AF100

Subsonic Wind Tunnel

User Guide

TecQuipment has taken care to make the contents of this manual accurate and up to date. However, if you find any errors, please let us know so we can rectify the problem.

TecQuipment supplies a Packing Contents List (PCL) with the equipment. Carefully check the contents of the package(s) against the list. If any items are missing or damaged, contact TecQuipment or the local agent.

AD/DB/bs/0710

Contents

AF100

Subsonic Wind Tunnel

User Guide

TecQuipment

Introduction

Compact Design

The AF100 Subsonic Wind Tunnel provides a compact and practical open circuit wind tunnel in which to study low speed aerodynamic effects.

Wide Range of Experiments

TecQuipment manufactures a comprehensive range of models and instruments to accompany the apparatus. This allows a wide variety of experiments and demonstrations to be conducted.

Figure 1 The AF100

This product works with VDAS®

In studies of aerodynamics, few engineers have access to full scale wind tunnels or actual airborne laboratories. Most rely on what is probably the most common tool for aerodynamic study; the laboratory based wind tunnel. This tool saves both money and time. It gives very accurate results, as long as the scale effect and reduced Reynolds numbers are taken into account.

The Wind Tunnel shown in Figure 1 is of the closed working section, open return suction type. It is supported on a tubular steel framework with lockable castors, this makes the apparatus very mobile.

Air enters the tunnel through an aerodynamically designed effuser (cone) that accelerates the air in a linear manner. It then enters the working section and passes through a grille before moving through a diffuser and then to the variable speed axial fan. The grille protects the fan from damage by loose objects. The air leaves the fan, passes through a silencer unit and then back out to atmosphere.

The speed of the axial fan (and therefore the air velocity in the working section) is controlled by an electronic drive control in the separate Control and Instrumentation unit. The Control and Instrumentation unit houses facilities for many of the optional ancilaries.

Working Section

The working section is of a square section with acrylic roof and floor. The sides are removable full length acrylic panels. The whole unit is supported in an aluminium framework. Each side panel has a special holder to support the optional wind tunnel models. On the top of the working section are holes for the two pitot devices and two wall tappings to measure the static pressure upstream and downstream of the working section.

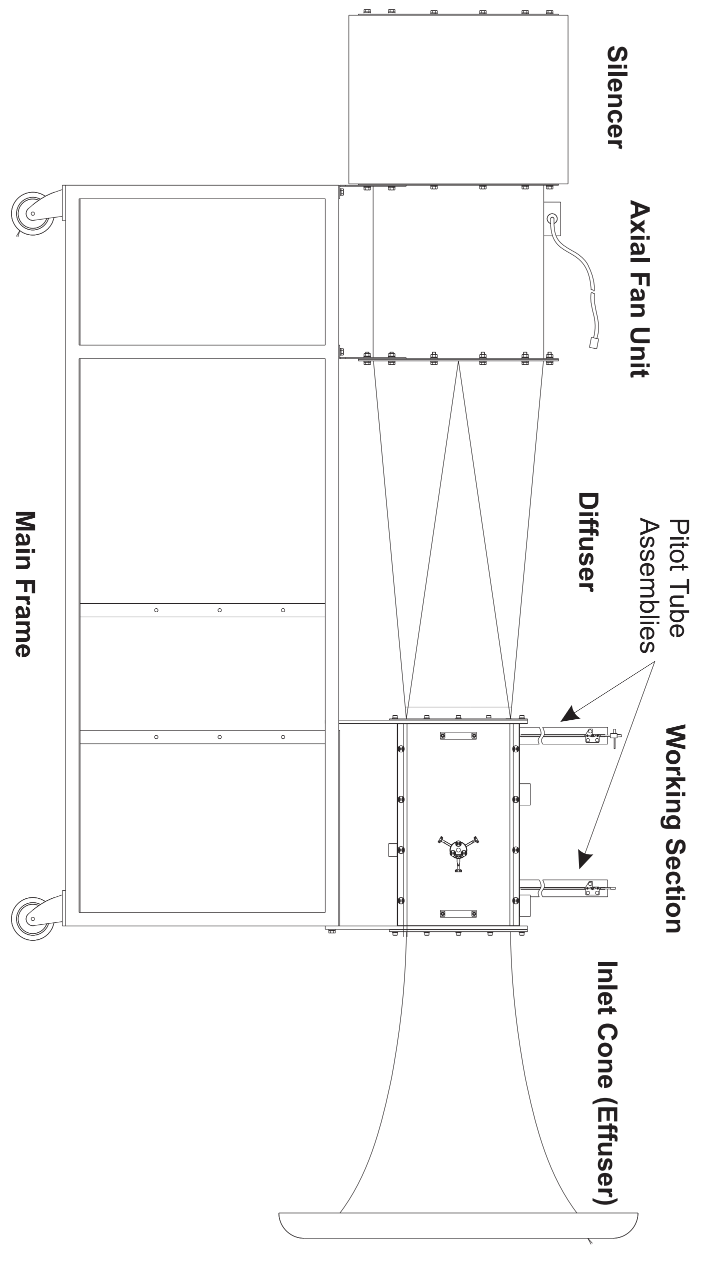

Figure 2 AF100 General Layout.

Associated Instruments and Models

TecQuipment manufactures and supplies an optional range of instruments and models to fit in the working section of the AF100 and other TecQuipment wind tunnels.

Refer to the System Diagram to see how the main units link together (see Figure 5).

VDAS®

This is TecQuipment's Versatile Data Acquisition System for use with several TecQuipment products. It is in two parts:

1. The VDAS-F Hardware

Figure 3 VDAS-F Hardware

This instrument collects data from the optional instruments for transfer to a computer (not supplied). It fits into the Control and Instrumentation Frame of the Wind Tunnel.

2. The VDAS® Software

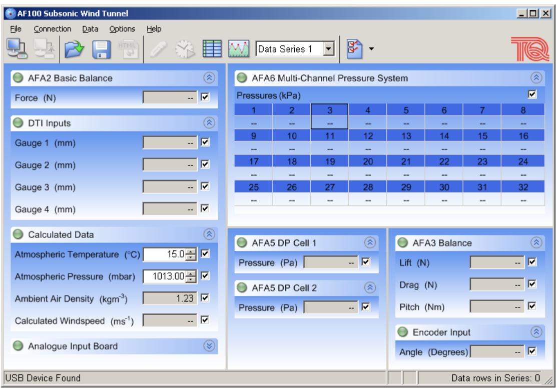

Figure 4 A Typical VDAS® Experiment Window

This must be installed on a suitable computer (not supplied) to process, log and display the information from the VDAS® hardware.

AFA1 Multi-tube Manometer

A 36 tube tilting manometer with a maximum rating of 600 mm water.

AFA2 Basic Balance

This is a basic balance with a single load cell. It may be fitted to the side of the Wind Tunnel working section and set to measure drag force or lift. It may be fitted underneath the working section to measure the drag forces on model cars and similar models. The balance is supplied with a display unit for a direct display of the force measured by the load cell on the balance. The display unit may also be connected to TecQuipment's VDAS®.

AFA3 Three Component Balance

This instrument is specially developed for use with Wind Tunnels AF100 and AF200, but may be used with other suitable wind tunnels.

The Balance mounts on the side of the working section and holds models with a 12 mm mounting stem. The model is held inside the working section. The balance connects to a separate display unit and measures the forces applied to the model during experiments. The display unit may be connected to the VDAS®.

The AFA3 measures:

- Drag Force (Newtons)
- Lift Force (Newtons)
- Pitching Moment (Newton metres)

AFA4 Angle Feedback

This instrument is used with the AFA3 Three Component Balance and VDAS®. It fits to the AFA3 and transmits the angle of the model to VDAS®.

AFA5 Differential Pressure Transducer

A Differential Pressure Transducer for use with the Pitot Traverse Mechanism. It includes an integral display of differential pressure and may be connected to VDAS®. The main section of the AF100 Control and Instrumentation Frame includes slots for up to two AFA5 units.

AFA6 32-Way Pressure Display System

This instrument allows the simultaneous measurement of 32 pressures. Readings may be shown in groups of 4 at any time by means of the integral display. The AFA6 may be connected to the VDAS® to show all readings in real time and log results.

AFA7 Pitot Traverse Mechanism

A single axis 300 mm Pitot-static traverse mechanism with a digital displacement indicator. It connects to the VDAS® for display of the position of the Pitot-static probe position. The pressure tapping may be connected to the manometer included with the AF100 or to the AFA5 or AFA6 units for electronic display and to link with the VDAS®.

AFA10 Smoke Generator

TecQuipment supply an optional smoke generator for flow visualisation.

WARNING ***Read the manufacturer's instructions before using the smoke generator***

AF100 Models (available separately)

A set of shapes and devices for use in the working section of the AF100. The Model set includes:

Aerofoils

Aerofoils of NACA 0012 symmetrical section, one with 150 mm span and one with 300 mm span. These aerofoils may also be mounted on the optional balance units AFA2 and AFA3.

Aerofoil with Flap

This aerofoil of NACA 2412 unsymmetrical section has a chord of 152 mm and a span of 300 mm. It is intended for balance mounting and is fitted with a flap, the incidence of which may be varied from +90 degrees to -90 degrees.

Cylinder Model with Pressure Tapping

A cylinder with a single pressure tapping at mid-span. The pressure distribution around the periphery of the cylinder may be obtained by use of the protractor and manometer supplied with the AF100. This model may also be mounted on the optional balance units AFA2 and AFA3 to measure drag.

Flat Plate

This plate has a diameter of approximately 100 mm and mounts on either of the two balance units AFA2 and AFA3. A separate dummy section arm is provided. This attaches to the side of the working section opposite the balance, so that the drag of the mounting may be distinguished from the drag of the flat plate itself.

Aerofoil with Pressure Tappings

A NACA 0012 aerofoil of 300 mm span and 150 mm chord, complete with 20 pressure tappings. This aerofoil demonstrates the pressure distribution around an aerofoil section.

Flat Boundary Layer Model

Illustrates boundary layer development and separation.

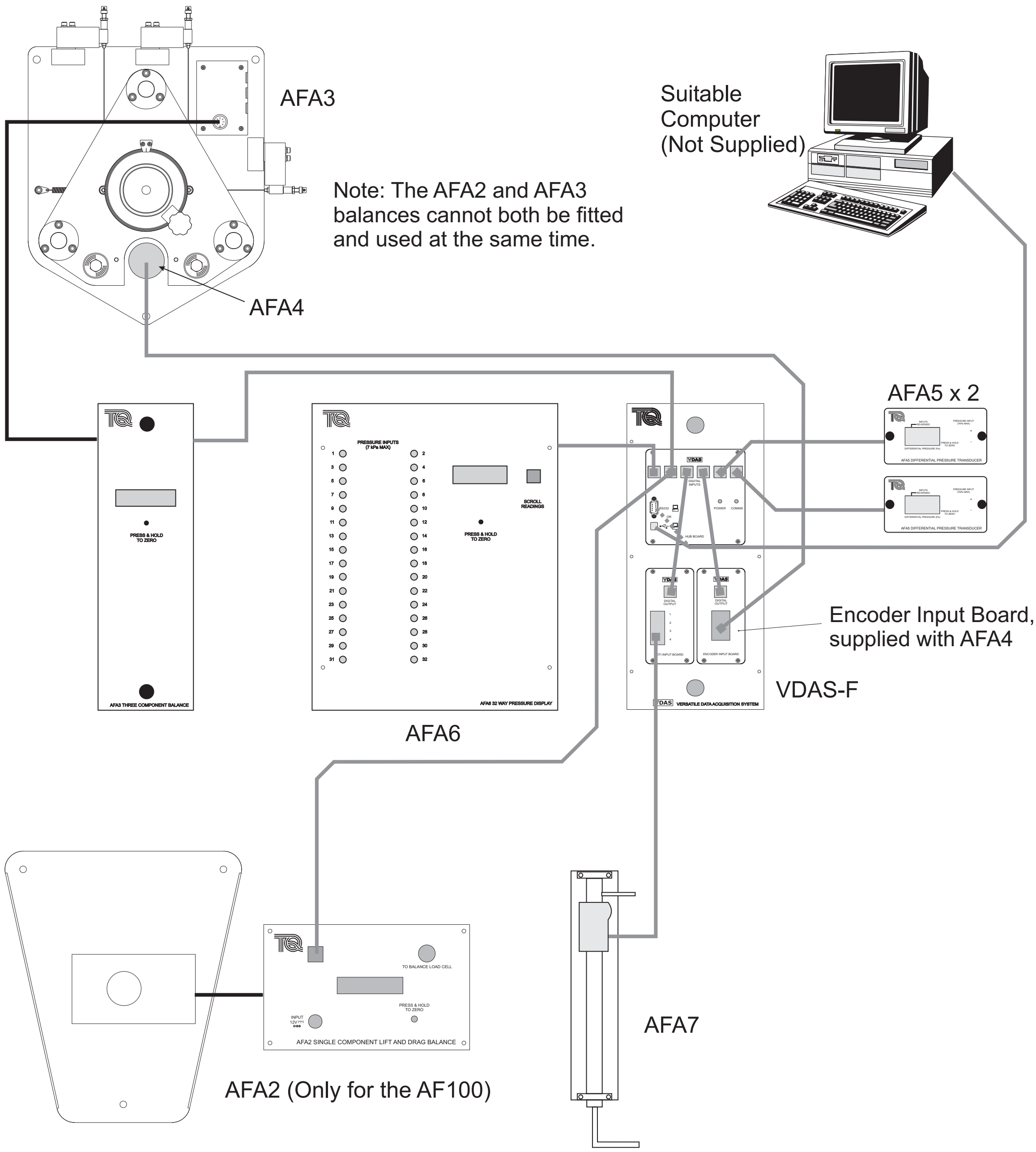

Figure 5 System Diagram

Controls and Instrumentation

The Control and Instrumentation Frame

Figure 6 The AF100 Control and Instrumentation Frame

The Control and Instrumentation Frame contains:

- The main electrical isolator for the apparatus
- The motor drive control
- The switchgear and circuit protection for the motor drive
- Two sets of electrical sockets for additional equipment (to the rear of the unit)
- A support frame for additional equipment/instruments

The Control and Instrumentation Frame is free standing, but must be close to the Wind Tunnel, because a power cable and manometer pipes connect between the two. For convenience the Frame is easier to use when it is mounted on a large table.

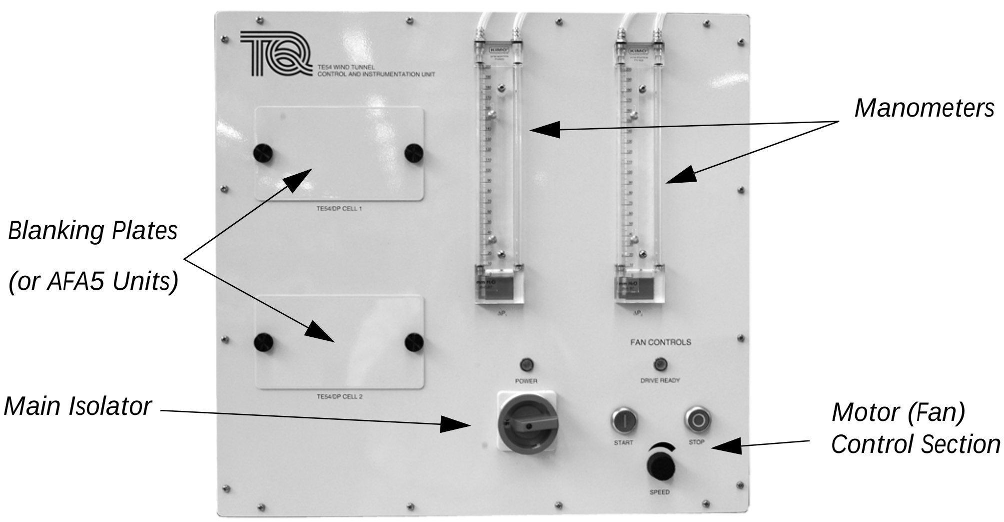

Figure 7 Control and Instrumentation Frame - Main Section

The Main Section

This section has all the control for the variable speed motor (fan). Lights show when the power to the unit is switched on and when the motor drive unit is ready.

At the side of the main section is the socket for connection to the fan of the wind tunnel.

Manometers

The two manometers connect to the two pitot tube assemblies on the working section of the wind tunnel.

Electrical Outlets

To the back of the main section are two rows of electrical sockets. These are for the optional additional equipment and instruments. The power to these sockets is disconnected when the isolator on the front of the unit is switched off.

Additional Instruments

Many of the optional additional instruments hook onto the frame, except for the AFA5, which normally locates in the main section (the main section can hold two AFA5 units). The main section is supplied with two removable blank fitted that must be removed before the AFA5 unit (or units) are fitted. The main section provides the power conections for two AFA5 units, these connections are reached from behind the main section.

Protractor

The apparatus is supplied with a protractor which fits onto the model holders of the working section. This device is used to set the angle of the models.

Pitot Devices

Two different pitot tube units are supplied with the wind tunnel. They both mount on the top of the working section (one or both must be removed for some experiments). Both units have a traverse mechanism, so that they may measure the air pressures across the working section from top to bottom. One device is a standard ***Pitot*** device with one connection, the other is a ***Pitot Static*** device with two connections.

Technical Data

AF100

Item	Specification
Total Length of Apparatus	3700 mm
Total Depth (front to back)	1065 mm
Total Height	1900 mm
Working Section	305 mm x 305 mm x 600 mm
Air Velocity	0 to 36 $m.s^{-1}$
Fan Motor	AC Three-Phase Axial Variable Speed
Electrical Supply	
Type	Three-Phase AC
Voltage (depends on order)	415 V or 220 V
Total Current (with all optional instruments connected)	21 A (415 V)/26 A (220 V)
Fuses	
Drive Unit	(415 V) Three phase 16 A MCB (Miniature Circuit Breakers) (220 V) Three phase 20 A MCB
IEC Outlets	10 A MCB
Low Voltage Instrumentation Supply	2 A MCB

Noise Levels

Product: AF100	
Position of Recording	**Level recording dB(A) at Leq Period = 2 Minutes**
At operators ear level	80
In front of the apparatus 1 m away at a height of 1.6 m	80
Back of machine 1m away at a height of 1.6m	80
Inlet of machine 1 m away at a height of 1.6 m	91.6
Outlet of machine 1 m away at a height of 1.6 m	84

WARNING

For sound pressure levels above 85 dB(A) it is a requirement that ear defenders are worn.

Installation and Assembly

The terms left, right, front and rear of the apparatus refer to the operators' position, facing the unit.

NOTE

- *A wax coating may have been applied to parts of this apparatus to prevent corrosion during transport. Remove the wax coating by using paraffin or white spirit, applied with either a soft brush or a cloth.*
- *Follow any regulations that affect the installation, operation and maintenance of this apparatus in the country where it is to be used.*

Handling Instructions

Nett Weights:

Main Frame: 217 kg

Inlet Cone: 34 kg

Control and Instrumentation Frame: 41 kg

Silencer Unit: 25 kg

Combined Weight of all Units: 317 kg

WARNING

Follow the correct handling procedures when moving this apparatus.

Location

Install the AF100 Subsonic Tunnel in a clean, well lit laboratory or classroom type area, on a solid level floor, preferably made of concrete.

NOTE

The AF100 Wind Tunnel creates high noise levels, install it in a place where it will not disturb others.

The Main Frame (when assembled) occupies a floor space of 3700 mm x 1065 mm and is 1900 mm high.

The Control and Instrumentation Frame occupies a floor or table top space of 550 mm x 1600 mm and is 700 mm high.

Allow at least 2 m of free space around the inlet and 4 m at the outlet (see Figure 8). Ideally, install the AF100 so that the outlet is directed to a suitable outlet or vent to outdoors.

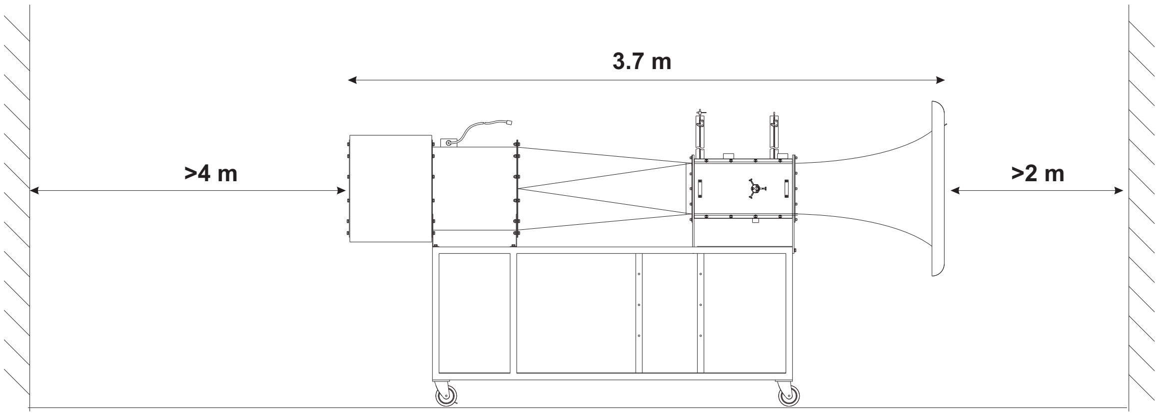

Figure 8 Minimum Space Requirements for the AF100.

Assembly

The apparatus is despatched in four main pieces:

- The Main Frame
- The Silencer
- The Effuser Cone
- The Control and Instrumentation Frame

The Control and Instrumentation Frame, the Silencer and the Effuser Cone fit into the Main Frame for packing and storage.

WARNING

Always use assistance when assembling the wind tunnel, some parts are heavy and are too difficult for one person to handle.

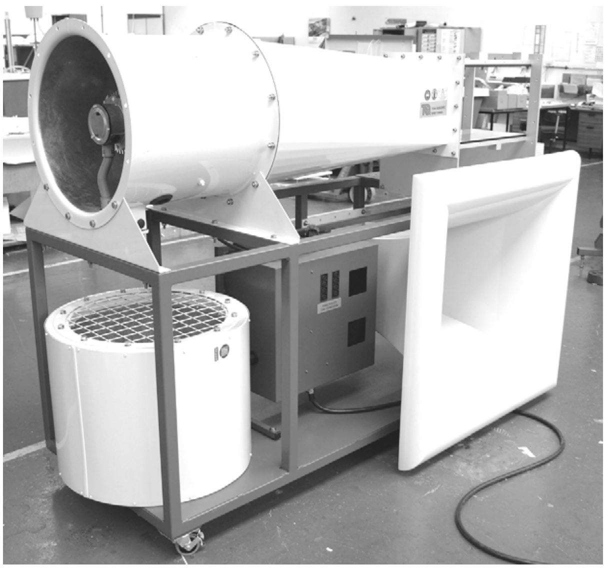

Figure 9 The Complete Assembly Packed for Shipping or Storage.

Assembly Procedure

1. Move the Main Frame into position and lock the wheels (two wheels have a locking mechanism).

2. Carefully unbolt the effuser cone from under the main frame (see Figure 10).

Figure 10 Unbolt the Effuser From Under the Main Frame

3. Remove both side panels from the working section.

4. Carefully hold the effuser cone flange next to the working section flange and make sure all the holes line up.

5. Make sure the black gasket (supplied) is on place on the flange of the working section (see Figure 11) and bolt the effuser cone to the working section. Do not use the fixings that held the cone to the frame, there are separate fixings (supplied) for this task.

Figure 11 Hold the Square Gasket Against the Working Section

6. Unbolt the silencer section from under the Main Frame (see Figure 12).

Figure 12 Unbolt Silencer from Frame

7. Support the fan unit and remove the four bolts which hold it to its end support bracket.

8. Hold the silencer flange against the fan unit flange and make sure all the holes line up.

9. Make sure the round black gasket (supplied) is in place on the flange of the fan unit (see Figure 13) and bolt the silencer to the fan unit.

Figure 13 Make Sure the Round Black Gasket is In Place on the Fan Unit Flange

10. Carefully unbolt and remove the Control and Instrumentation Frame from under the Main Frame.

11. Fit the four feet (supplied) to the Control and Instrumentation Frame. Place the frame near to the wind tunnel.

12. Use the silicone (supplied) to seal the effuser cone - working section joint from inside. Make sure that the seal has a level surface. Any lumps or steps in this joint will cause a disruption in the airflow. Some strips of masking tape either side of the joint will help to make the job neater (see Figure 14).

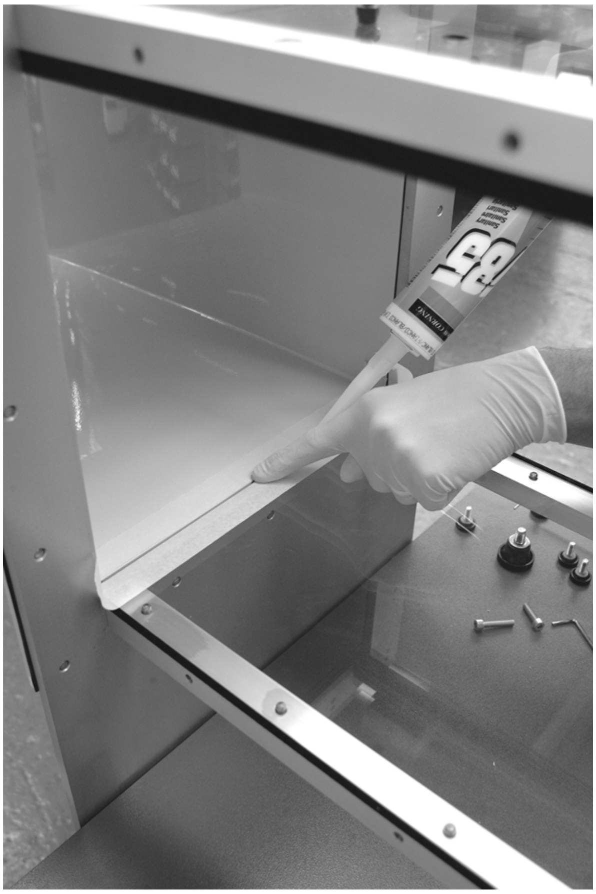

Figure 14 Apply Silicone to the Cone-Working Section Joint.

13. Fix the two pitot devices to the top of the working section. The Pitot tubes must point towards the inlet (see Figure 15). The Pitot Static device is usually downstream and the standard pitot device is usually upstream.

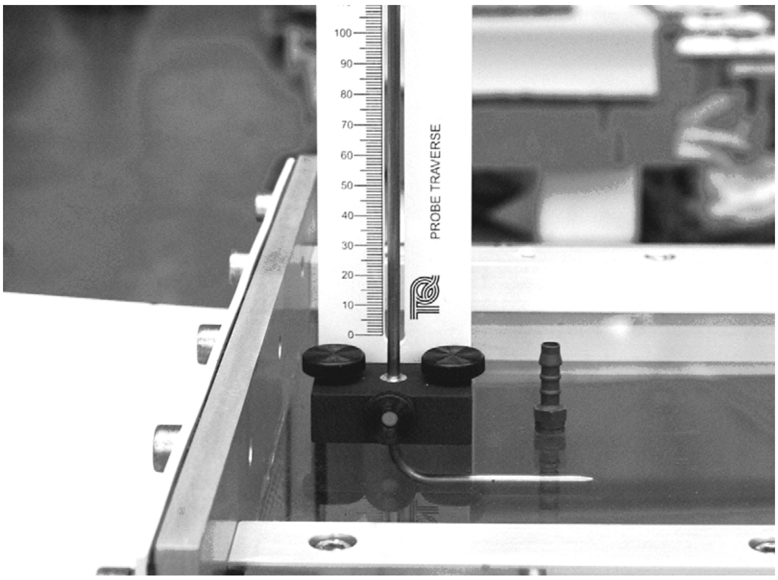

Figure 15 Fit Pitot Tubes to the Top of the Working Section

14. Check the fluid levels of the two manometers on the Control and Instrumentation Frame. It should be at the zero mark (see Figure 16). Add more fluid (supplied) if necessary. The zero position can be adjusted if required.

WARNING ***The manometer fluid can stain and is harmful if swallowed. Use suitable gloves and take care when filling the manometers.***

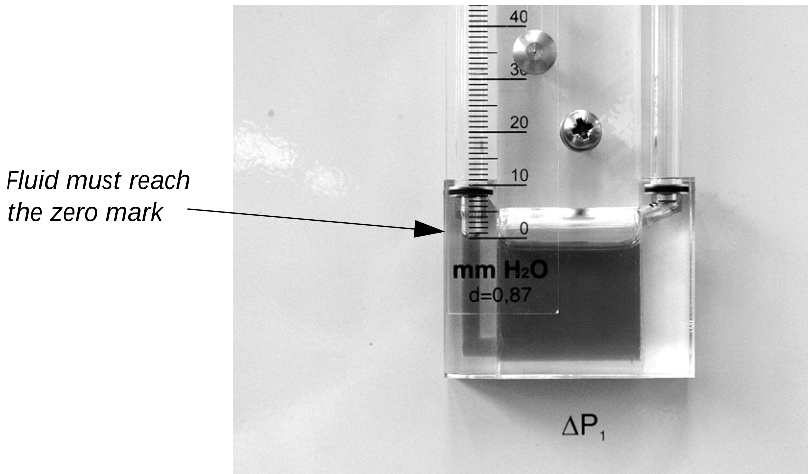

Figure 16 Make Sure the Manometer Fluid is at the Zero Mark.

15. Connect the two pipes (supplied) from the manometers on the Control and Instrumentation Frame to the Pitot Tube assemblies on the wind tunnel working section. Figure 17 shows the typical pitot connections for most experiments.

16. Connect the fan supply lead from the wind tunnel to the socket on the side of the Control.

17. Check all fixings are tight.

18. Connect the Control and Instrumentation Frame to the electrical supply as described in 'Electrical Connection'.

19. The apparatus is ready for use.

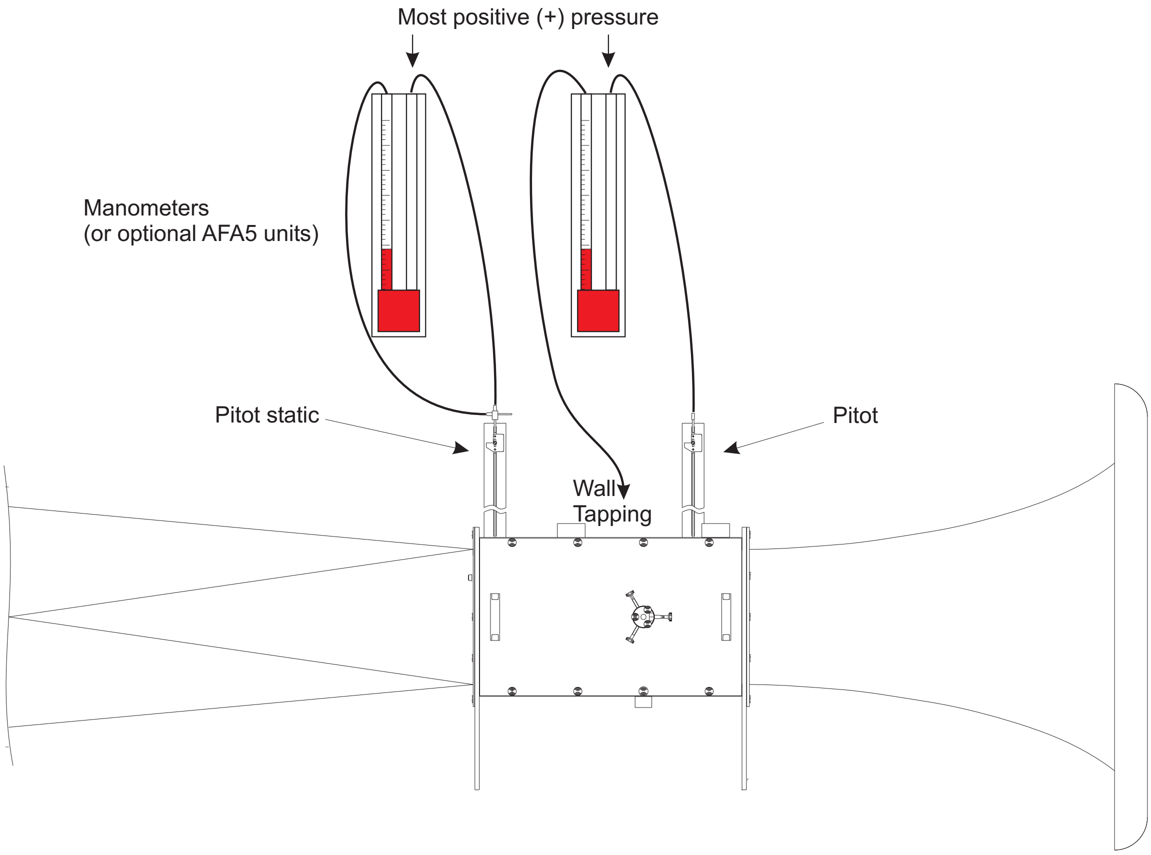

Figure 17 Typical Pitot Connections

Electrical Connection

Connect the apparatus to an electrical supply using the cable(s) provided.

WARNING **_Connect the apparatus to the supply through a switch, circuit breaker or plug and socket. The apparatus must be connected to earth._**

Refer to the following colour code to identify the individual conductors:

GREEN AND YELLOW:	EARTH E OR ⏚
BROWN:	PHASE
BLACK:	PHASE
GREY:	PHASE
BLUE:	NEUTRAL

CAUTION **_The Drive Control includes Filters which have an inherent earth leakage, and will cause nuisance tripping with some types of RCD. For this reason, if you have RCD protection, it must be type B (IEC755) to allow adjustable time and tripping characteristics._**

Connect the Fan motor to the socket on the side of the Control and Instrumentation Frame with the special connector and lead attached to the apparatus (see Figure 18).

Figure 18 Connect the Fan Motor to the Control and Instrumentation Frame.

Test Procedure

Safety

The AF100 Apparatus is very safe and will give many hours of use, providing that it is used properly and that students act in a sensible manner. However, there are some points which must be noted:

1. The air pressure at the outlet of the wind tunnel is high enough to blow small structures over and will certainly disturb dust and debris and scatter papers and documents if they are left nearby. Where possible, fit a chain barrier around the outlet of the wind tunnel to stop people walking into the air blast.

2. The pressure reduction at the inlet is low enough to suck in papers and clothing if it gets too near. Make sure that students using this apparatus are not wearing loose clothing.

3. The noise levels from this apparatus are high enough to cause damage to hearing. Make sure that all persons using or near the apparatus wear ear protection.

WARNING 

Keep away from the inlet and outlet of the wind tunnel.

Do not operate the wind tunnel with any guards or covers removed.

When using the smoke generator, divert the outlet of the wind tunnel, in a safe manner, away from the teaching area. (Refer to the smoke generator manual).

WARNING  

Wear ear protection when using or working near to this apparatus.

WARNING  

Wear eye protection when using or working near to this apparatus.

Operating the Tunnel

Tests with the Wind Tunnel are made easier if two students work together. One student operates the fan controls and records results, while the other student monitors and adjusts the model.

Start Up

1. Switch on the electrical isolator on the Control and Instrumentation Frame.

2. Set the speed control to the minimum position (fully anticlockwise).

3. Press the green START button.

NOTE *The first time you switch on the isolator and press the start button, the fan may take several seconds to work. This is normal. The drive needs a few seconds to energise correctly.*

4. Gradually turn the speed control clockwise until the tunnel is operating at the speed needed for the experiment.

Shut Down

1. Slowly turn the speed control fully anticlockwise.

2. Press the red STOP button.

Emergency Stop

1. Press the red STOP button.

2. Turn the speed control fully anticlockwise.

Ramp Start

The motor drive unit includes a ramp start to slowly increase the motor speed to the level set by the speed control. This means that the motor may be stopped and restarted at the same speed if necessary, without damaging the motor. This helps when repeating an experiment, there should be no need to re-calculate the wind tunnel velocity, provided that no-one has adjusted the speed control while the machine is off.

To use this facility, simply turn off the the motor with the STOP button - do not touch the speed control.

Restart the motor as normal but do not touch the speed control. The motor will slowly ramp up to the last speed it was set to.

Calibration of the Tunnel

A suitable initial experiment to perform with the tunnel is to survey the velocity at the inlet to the working section. This allows students to become familiar with the operation of the tunnel and yield useful data for further work.

The velocity is surveyed at:

1. The working section centre line - to establish a reference velocity.

2. Various distances from the floor to the ceiling of the working section to check the uniformity of the velocity and show the height of the boundary layer.

3. Various planes along the length of the working section. To illustrate boundary layer growth and its effect on velocity in the working section.

The pitot tube and static wall tapping measure the stagnation pressure and the static pressure at the wall. Referring to Bernoulli's equation, the difference between the stagnation and static pressures gives us the ***dynamic*** pressure from which the velocity can be found.

The dynamic pressure is given directly on the AF100 if the stagnation pressure and static pressure are connected to each limb of either one of the manometers provided on the Control and Instrumentation Frame.

The velocity at the point of measurement is given by:

$$V = \sqrt{\frac{2 \times \Delta P_1 \times 9.81}{\rho_a}} \text{ and } \rho_a = \frac{P_a \times 100}{RT_a}$$

Where:

ΔP_1 = Dynamic pressure (mmH_2O)
V = Velocity (m.s^{-1})
$\tilde{n}_a$ = Local air density (kg/m3)
T_a = Ambient air temperature (K)
P_a = Ambient atmospheric pressure (millibar)
R = Gas constant = 287m^2/s^2K

Procedure

To Establish the Reference Velocity:

1. Ensure that the ***Pitot Tube*** is fitted to the front position (nearest to the inlet). Check that the mechanism allows the probe to traverse the entire section. (The bend radius will prevent them from coming flush to the top). If not, undo the screw holding the pitot tube to the pointer and adjust it.

2. Connect the pitot tube and wall tapping to the manometer ΔP_1. Connect the wall tapping to the left limb and the pitot to the right limb.

3. Zero the manometers and take readings of the ambient air temperature and barometric pressure. Position the pitot tube in the centre of the tunnel (152.5 mm from the bottom).

4. Start the fan and run it at full speed. Take a reading from the manometer. Reduce the fan speed and take another manometer reading. Continue to take manometer readings for a range of fan speeds.

5. Plot a graph of manometer reading versus reference velocity.

The graph of reference velocity versus manometer reading produced is valid only for the temperature and pressure at the time of measurement since the ambient conditions may vary. To produce a more comprehensive graph that can be used at any time, the values should be corrected to account for ambient conditions.

To Establish the Uniformity of the Velocity:

1. Set the pitot tube mid way and set the fan running to give a speed of around 35 $m.s^{-1}$ (use the table from the previous procedure).

2. Position the pitot at the floor of the tunnel. Take a reading of the dynamic pressure and the position of the pitot from the scale. Move the pitot away from the wall by approximately 1 mm and repeat the dynamic pressure reading. Continue to take readings of dynamic pressure every millimetre up to 15 mm and then every 20 mm up to the centre line of the working section.

NOTE

Your dynamic pressure readings at the bottom of the Working Section may be unstable. This is not a fault. It is caused by the turbulent flow (due to the boundary layer) at the sides of the working section. You may just note that the readings are unstable for the first few readings, or make a 'best judgement' of the value.

3. Plot a graph of the height in the working section against the velocity (remember to subtract the radius of the pitot tube for a true position relative to the tunnel floor). The graph should show a reduced velocity near to the tunnel floor due to the boundary layer with a sensibly constant velocity over the remainder of the working section.

The above measurements and graphs can be repeated at the downstream pitot position (i.e. in a second plane). This will show a higher velocity in the centre of the tunnel due to a thicker boundary layer (this effectively makes the working section smaller), this is confirmed when the section is traversed with the pitot.

To establish an accurate velocity at the position (plane) of the model (or any other plane) the reference velocity can be plotted against position along the working section for the front and rearmost pitot positions. The velocity at any other plane in the working section can be read off the resulting plot. This can be referred to when models are placed in the working section.

Maintenance

General

When it is not in use, disconnect the apparatus from the electrical supply.

Regularly check the seals around the removable window of the working section. They should have a thin coating of silicone grease to help the window seal correctly.

To clean the apparatus, wipe clean with a damp cloth - do not use abrasive cleaners.

WARNING ***Disconnect the electrical supply to the apparatus before opening any covers or guards.***

Electrical

WARNING ***A qualified person must carry out electrical maintenance.***

Ensure the following procedures are followed.

- Assume the apparatus is energised until it is known to be isolated from the electrical supply.
- Use insulated tools where there are possible electrical hazards.
- Confirm that the apparatus earth circuit is complete.
- Identify the cause of a blown fuse or tripped circuit breaker before renewing or resetting.

To change a fuse (or reset an MCB)

- Isolate the apparatus from the electrical supply.
- Renew the fuse or reset the MCB.
- Reconnect the apparatus to the electrical supply and switch on.
- If the apparatus fails again, contact TecQuipment Ltd or your agent for advice.

NOTE *Renew faulty or damaged parts with an equivalent item of the same type or rating.*

Fuse Location

All the fuses are located inside the main section of the Control and Instrumentation Frame. The cover of the main section cannot be opened unless the red isolator switch is in the ‘O’ (OFF) position.

Spare Parts

Refer to the Packing Contents List for any spare parts supplied with the apparatus.

If you require technical assistance or spares, please contact your local TecQuipment agent, or contact TecQuipment direct.

To assist us in processing your request quickly and efficiently, when requesting spares please include the following:

- Your name
- The full name and address of your college, company or institution
- Your email address
- The TecQuipment product name and product reference
- The TecQuipment part number (if known)
- The serial number
- The year of purchase (if known)

Please provide us with as much detail as possible about the parts you require and check the details carefully before contacting us.

If the product is no longer under warranty, TecQuipment will send you a price quotation for your confirmation.