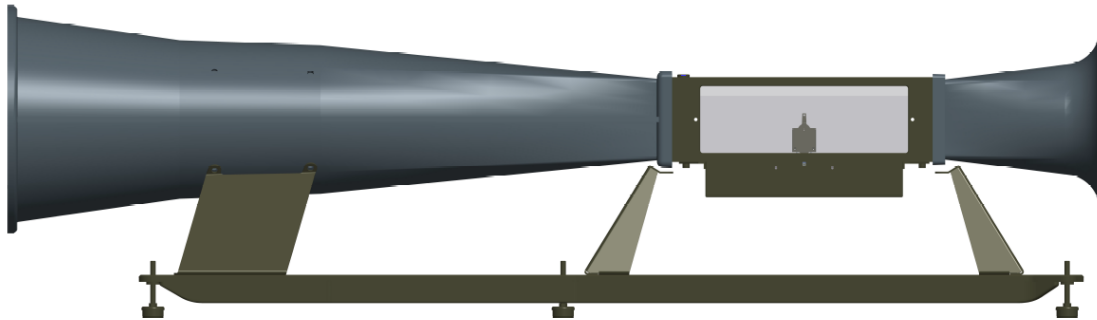




**INTERACTIVE
INSTRUMENTS**



Jet Stream 500

Instruction Manual

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Safety Guide

- **Follow the instructions** and be sure to follow all warnings on the equipment and in the manual for trouble free service.
- **Be sure that a supervisor is present** whenever the Jet Stream 500 is in operation. It is the responsibility of the supervisor to read and understand this manual before operating the equipment.
- **This product is supplied with a grounded power cord.** Be sure that you use a wall socket that conforms to this cord. Bypassing the ground for any reason may cause personal injury. When using an extension cord, be sure the cord is capable of handling the power requirements of the wind tunnel. The cord should not be any longer than required.
- **Everyone within the immediate area of the Jet Stream 500 must wear proper ear protection** before the instrument is started. The wind tunnel is capable of producing sounds in excess of **100 db** which may cause loss of hearing.
- **Before starting the Jet Stream 500, be sure that the room is secure of any objects** that may be blown around while the Jet Stream 500 is under operation. This includes papers, books, and small objects that may become airborne due to the exhaust wind.
- **It is the supervisor's responsibility to inspect the Jet Stream 500** to insure it is in proper working order and that none of the built-in safety features are bypassed before and during operation.
- **Be sure that the pitot tube is not bent or plugged before operating the Jet Stream 500.** If the pitot tube becomes blocked or damaged, the wind speed will not be under the proper control of the tunnel controller and the wind speed may increase until the error condition is displayed.
- **Do not bypass the fan's power cord.** Doing so *will* damage the wind tunnel as the propeller blade is not designed for full speed operation. Since the speed is controlled by the controller, the final speed is regulated to prevent full speed operation under normal use.
- **Turn off this product when not in use or during a lightning storm.** Unplug the wind tunnel from the wall to avoid damage due to lightning or when left unattended for long periods of time.
- **Do not attempt to service, repair or disassemble this product yourself** as removing covers may expose you to dangerous voltage or other hazards. *No* user serviceable parts are inside. Refer all servicing to Interactive Instruments, Inc.
- **Do not expose this unit to rain or moisture.** The wind tunnel must be used in a protected building to prevent shock hazards.
- **This product is intended for instructional use only.** It should not be used for the development of designs that could potentially injure humans.

Installation and Setup

Unpack the wind tunnel from the shipping container. Retain the packing material provided the unit must be returned to the factory at a later date. **Do not ship the unit in anything other than this container or damage to the tunnel will result.**

After unpacking everything, you will find a wind tunnel with the test bed, control panel, 9 pin data cable, USB cable, power cord, and manual. If you are missing any of these parts, please contact Interactive Instruments immediately.

To assemble the wind tunnel, place the tunnel on a flat stable, surface near a wall socket. Place the tunnel in a location at room temperature (70 - 80 degrees) and preferably out of direct sunlight. Be sure that the test bed is on the right hand side of the operator so the wind exhausts to the left. Place the control panel in front of the wind tunnel so it is accessible to the operator. Plug the 9 pin data cable into the rear of the test bed and also into the side of the control panel. Secure both ends with the cable screws supplied.

Plug the power cord into the rear of the control panel, but do not plug the power cord into the wall socket yet.

Inspect the wind tunnel for shipping damage. If any damage was caused in shipping, please contact Interactive Instruments immediately. Operating a damaged tunnel may result in additional damage to the tunnel or personal injury.

Be sure the intake and exhaust ports are free from obstruction. There should be no papers or shipping material in the test area or around the Jet Stream 500 during operation.

Level the wind tunnel using the 5 adjustable feet to eliminate measurement errors. If the tunnel is operated on an uneven surface, the lift and drag forces may be inaccurate. If the tunnel is not stable during operation, vibrations may also affect the results. To level the Jet Stream 500 properly, start by shortening all of the adjustable feet to the shortest position. Then look at the level above the test area and use this as a guide to make the remaining adjustments. If the bubble in the level is out of the center circle, adjustments will be necessary. If the bubble is closest to the motor (large end of the tunnel), lengthen the feet nearest the intake (small end) first. If the bubble level is closest to the intake, lengthen the feet under the motor. Be sure to adjust them in pairs. Next, adjust the feet side to side to place the bubble in the center of the level. Once the tunnel is level, be sure that all of the outside feet are touching the ground. This can be checked by placing paper under each foot and pulling on it to check the clearance. If a foot is not touching, adjust it so it is. Once the tunnel is level and stable, adjust the foot in the center of the tunnel base until it touches the floor. Check to see that the Jet Stream is stable by rocking the tunnel. If it is balanced properly, the tunnel will not rock.

Verify that the control panel's main power is off before plugging the control panel into a 110 volt, 50 or 60 Hz grounded wall outlet. Since the wind tunnel's fan motor may draw as much as 10 amps, be sure the wiring and circuit protection is rated at 15 amps or more. Do not bypass the ground pin on the power cord, this is needed for your safety.

Activate the wind tunnel by turning the Security key counterclockwise to unlock the controller.

Power up the unit by toggling the power switch located in the rear of the control panel. As the control panel is powering up, it should display the following messages on the LCD panel:

Testing System

If the display prompts

***** SYSTEM ERROR *****

This is due to the controller detecting an error in the system. Please refer to the **Error Condition** section of this manual for more information.

The control panel will default all values in English units (pounds and miles per hour). The controller can be configured to display the data in metric units (kilograms, kilometers per hour). See Menu for Select Units option.

Be sure that *everyone* in the immediate area is wearing proper ear protection as the Jet Stream 500 can produce noise levels in excess of **100 db**. **Continued use without proper ear protection can cause hearing loss.**

If everything is OK, press the ▲ (up arrow) or enter a wind speed number followed by ↵ (enter) key on the keypad to increase the wind speed. The fan should begin to run and the display will prompt with the actual wind speed. If there are any strange noises, turn off the control panel and call Interactive Instruments for further instructions.

Please review the remainder of this manual for useful information and testing details.

Overview

The Jet Stream 500 is a complete wind tunnel package, engineered to study basic aerodynamic principles of model aircraft wings, CO₂ cars along with other objects. The design is optimized to instruct students in junior high, middle school, high school and university level classes with a focus on ease of use. Since the wind tunnel is designed as a general instrument, the uses are limitless. From airfoil to automobile or even rocket research, the learning value goes a long way.

Easy to Operate

The tunnel is controlled with an easy to use control panel. Starting the tunnel is as easy as entering the desired air speed on the control panel. The graphical display is continuously updated to accurately reflect the system's wind velocity along with the forces generated on the test model. A one horse power electric motor with a 10" propeller is powerful enough to produce winds of 80 miles per hour in the test section. This is fast enough to test most any model. Instrumentation located in the test area also monitors lift and drag forces exerted on the test model so forces can be displayed in *real time* on the display panel. Precision strain gages mounted under the test bed accurately measure the forces on the model without having to attach them directly to the model. This allows for easy mounting and unmounting of the test model. The lift over drag (L/D) ratio is also computed and displayed on the display panel to demonstrate airfoil design efficiency.

Quality Design

The test area is free of turbulence due to following stringent wind tunnel design rules. By extending the length of the tunnel and using a special flow straightener, the Jet Stream 500 has virtually eliminated the test area turbulence, common in poorly designed tunnels. This allows the instrumentation to *precisely* measure the forces within the tunnel to less than 0.5%. Wind velocity is constantly monitored hundreds of times a second to maintain a steady flow over the test model. Using a pitot static tube connected to a differential pressure transducer, the wind velocity is electronically monitored and controlled. This provides a *constant* wind speed independent of the size or angle of the test model. The actual wind velocity is displayed on the control panel which allows studies to be conducted over a wide range of conditions.

Versatile

An easy to access 5.25" x 5.25" x 16" test chamber allows various models to be quickly mounted for testing. The test bed is easily removed from the tunnel for unrestricted access in mounting and un-mounting models. The test section is made of a clear plastic so the model can be viewed while under test. An angle of attack adjustment is available to adjust the airfoil +/- 30° with a resolution of 5° so the model can be tilted without remounting airfoil models. This allows the lift and drag forces to be measured at various angles and is very useful for demonstrating an airfoil's stall speed. CO₂ car designs can also be optimized for speed by measuring the models cross sectional drag at various wind velocities. With the drag force measured to 0.001 lbs., small design changes can be studied.

Self Contained

The tunnel also performs an automatic self test every time the unit is powered up. If an error is detected within the wind tunnel, the display informs the operator of the error condition and disables operation. The test also detects calibration and functional problems before allowing the tunnel to operate. The built-in force gages are *automatically* zeroed before each test to keep the display results in calibration, therefore the unit should *never* require recalibration.


Safety

The Jet Stream 500 is designed with safety in mind. The Jet Stream 500 is capable of automatically shutting down if it detects a problem.

Overall, the Jet Stream 500 is an invaluable tool when it comes to visually demonstrating basic to advanced aerodynamic principles to students.

Guide to the Jet Stream 500

Loading a test model:

To load a test model, be sure the wind tunnel is stopped by pressing the  (enter) key to return to 0 MPH. Then turn off the main power on the back of the control panel. Turn the two test bed fasteners under the test area counterclockwise 1/4 turn each to drop the test bed from the main wind tunnel. Be careful not to bend the pitot tube. Once the test bed is cleared from the tunnel, you may attach the test model to the angle of attack arm using the supplied T brackets. The best position to mount the model is in the center of the test area (away from the walls of the test area). If the model is close to a clear test wall, the wind effects will disrupt the results. Also, be sure the model is attached firmly or it may vibrate or come loose from the arm, damaging the flow straightener behind the test area. Once the model is in place, carefully reinsert the test bed back into the wind tunnel and lock in place by turning the two fasteners 1/4 turn clockwise. Once secured, verify that the model and test bed is properly aligned and locked in place before applying power to the tunnel.

Important Note: Be sure that while attaching the model you don't exert excessive force to the arm or damage will result to the sensitive sensors in the test bed. If a sensor is damaged, it must be returned to Interactive Instruments for repair.


Before starting a test:

- Verify that the wind tunnel is properly setup (*see Installation and Setup procedure*)
- Be sure the test model is firmly attached to the test arm
- Check to see that the test bed is inserted and locked into the test area
- Set the desired angle of attack by adjusting the knob under the test bed
- Make sure that everyone in the room is using proper ear protection
- Turn on the wind tunnel's main power

Starting a test:

It would be best to let the tunnel warm up after powering the unit for a few minutes before pressing the start button. This would allow the sensitive electronics to warm up and give more accurate results. If the tunnel is very cold (below 60 degrees F), be sure to let the tunnel warm up for at least 15 minutes (with the wind tunnel powered up but not operating) to allow time to reach calibration temperature. Since the tunnel is calibrated in room temperature between 70 to 80 degrees F, more accurate results will be obtained if operation is limited to room temperature. Operation outside of this range may give inaccurate wind speed and force measurements.

You are now ready to activate the wind tunnel:

Key in the desired wind speed value (in MPH or KPH) followed by  to activate the wind tunnel fan. With the fan running other wind speed values can be entered as well. The up/down keys will increase or decrease the wind speed in 5 MPH increments. You may also hold the up or down key down and the wind speed will ramp up or down.

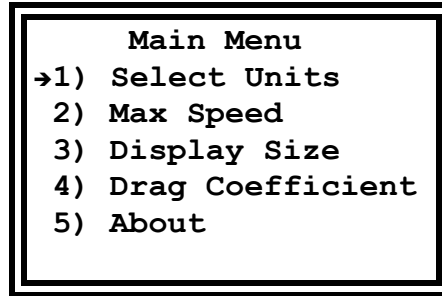
Note: Whenever the wind speed is set to 0 MPH, the lift and drag forces are automatically set to zero. This is to compensate for the weight of the model under test.


Adjusting the wind speed:

Various wind speeds can be set at any time by keying in a new speed on the keypad or use the ▲ or ▼ arrows to increase or decrease the wind speed in 5 mph increments. As the wind speed is adjusting to the new wind speed, the desired wind speed is displayed on the bottom of the LCD. Wind restrictions created by the test model will be compensated by the controller to maintain the desired wind speed even if the angle of the model is adjusted, altering the tunnel's internal wind resistance.

Options Menu:

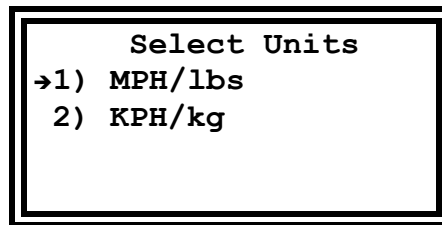
Pressing the Menu key displays a list of options as shown below



The menu options can be selected by entering a number on the keypad or by using the up/down arrows followed by . The main menu items enable the operator to select the display units, establish the maximum allowed wind speed, change the LCD character size, program a cross sectional area for Cd calculations or display the software rev. Pressing the menu key a second time will cancel the menu.

Select Units

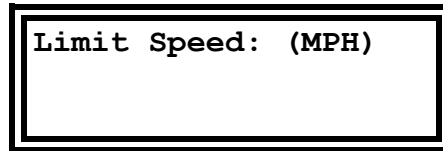
Pressing the 1 key in the main menu displays a menu to selection between English and Metric display units as shown below.



With MPH/lbs units selected, the lift and drag forces are displayed in pounds (lb) and the wind speed in miles per hour (MPH). Selecting metric units displays the lift and drag forces in kilograms (kg) and the wind speed in kilometers per hour (KPH). Since L/D is unit-less the units are not displayed. When the controller is powered up the display units default to English.

Max Speed

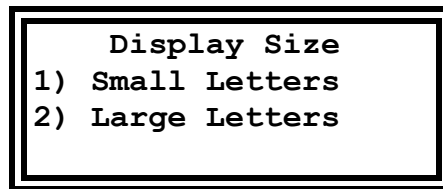
Pressing the 2 key in the main menu prompts for the maximum allowed wind speed as shown below. This option is useful to limit the tunnels capability. In some environments it is sometimes necessary to limit the speed for safety reasons or to minimize the noise level.



Enter a value between 10 and 80 MPH and any command larger than the max wind speed will be clamped to the max speed. To prevent a student from raising the max speed, the controller will not allow the max wind speed to be raised above a previously set value. When the controller is powered up it is automatically configured for a maximum allowed speed of 80 MPH.

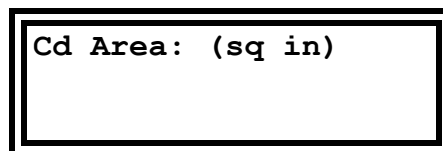
Display Size

Select between large and small letter display. The small letters display more information but the large letters can be useful for demonstrating results before a large group.



Drag Coefficient


You can enter the cross sectional area of your race car (in sq. inches or sq. cm) and the controller will calculate the cross sectional drag in real time on the LCD. Entering a value between 0.01 and 10 sq in (or 64 sq cm) will display the Cd with respect to the current wind speed. Setting the area back to zero will restore the L/D calculation.



Viewing the results:

The LCD panel will display the current wind speed in miles per hour (or kilometers per hour) along with the lift (both positive and negative), and drag forces exerted on the test model due to the wind. The lift over drag (L/D) of the test model is also calculated and displayed which is a common measurement in airplane wing designs. If the drag force is zero the L/D becomes infinite so the display prompts with the value "---.--". If the cross sectional area of an object is entered, the LCD will also prompt with the cross sectional drag coefficient (Cd) as well.

IMPORTANT:

If the test model should become loose or disconnect from the test bed during a test, quickly decrease the wind speed to 0 to shutdown the tunnel by pressing the  key. Once the wind speed has reached zero, you may remove and repair the test model. If the wind tunnel has been damaged, have the tunnel repaired by Interactive Instruments before continuing any further testing.

Analyzing the test results:

The wind speed is displayed on the LCD panel as a measured wind speed. The static pitot tube in the test area takes a sample of the active and passive air pressures and passes them to a sensor that estimates the wind speed. This speed is used for two reasons. One is to display the wind speed for your reference, and the second reason is for the controller to control the speed of the fan. Without the wind speed control, the controller would not be able to compensate for test variations and fluctuations in line voltage.


The Lift and Drag force calculations are measured with sensitive electronic sensors that are capable of measuring up to 1.8 lbs. The measurements are averaged to remove possible errors due to mechanical vibrations. As noted earlier, since the model exerts its own weight on the sensors, this force must be subtracted from the measured force when the wind speed is 0. The wind speed and drag force is also automatically zeroed at this time to automatically calibrate the electronics before every test. This is to insure accurate and consistent results on every test.

The L/D ratio is derived by dividing the lift force by the drag force. This measurement is an important parameter in the study of airplane wing design. As you can see, if the lift force is high and the drag force is low the model wing would be very good for gliders. Inversely, if the lift is low and has a large drag, it would be very poor in a glider design. The larger the L/D ratio the longer a glider can stay up. Varying the angle of attack or placing the wing into a stall condition will vary the L/D for a wing. The L/D ratio can be positive or negative depending on the direction of lift. If the lift force is in the positive direction (upward) the L/D ratio is positive, but if the lift is negative (downward) the L/D ratio will also be negative.

Adjusting the Angle of Attack:

The angle of attack can also be adjusted either before starting a test or while a test is underway. To adjust the angle, wind speed should be zero before making the adjustment. If adjustments are made with forces exerted on the model, the adjustment knob may not operate properly. Be sure the wind speed is 0 before adjusting. The test arm may be adjusted +/- 30° by turning the adjustment knob in front of the test bed. To make the adjustment, gently push the knob in to align with the test bed and rotate the knob to the desired angle. Lift and drag forces are directly affected by the angle of attack adjustment. This is an excellent tool to demonstrate the effects of stall velocity and stall angle by adjusting the angle until stall occurs.

Stopping a test:

Pressing the  key will return the wind speed to 0 MPH. Once the wind speed has returned to zero, the test bed may be removed to substitute test models. If the tunnel is not to be used for extended periods of time or the supervisor is leaving the room, be sure to turn off the tunnel's main power to prevent unsupervised operation of the tunnel. As the wind tunnel is capable of strong wind speeds, a supervisor must be present during operation to prevent injury.

Error Conditions:

If during a test the wind tunnel detects an error condition, the fan will automatically be turned off and the display will prompt with the error. The following table explains each error condition:

"SYSTEM ERROR"

When the microprocessor detects a problem during power up, this message is displayed. If this problem occurs, power down and back up to see if the problem re-occurs. If the problem persists, call Interactive Instruments.

"Wind Sensor Error"

"Drag Sensor Error"

"Lift Sensor Error"

One of these messages is displayed if the microprocessor detects a problem with an internal sensor. This may be due to the test bed not being properly secured to the test area or the pitot or fan intake being blocked. Also verify the wind tunnel power and data cable are properly plugged into the rear of the control panel. Check for these possible problems before calling Interactive Instruments.

"Cable Disconnected"

If the tunnel's data 9 pin cable becomes disconnected from the control panel, this message will be displayed until the cable is reconnected between the control panel and the test bed. Be sure to only use the DB9 cable supplied by Interactive Instruments.

"Wind Speed Error"

If the controller can't properly control the wind speed, the wind tunnel is disabled and this message is displayed. This error is typically caused by the fan power cord being unplugged from the controller or something blocking the air flow to the pitot static tube. Check for these conditions before calling Interactive Instruments.

"USB Disconnected"

If the USB cable is disconnected at either end, this message will be displayed momentarily. The wind tunnel will continue to operate properly but the computer program will not be able to control the wind tunnel.

Windows Control Program

The Jet Stream 500 can be controlled using a Windows An optional Microsoft Windows™ graphical computer interface is available which allows full functional control of the wind tunnel. The software is an easy to use Windows program with built-in help that will allow you to quickly master the features of the Jet Stream 500 (see **Figure #1** below). The lift and drag forces are displayed graphically in real time with respect to the wind velocity. Lift/Drag (L/D) and cross sectional drag Cd can also easily be displayed graphically to show the relative performance of aircraft wings and automobiles at various wind speeds. The graphical and tabular data can then be printed or stored to disk for further comparison.

Windows Control Program Screen

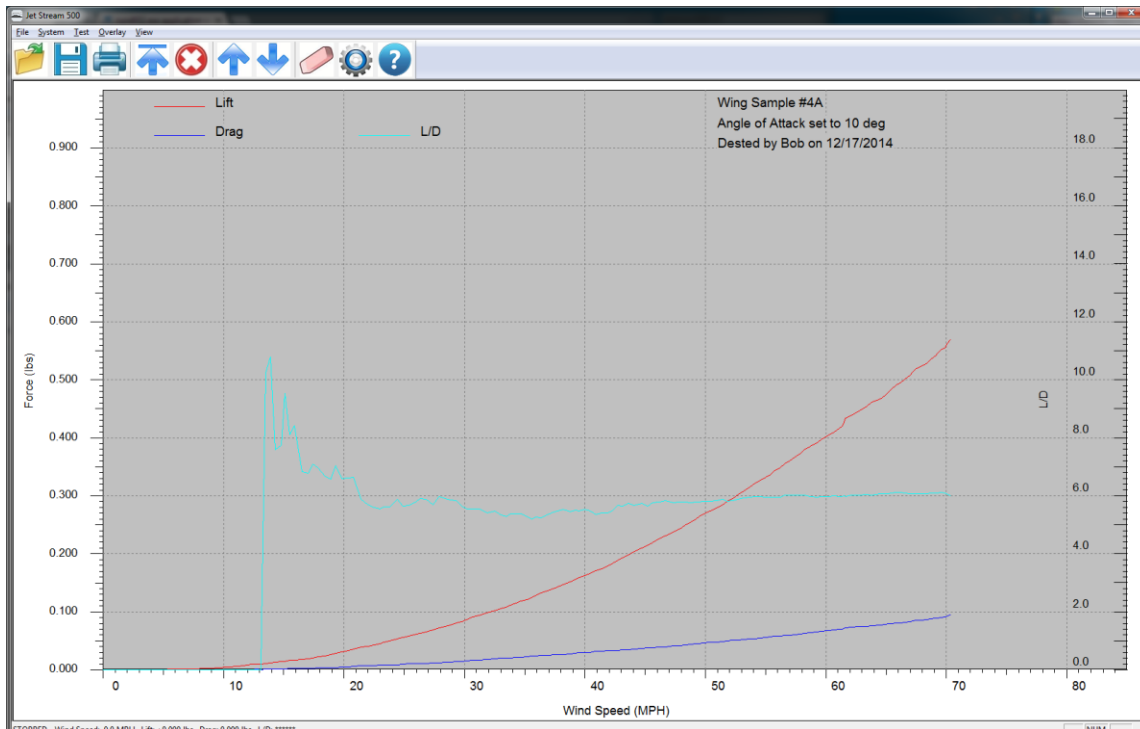


Figure #1

CO₂ Project car test platform

An optional test platform is available that would allow CO₂ project cars to be evaluated within the Jet Stream 500. With a car mounted in the tunnel, drag can be monitored at various wind speeds to improve model designs. Since the road effect on a car is significant it would be difficult to perform proper car drag tests without a road bed adaptor. The Road Bed Adaptor is designed so CO₂ cars are easily installed and removed without the need for tools.

Jet Stream 500 Specification

Wind Tunnel:	Rugged ABS Plastic construction for superior flow Total tunnel length of 6' 2" Dimensions derived from professional tunnel designs Computer generated design Maximum wind velocity of 80 MPH Safety guards before and after the propeller
Test Area:	Measures 5.25" - h, 5.25" - w, 16.0" - d Precision flow straightener before and after the test area for linear wind flow Clear unobstructed 3 sided viewing area with reflective bottom Measures both lift (+/-) and drag up to 1.8 lb. (0.001 lbs. resolution) Airfoil angle adjustment +/- 30° (5° resolution), without removing model Optional Test bed supports CO ₂ project cars
Fan Motor:	Industrial 1 HP, 110 volt ball bearing AC motor for long life 10.5" - 3 blade high speed nylon propeller Microprocessor controlled for constant wind speed
Instrumentation:	Lift and drag forces measured via precision strain gages (0.001 lb resolution) Wind speed measured and controlled via pitot tube (0.1 MPH resolution) Data is collected by a microprocessor with a 12 bit A/D converter Displays values in Metric or English units
Controls:	Control panel plugs into the tunnel for manual control Simple 16 key keypad controls wind speed and selects options Programmable Maximum wind speed limits Manually enter wind speed or ramp speed up or down Display constantly displays lift, drag, and wind speed in real time Lift/Drag (L/D) is also calculated and displayed in real time Cross sectional drag (Cd) calculated and displayed in real time
Electronics:	72 MHz, 32 bit ARM Microcontroller Multi-channel, 12 bit A/D converter USB Computer interface 128 X 64 pixel graphical LCD panel 0 - 1 PSI differential pressure transducer to measure and control the wind speed 0 - 1.8 lb. strain gages to measure the model's lift and drag Computer controlled solid state motor speed controller
Windows Software:	Easy to use Windows graphical interface with built-in help Graphically displays lift, drag, L/D, and Cd with respect to wind speed Overlay graphical test results for quick comparison Displays graphical results in Metric or English units Data can be imported to most spreadsheets for further analysis High resolution graphs can be printed on color printers Windows app allows for remote keypad access

Troubleshooting

LCD does not display information

- Check to see that the control panel fuse is not blown.
- Check to be sure the control panel is properly plugged in and turned on.

Calibration Error is displayed

- Be sure the test bed is properly secured.
- Check the pitot tube for blockage or damage.
- Make sure the wind tunnel intake or exhaust ports are not blocked.
- Verify that the model does not touch the walls of the test area.
- Check that the 9 pin data cable is plugged into the control panel, test bed, and secured.

Numbers are erratic

- Low wind speeds may give erratic L/D results. Wind speeds greater than 30 MPH are recommended for proper L/D measurements.
- Make sure the model is firmly attached to the test arm. Vibrations can cause erratic results.
- Large test models may cause excessive turbulence within the tunnel and cause the model to vibrate. Reduce the size of the model and re-test.
- Check to see that the wind tunnel is on a stable platform and all of the feet are properly adjusted.

System Error

- If a system error occurs, be sure that the test model does not weigh more than 1 lbs. Oversize models may place too much weight on the instrumentation. Remove the model and power up the tunnel to see if the model is causing the system error. If problems persist, call Interactive Instruments for further instructions.

Wind Speed not controllable

- Check the pitot tube for blockage or damage.
- Check that the 9 pin data cable is plugged into the control panel, test bed, and secured.

Tunnel Not Connected is displayed

- Check that the 9 pin data cable is plugged into the control panel, test bed, and secured.

Fan not running

- Be sure the fan power cord is properly plugged into the rear of the control panel.
- Check to see that the fan fuse is not blown.

Angle of Attack not adjustable

- Check that the wind speed is at zero MPH before making adjustments to the angle of attack.
- Be sure to press in on the adjustment knob to link the knob with the test area.

Circuit Breakers keep tripping

- Be sure the wind tunnel is plugged into an outlet capable of 15 amps or more.

Limited Warranty

Interactive Instruments, Inc. warrants the **Jet Stream 500** against defects in material and workmanship for a period of *one* year from receipt by the end user (*proof of purchase required*). If Interactive Instruments, Inc. receives notice of such defects during the warranty period, Interactive Instruments will either, at its option, repair or replace products which prove to be defective.

Should Interactive Instruments be unable to repair or replace the product within a reasonable amount of time, customer's alternative exclusive remedy shall be a refund of the purchased price upon return of the product.

If this product was purchased as part of a system in a coordinated shipment or as a system add-on, it is warranted against defects in material and workmanship during the same period as the system.

Exclusions

The above warranty shall not apply to defects resulting from:

improper or inadequate maintenance by customer; customer-supplied software or interfacing; unauthorized modification or misuse; operation outside of the environmental specifications for the product; or improper site preparation and maintenance.