layer

Suggested Experiments (Sophomore)

- Introduce the concept of boundary layer development
- Observe the phenomenon of boundary layer growth

Suggested Experiments (Junior)

- Calculate the expected boundary layer thickness and compare against experimental measurements

Wake "Rake":

- 18 total-pressure "taps"
- Mounts into EWT test section through turntable
- Ports span approx. 1.75 inches (4.4cm) and are 2.125 inches (5.4cm)in front of the 90° bend
- 10 inches long
- Supplied with all necessary tubing

Suggested Experiments (Junior)

- Determination of drag through wake study

Yaw Probe:

- Three pressure ports w/ 60° separation
- Overall length of 10.5 inches (26.7cm), outside diameter of 0.125 inches (32mm)
- Mounts easily in EWT test section window probe port
- Adjustable aluminum triangular base used for angular indication
- Supplied with ample tubing for connection to your choice of indicators

Suggested Experiments (Sophomore)

- Demonstrate the fundamental principles behind flow discovery using differential pressure measurements.
- Explore the difference between instrument and tunnel inclinations.

Suggested Experiments (Junior)

- Calibration and alignment of the yaw probe
- Implications of uncertainty in measurements
- Locate the angle of flow separation on a cylinder
- Investigate the tunnel angle variation.

Pilot Static Probe:

- Mounts easily in EWT test section window probe port
- Rounded tip total-pressure tap and 6 static ports
- Reaches 2.6 inches (6.6cm) forward of the bend and extends 13 inches (33cm) to the bend with an outside diameter of 0.125 inches (32mm)
- Supplied with ample tubing for connect to your choice of indicators

Suggested Experiments (Sophomore)

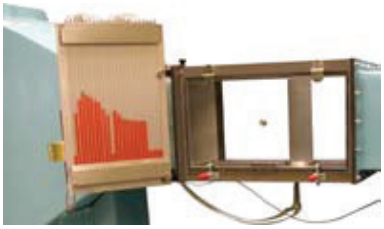
- Study "analog" airspeed measurement and probe design
- Effects of alignment

Turbulence Sphere:

- Highly polished
- 3.75" (10.2cm) diameter
- Equipped with a 3/8 inch sting mounting post
- Critical Reynolds number determination with balance data only - sphere has no pressure taps

Recommended Experiments (Junior)

- Measure wind tunnel turbulence level, study effect of size and Reynolds number



Multi-nanometer:

- 24-tube
- 0 – 14 inches (0 – 35cm) of water
- Reservoir and fluid included
- Easy-to-read inch scale
- Applicable to all AEROLAB models with pressure taps

Model Storage and Display Cabinet:

- Fiberglass construction
- Designed and molded to perfectly fit the EWT base
- Plexiglass top-hinged door
- Convenient storage for models, tools and CDs

Custom Options:

- Contact AEROLAB with your ideas!
- We'll be glad to write a quotation to meet your exact needs

ACCESSORIES

Not included in the complete EWT System

Smoke Generator:

- Produces thick, white smoke (vaporized white mineral oil)
- 110 VAC only
- *Not* included in complete EWT system

SUPPLEMENTAL INFORMATION

SUMMARY:

The information in this document provides an internal assessment of the performance quality of AEROLAB's Educational Wind Tunnel. Should any additional information be needed, please contact AEROLAB.

A Dantec Constant Temperature Anemometer was used to assess the flow uniformity and turbulence levels in AEROLAB's Educational Wind Tunnel. The results of the findings are presented below:

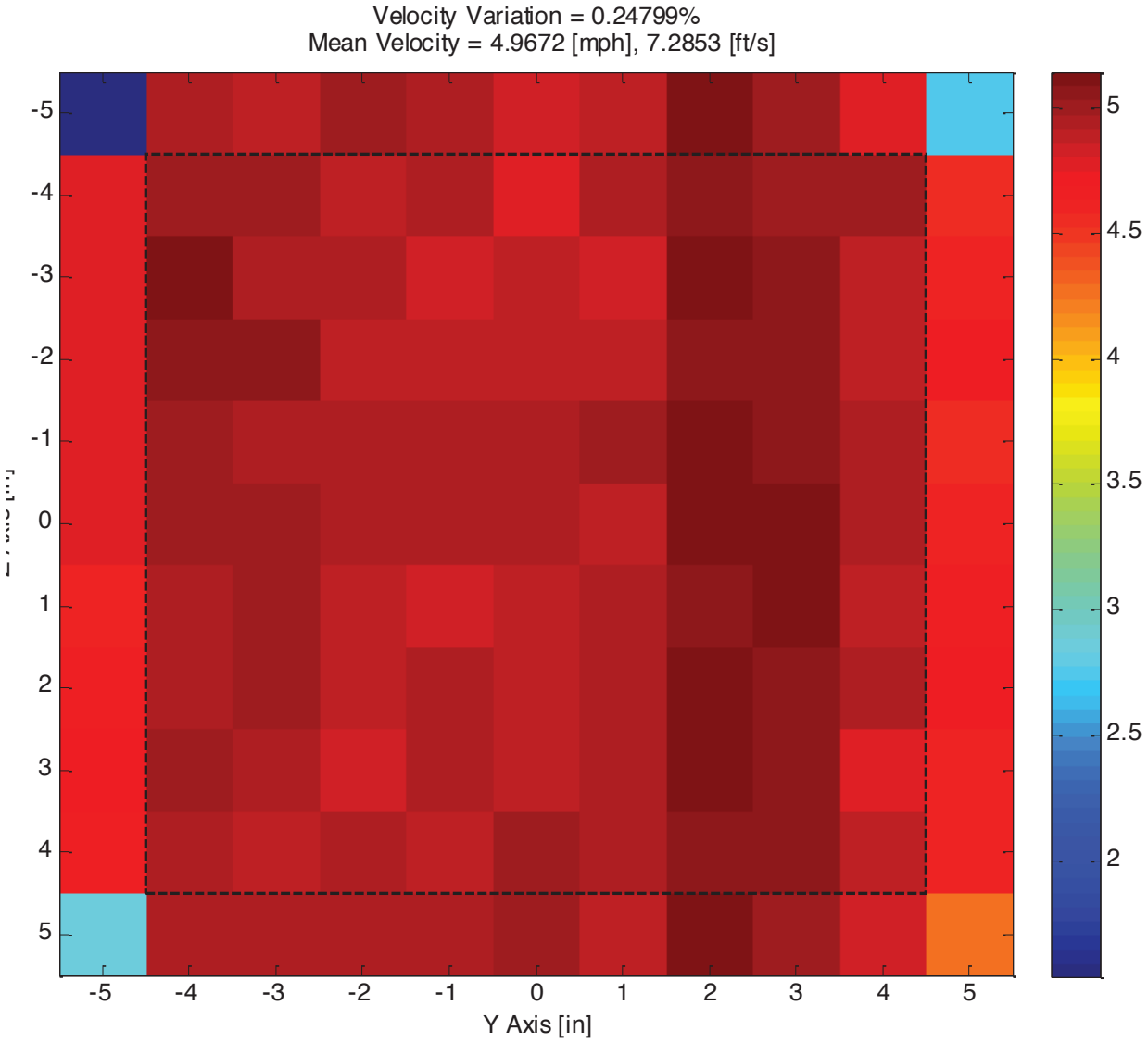


FIGURE 1: 12"x12" EWT Turbulence Intensity Test

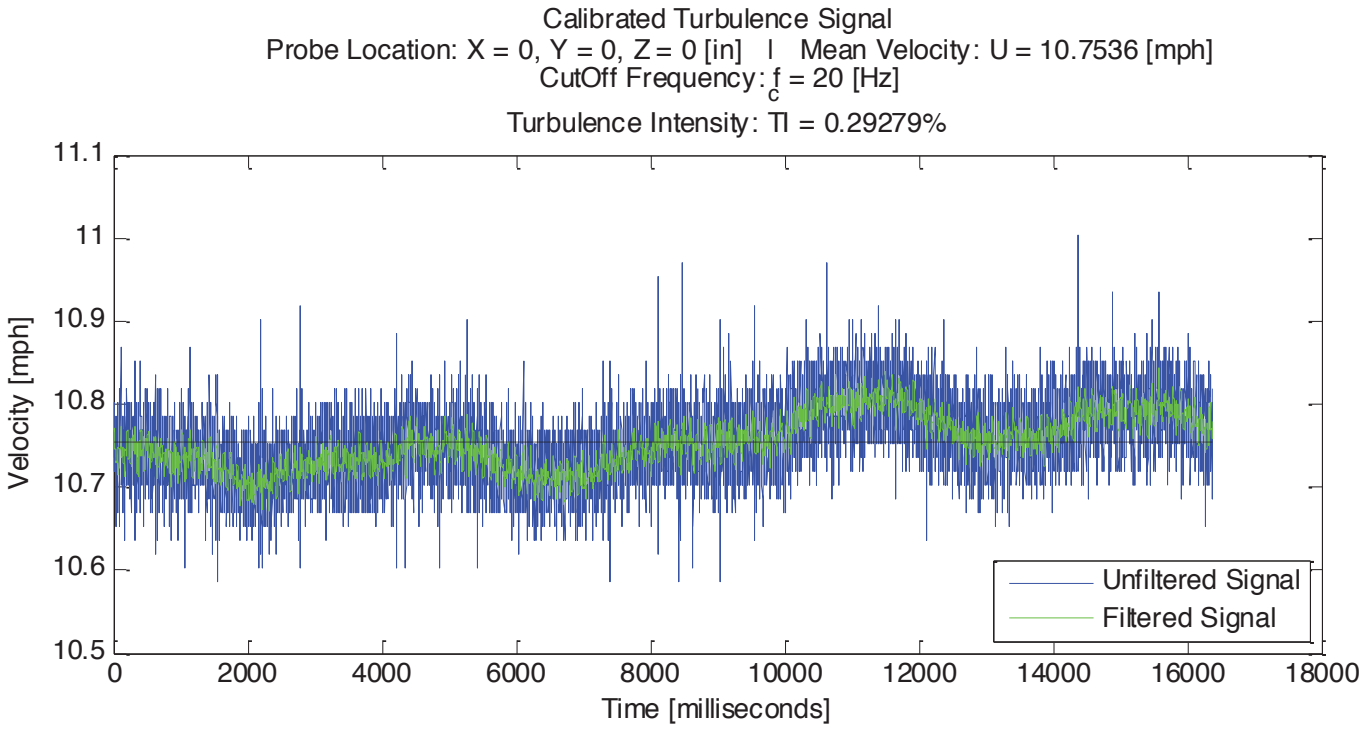


FIGURE 2: 12"x12" EWT Turbulence Intensity Test

TABLE 1: EWT Turbulence Intensity Results

Sampling Frequency	Dominant Frequency	Cut-Off Frequency	Sample Length	Turbulence Intensity	Mean Velocity	X	Y	Z
[Hz]	[Hz]	[Hz]	[Seconds]	[Percent]	[mph]	[In]	[In[	[In]
3000	1145	20	5.4613	21.351	-0.021	0	0	0
3000	1140	20	5.4613	0.346	1.945	0	0	0
3000	1141	20	5.4613	0.602	2.428	0	0	0
3000	1142	20	5.4613	0.383	2.809	0	0	0
3000	1143	20	5.4613	0.266	3.037	0	0	0
3000	1154	20	5.4613	0.851	3.389	0	0	0
3000	1159	20	5.4613	0.354	3.496	0	0	0
3000	1159	20	5.4613	0.506	4.11	0	0	0
3000	1162	20	5.4613	0.416	4.541	0	0	0
3000	1163	20	5.4613	0.485	5.298	0	0	0
3000	1163	20	5.4613	0.278	5.999	0	0	0
3000	1160	20	5.4613	0.591	7.032	0	0	0
3000	1162	20	5.4613	0.313	7.385	0	0	0
3000	1162	20	5.4613	0.439	8.738	0	0	0
3000	1163	20	5.4613	0.255	9.711	0	0	0
3000	1166	20	5.4613	0.293	10.754	0	0	0
3000	1167	20	5.4613	0.724	12.617	0	0	0
3000	1168	20	5.4613	0.213	14.246	0	0	0
3000	1171	20	5.4613	0.208	15.743	0	0	0
3000	1171	20	5.4613	0.224	18.075	0	0	0
3000	1174	20	5.4613	0.359	20.256	0	0	0
3000	1210	20	5.4613	8.008	-0.08	0	0	0

- The mean turbulence Intensity at 10 mph is proven to be about 0.29%.
- Calibration data from 1.945 – 20.256 [mph] the mean turbulence intensity is 0.405%.
- Turbulence Intensity: TI ≤ 0.5%, Cut-off Frequency ≤ 20Hz, (Velocity Range: 1.945 – 20.256 mph)
- Velocity Variation: Uvar ≤ 0.25%, Mean Velocity = 3.387 mph, (Within boundary layer, black dashed line)
- Controllable Wind Speed ± 0.5 mph (Velocity Range: 6 mph – 150 mph) Approximately

TUNNEL GEOMETRY

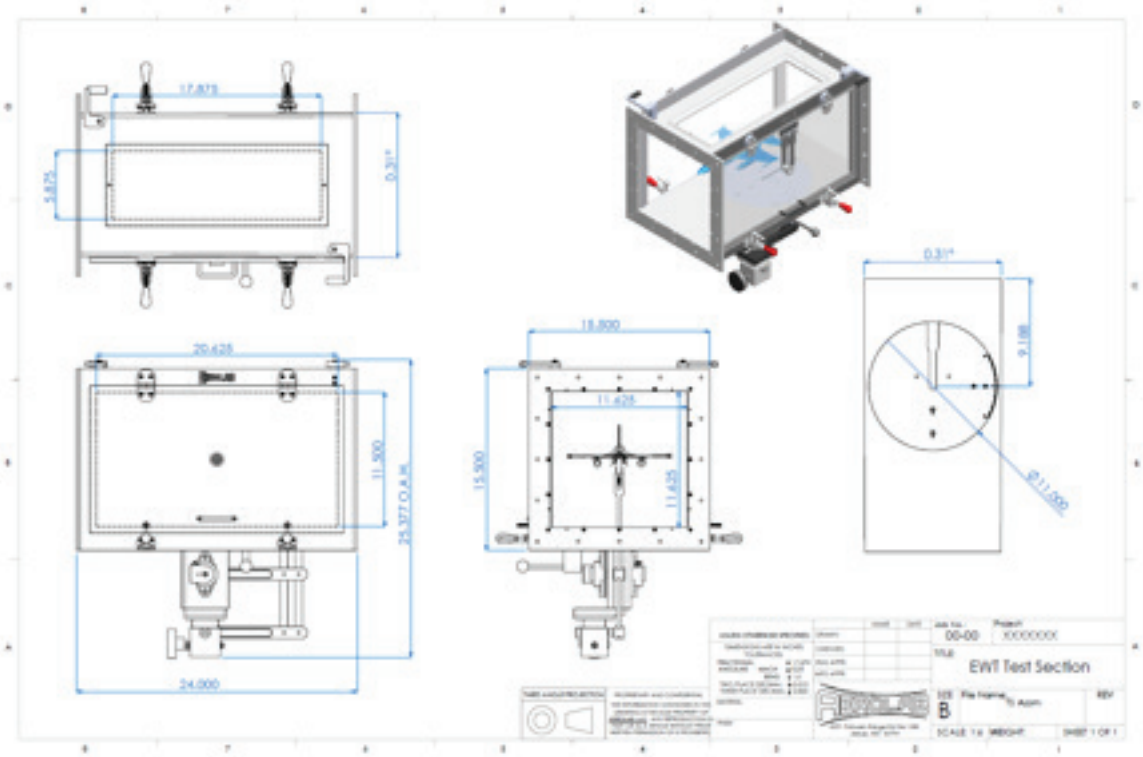


FIGURE 3: 12”x12” EWT Test Section

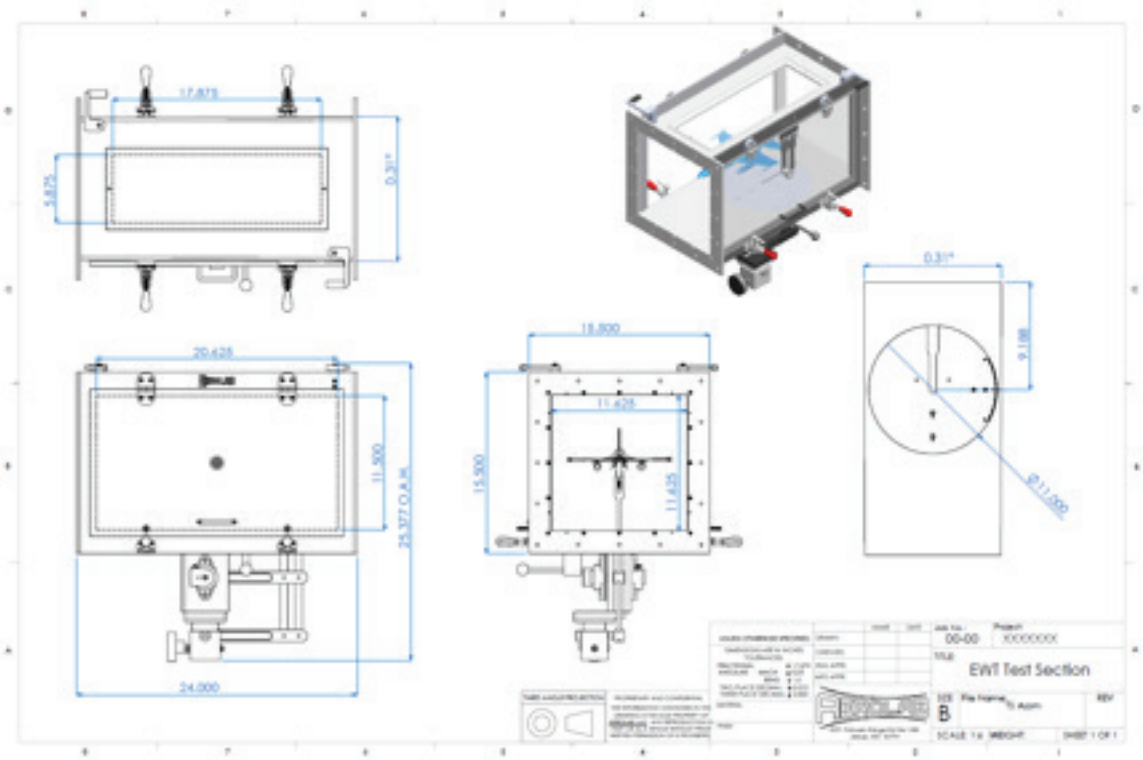


FIGURE 4: 12”x12” EWT Footprint

TUNNEL VELOCITY VS. RPM

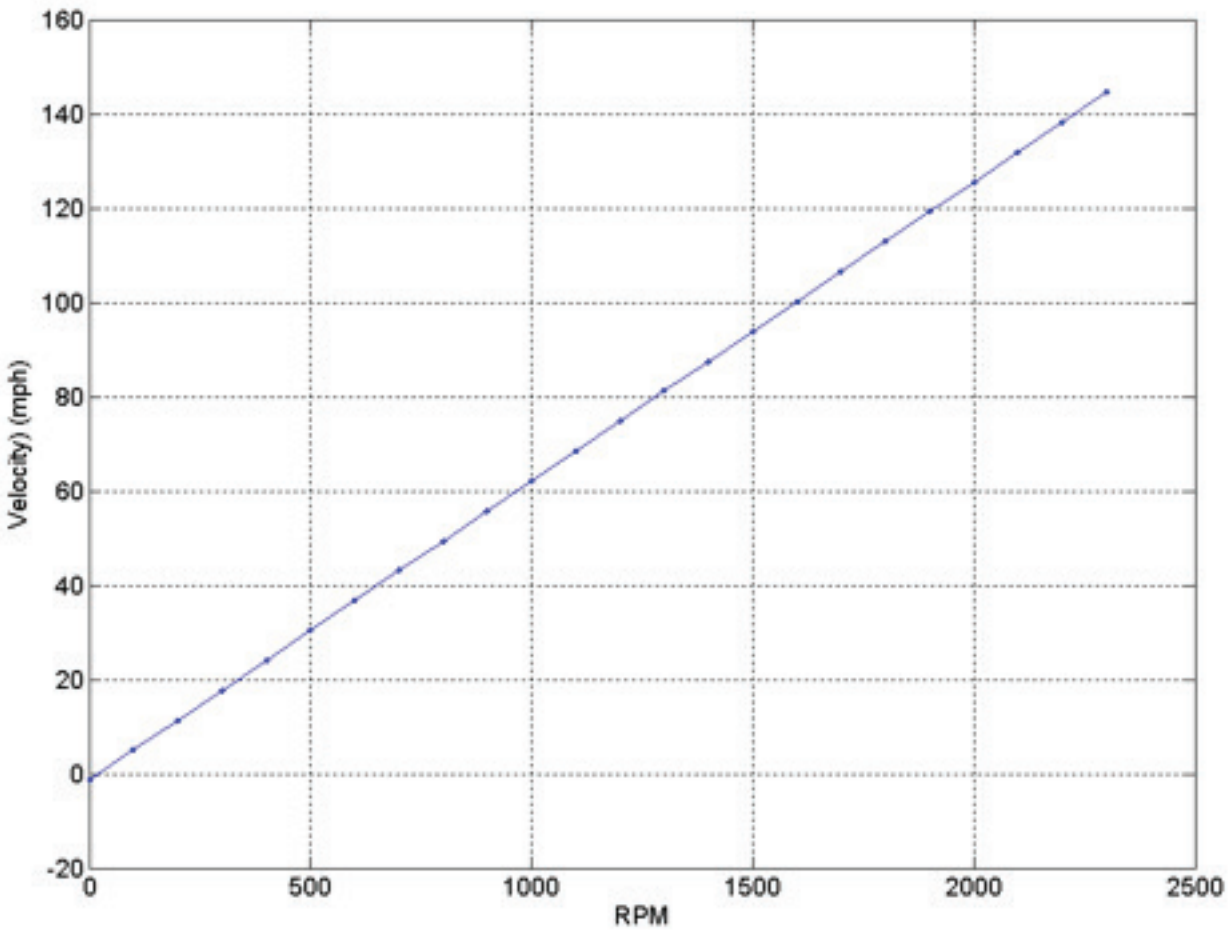


FIGURE 5: Test Section Velocity Versus RPM

The nominal RPM of the fan motor included with the tunnel is 1800 RPM. A 15 HP Variable Frequency Drive on the EWT can overdrive the 10 HP fan motor up to 2300 RPM safely. A study was conducted that demonstrates the increase in power with RPM. It is generally not recommended to run the motor at max RPM for extended periods of time in order to conserve motor life, however, permanent damage will not occur as long as the motor is not driven beyond the 1.15 service factor (11.5 HP).

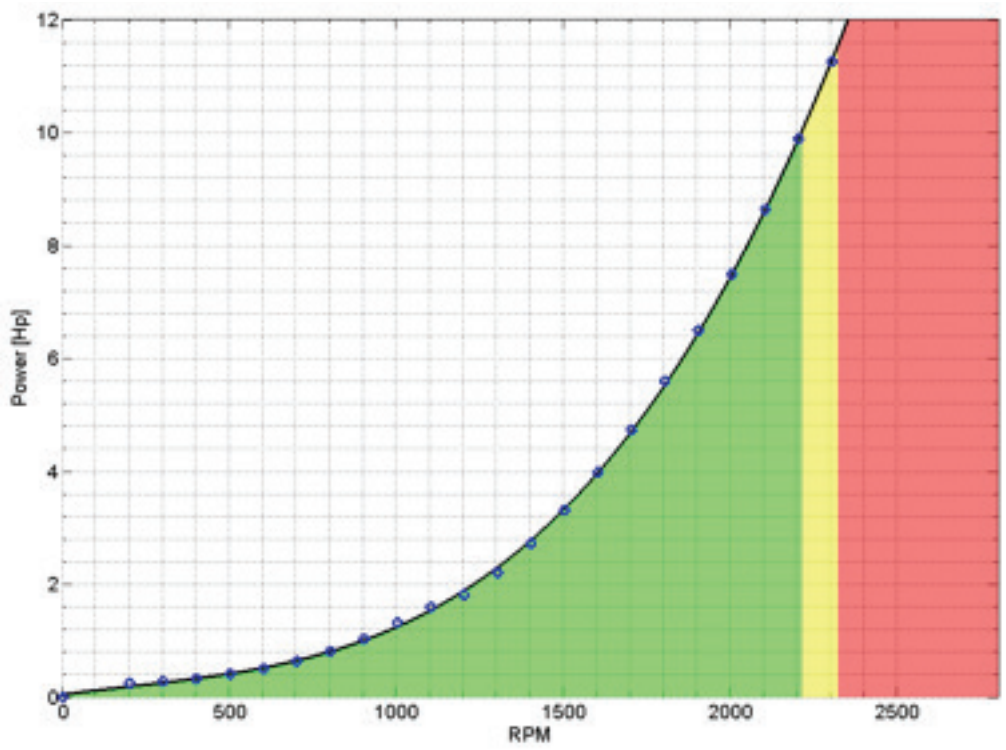


FIGURE 6: Power Versus RPM

EWT SOUND ANALYSIS

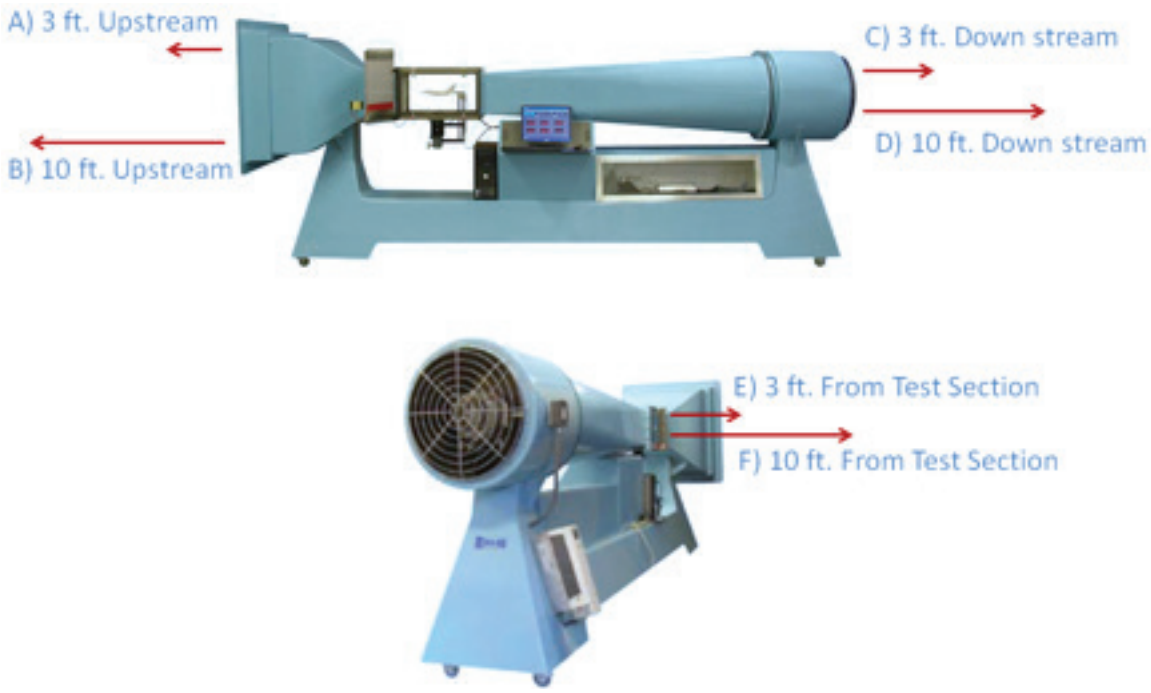


FIGURE 7: Sound Level Stations

TABLE 2: Sound Levels in Decibels (dB)

Station	80mph (36 m/s)	100mph (45 m/s)	120mph (54 m/s)	145mph (65 m/s)
A	68	76	80	87
B	67	72	76	82
C	67	77	82	85
D	64	75	80	82
E	67	70	74	78
F	66	69	73	77

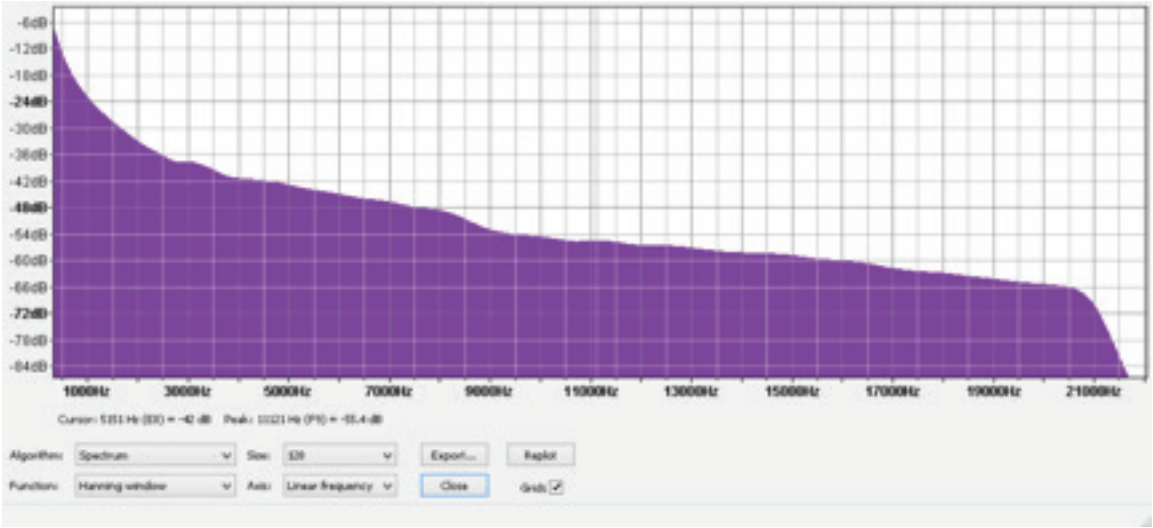


FIGURE 8: Sound Spectrum Analysis (VFD @ 60 Hz, Velocity=145 mph (65 m/s)