AFA3

Three Component Balance

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 supply 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.

DB/MB/AD/0710

TecQuipment

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AFA3

Three Component Balance

User Guide

Introduction

The AFA3 Three Component Balance fits to the working section of AF100 Wind Tunnel, but may be used with any other suitable designs.

The AFA3 Three Component Balance is part of TecQuipment's subsonic wind tunnel range. It provides an easy to use support system for wind tunnel models to measure three key forces exerted on the model:

- Lift
- Drag
- Pitching moment

Figure 1 The AFA3 (shown fitted to a TecQuipment Wind Tunnel)

This product works with VDAS

Figure 1 shows a general view of the AFA3, attached to the working section of a wind tunnel.

Figure 2 shows the construction and the main parts of the balance, including dimensions of the balance mounting points. The balance mounts on a vertical wall of the working section and works for air flows from right to left (when you view the balance from the front).

The main parts of the balance are aluminium alloy. Its has a mounting plate that fits to the wind tunnel working section and carries a triangular force plate. Three supporting legs at the corners of the force plate connect it to the mounting plate. Spherical universal joints attach each leg to the force plate and mounting plate. This only allows the force plate to move in a plane parallel to the mounting plate, while leaving it free to rotate about a horizontal axis, giving three degrees of freedom.

Models for use with the balance must have a 12 mm diameter x 220 mm mounting stem. This stem fits in the bore of the model support and secures by a collet tightened by the model clamp. The model

support has graduations on its periphery and is free to rotate 360 degrees in the force plate to allow adjustment of the angle of incidence of the model. An incidence clamp locks it in position.

Two centering clamps lock the force plate in position.

CAUTION 

Always lock the centering clamps when the balance is not used. This stops damage to the load cells.

Flexible cables transmit the forces acting on the force plate to strain gauge load cells that measure the fore and aft vertical forces and the drag force. The drag cable is horizontal and acts on a line through the centre of the model support. The two vertical cables act vertically through points equidistant from the centre of the model support and in the same horizontal plane as the support. The sum of the forces on the fore and aft lift cables gives the lift on the model while the difference, when multiplied by 0.0635, gives the pitching moment in Newton-metres. A drag balance spring acts on the force plate to apply pre-load to the drag load cell.

A strain gauge amplifier on the mounting plate amplifies the output from each load cell then sends the signal to a separate display module. The display module has a digital display that shows the output from the load cell circuits. The display shows lift and drag forces in Newtons, and pitching moment in Newton metres. The display module fits onto the wind tunnel Control and Instrumentation Frame. The display module can connect to TecQuipment's VDAS Versatile Data Acquisition System (available separately). The VDAS allows you to display, capture, tabulate, graph and export the lift, drag and pitching moment on a suitable computer.

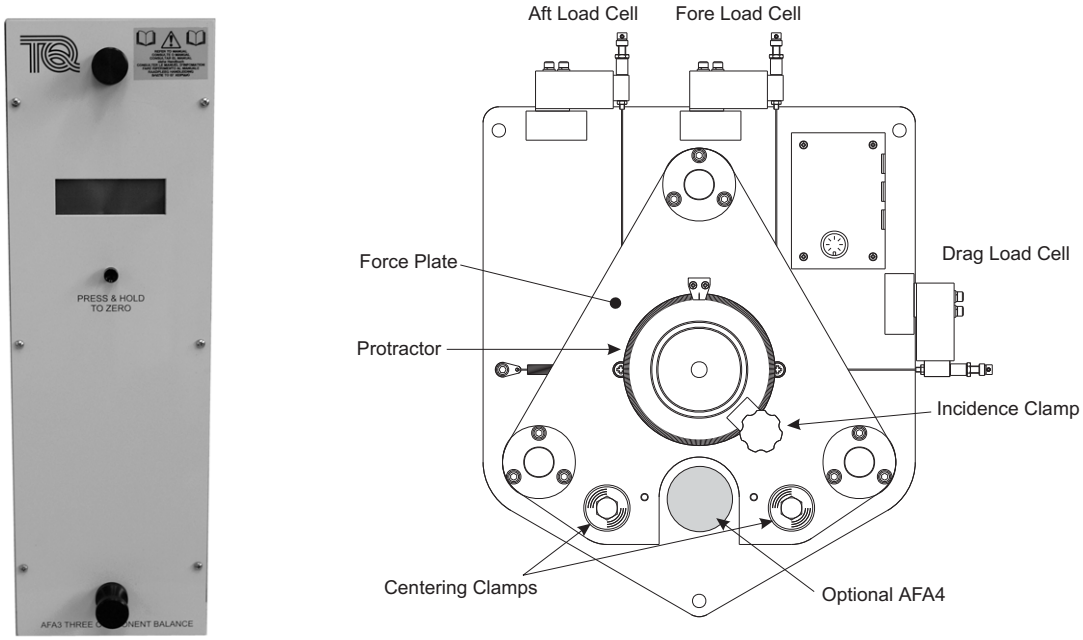

Figure 2 The AFA3 Display Module and General Layout of the AFA3 Balance.

An optional extra to the AFA3 is the AFA4 Angle Feedback Device. The AFA4 fits into the AFA3 and transmits the angle of the model back to TecQuipment's VDAS.

Figure 3 shows a system diagram for the other parts available for the TecQuipment wind tunnels and how they connect to TecQuipment's VDAS.

NOTE *The AFA4 Angle Feedback Device only works with VDAS*

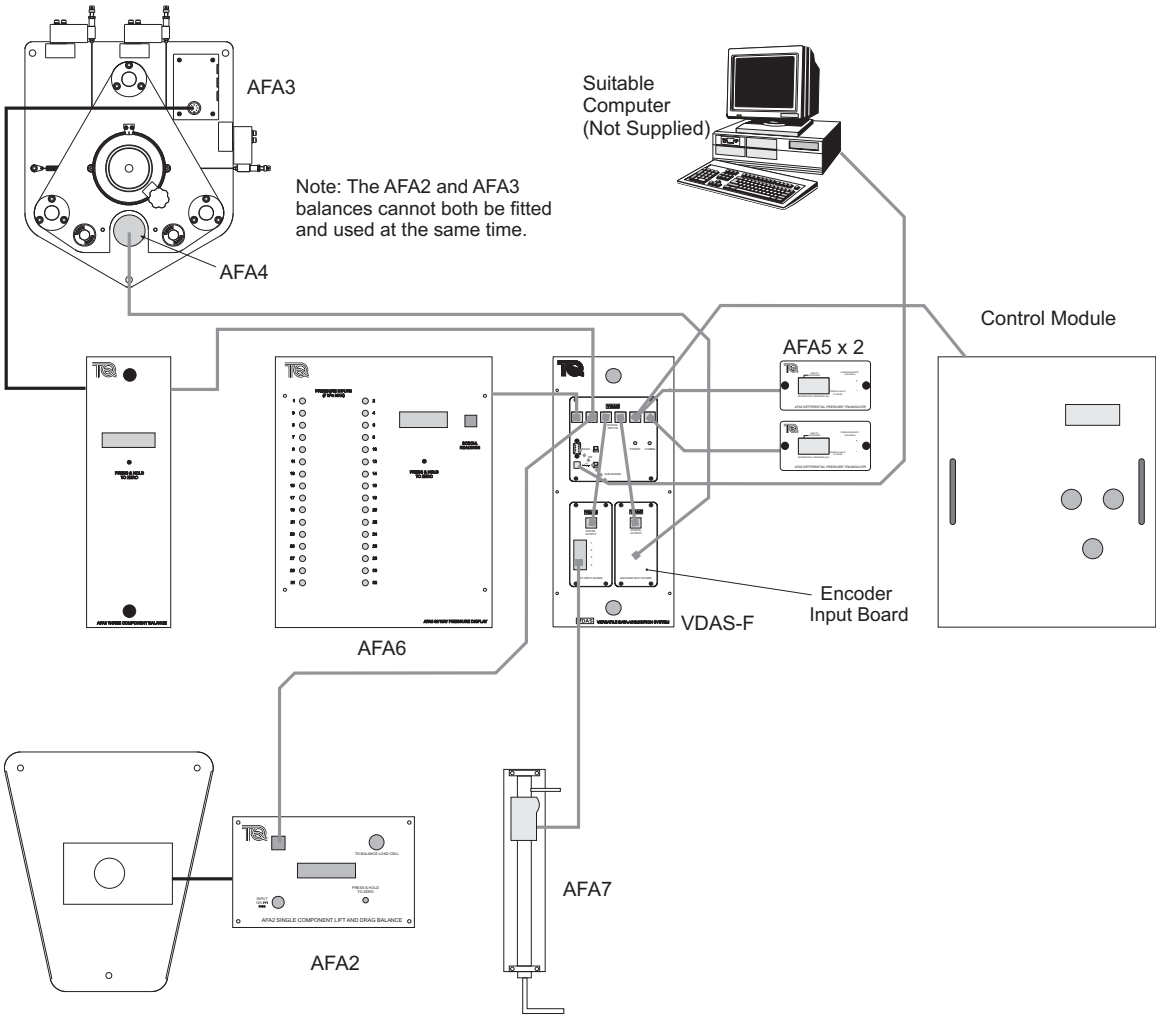

Figure 3 System Diagram

Technical Data

Item	Specification
AFA3 Balance (when mounted on calibration frame)	
Total Width	480 mm
Total Depth (front to back)	360 mm
Total height	550 mm
Weight	18 kg
Display Module	
Width	140 mm
Depth (front to back)	125 mm
Height	450 mm
Weight	3.5 kg
Electrical Supply	
Type	Single Phase 50/60 Hz TN-S (Refer to IEC 60364)
Voltage	85 VAC to 264 VAC 50 Hz to 60 Hz
Nominal Power Consumption	45 W
Fuses	
At the IEC socket on the rear of the apparatus	F6.3 A

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:

AFA3 Balance on the Calibration Frame: 18 kg

AFA3 Display Module: 3.5 kg

Assembly

The AFA3 Balance is supplied bolted to its calibration/storage frame. See details later in this guide for installation to the wind tunnel and connecting up the cables from the balance to the display module.

WARNING

Disconnect the electrical supply to the wind tunnel before you install the AFA3 display module.

1. Lift the Display Module up and onto the top and bottom bars of the Control and Instrumentation Frame as shown in Figure 4.
2. Slide the module to the most convienient position on the frame.
3. If you are to use the AFA3 with the VDAS, refer to 'To Connect to the VDAS on page 9'.
4. Use the mains electrical IEC type cable (supplied) to connect from the mains socket on the rear of the AFA3 display module to the supply sockets on the main section of the Control and Instrumentation Frame (or the main drive drive box on the AF200 wind tunnel).

Figure 4 Lift the Module Up and Onto the Frame

To Connect the Display Module to the Balance

Use the 7-pin DIN type cable (supplied) to connect the socket on the balance to the socket on the rear of the display module (see Figure 5).

Figure 5 Use the 7 pin DIN type Lead to Connect the Balance to the Display Module

To Connect to the VDAS

If you need to use the AFA3 with the VDAS, use one of the data cables supplied with the VDAS to connect the 'Digital Output' of the AFA3 Display Module to a 'Digital Input' of the VDAS Hardware Module. Refer to the VDAS User Guide for more details.

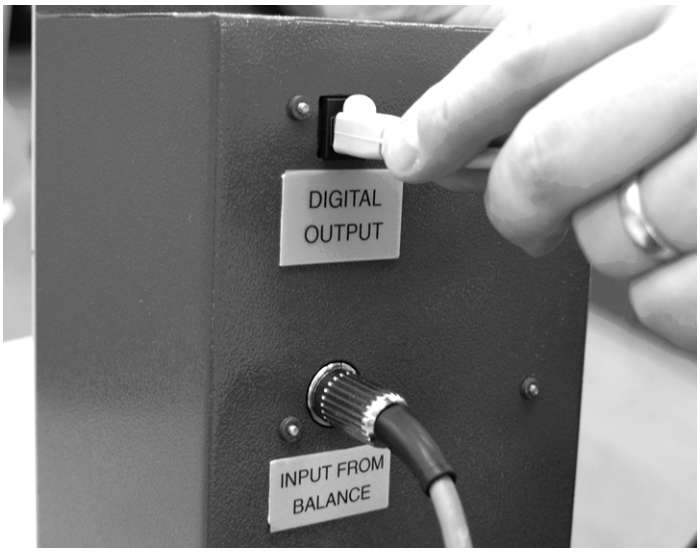

Figure 6 Use the Cable Supplied with the VDAS To Connect up the AFA3 Display Module

To Fit the AFA4 Angle Feedback Unit

If the AFA3 is ordered with the optional AFA4 Unit, they are assembled at the factory. If you have ordered them separately, you will need to fit them together.

NOTE *The AFA4 unit will not operate without the VDAS System.*

1. Fit the male ends of the two hexagon spacers (supplied) into the force plate (see Figure 7).
2. Carefully set the protractor to the zero position (see Figure 8).
3. Fit the AFA4 mounting plate to the hexagon spacers and leave the screws loose (see Figure 9).
4. Slide the belt (supplied) onto the AFA4 pulley and the AFA3 pulley.
5. Rotate the AFA4 mounting plate (by hand) to tension the belt and tighten the screws. Make sure that you can just twist the belt with your fingers.

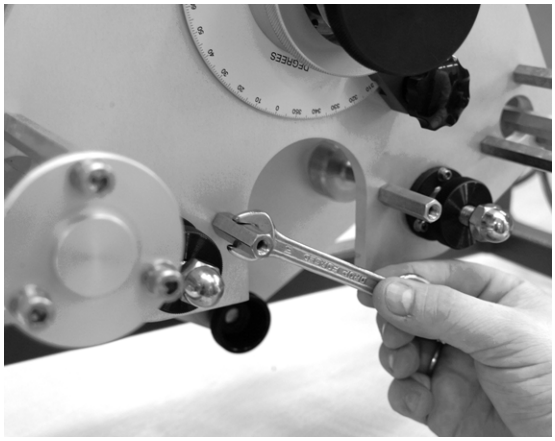

Figure 7 Fit the Two Hexagon Spacers

Figure 8 Set the Protractor to Zero

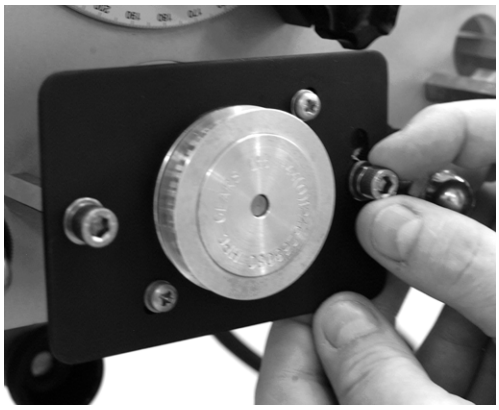

Figure 9 Fit the Mounting Plate and Leave the Screws Loose

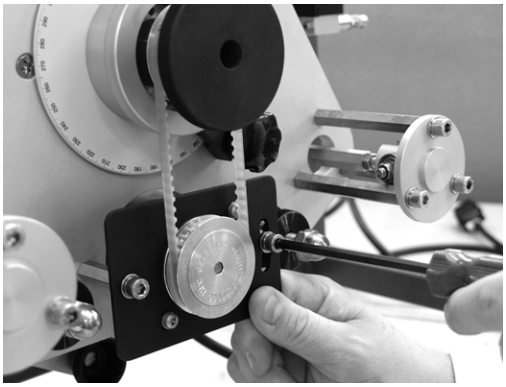

Figure 10 Tension the belt by Hand and Tighten the Screws

6. Change the ‘Analogue Input Board’ on the VDAS Hardware for the ‘Encoder Input Board’ supplied with the AFA4 (Refer to the VDAS User Guide to change the boards). Connect the cable from the AFA4 to the socket on the ‘Encoder Input Board’ on the VDAS Hardware Module. Start the VDAS software and switch on the VDAS hardware module.

7. Loosen the two small screws on the AFA4 mounting plate (see Figure 11).

8. Rotate the body of the AFA4 until its reading on the VDAS software is zero (+/- 0.2°).

9. Tighten the two small screws and make sure that the software reading does not change.

10. Adjust the protractor on the AFA3 and check that the VDAS software displays the same reading as the protractor.

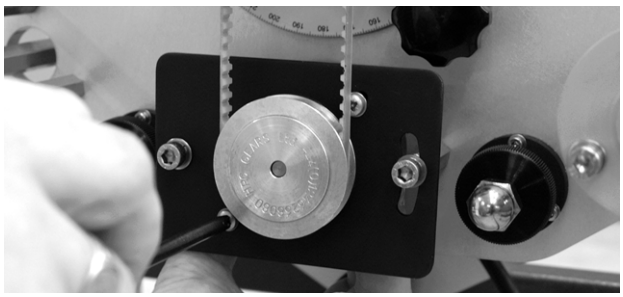

Figure 11 Loosen the Two Small Screws on the AFA4 Mounting Plate

Preparing the Instrument

1. Switch on the display module.
2. Let the apparatus warm up for fifteen minutes before taking any readings.
3. Release the centering clamps, the display unit will indicate values corresponding to the zero readings of lift, drag and pitching moment.
4. Press the ‘zero’ button on the display unit - BEFORE STARTING THE WIND TUNNEL.
5. Set the incidence of aerofoil models to give a lift force acting downwards, thus giving positive values of lift load cell read-out. This means that the aerofoils will be flying "upside down" in order to take meaningful readings. If the aerofoils were to fly in the conventional manner, once they had generated enough lift to overcome their own weight, the fore and aft lift cables would become slack and no further readings could be taken, since the load cells are only measuring uni-directionally.

To Fit a Model

Make sure the AFA3 balance is securely fitted to the wind tunnel before fitting a model. The balance simply bolts to one side of the working section with the three fixings (supplied). Make sure that you remove the blanking plug or standard protractor already fitted to the working section.

To fit a model,

1. Tighten the centering clamps
2. Set the model support at zero incidence and tighten the incidence clamp
3. Remove the window at the opposite side of the working section
4. Slide the model supporting stem into the model support, set the model at zero incidence and tighten the model clamp

NOTE  *The models should face upstream of the wind tunnel and ‘fly’ upside down.*

5. Refit the window at the opposite side of the working section.
6. Release the incidence clamp and ensure that the model moves freely without touching the tunnel walls.

CAUTION  *Do not tighten the model clamp without a model in position. The collet will be damaged.*

Operation

To operate the AFA3, a minimum of two students is needed. One student operates the balance and adjusts the model, while the other student monitors the display module readout (or the VDAS software) and takes results.

Measuring the forces

To measure the aerodynamic forces acting on the model

1. Set the tunnel speed to the desired value
2. Record the readings of the display module

To make a series of measurements of lift and drag over a range of model angles of incidence, set the angle by releasing the incidence clamp (a hexagon tool is supplied), rotating the model support to the desired angle and re-tightening the clamp.

At the end of the test:

1. Switch off the wind tunnel
2. Recheck the zero readings on the displays
3. Relock the centering clamps.

Calibration

The AFA3 unit is delivered already set up and calibrated by TecQuipment, however, it may sometimes be necessary to recheck the calibration of the apparatus.

To calibrate the AFA3 balance:

1. Fit the balance to its calibration/storage frame, place the assembly onto a table so that the back of the apparatus is close to the edge of the table.

Figure 12 The AFA3 Three Component Balance on its calibration/storage frame.

2. Make sure the large pulley wheel is fitted to its correct position at the lower rear of the frame (it may have been shipped at the top for easy packing).

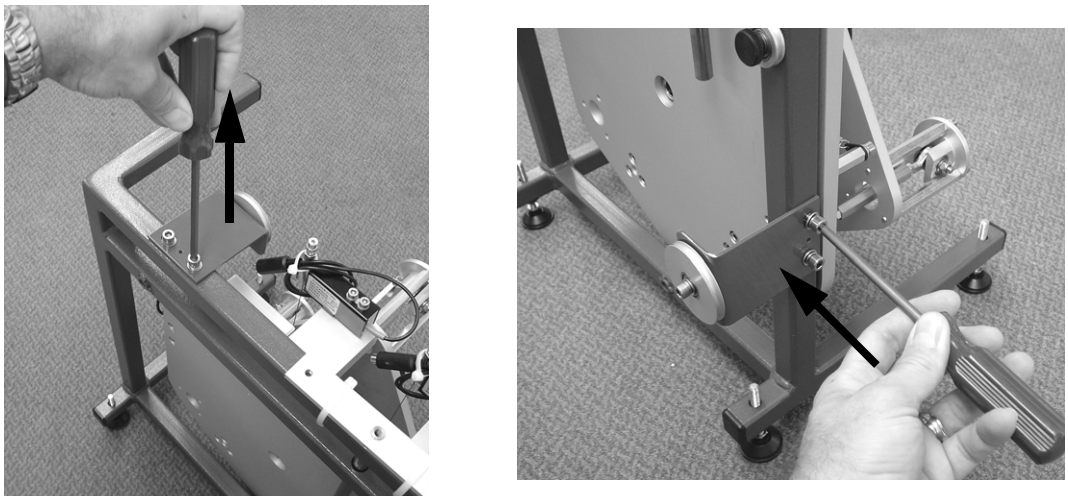

Figure 13 Make Sure the Large Pulley Wheel is Towards the Back.

3. Connect the cable from the balance to the display unit.

4. Use a spirit level across the top of the back plate to make sure that the balance is level, adjust the four feet of the calibration frame if necessary. Also, place the spirit level up the back of the back plate to check that it is vertical.

5. Slide the 'T' shaped calibration arm from the top of the calibration frame and insert it into the model holder from behind, with the bar roughly horizontal.

6. On the display module, press and hold the 'zero' button. At the same time, switch on the power. Wait a few seconds for the unit to settle. The display is now in the calibration mode (see Figure 14). It will show the individual readings from the load cells as 'FORE', 'AFT' and 'DRAG' (the display normally shows lift, drag and pitching moment).

NOTE 

Do not press the zero button again until you are instructed, or the unit will exit from the calibration mode.

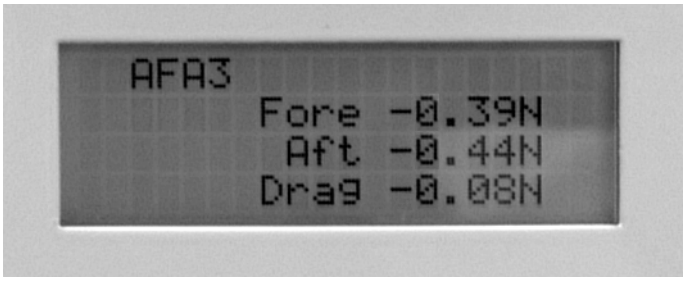

Figure 14 Display in Calibration Mode

7. Undo the centering clamps. The zero readings for each of the load cells should be 0 +/- 5 N. Make a note of all the 'zero' readings.

8. Proceed with the following calibration procedures.

Drag Calibration

Referring to figure 15:

1. Unscrew and fit the small pulley to the central hole on the calibration arm.
2. Fit the looped end of the cord (supplied) around the small pulley.
3. Run the cord around the large pulley.
4. Hang a 5 kg mass from the ringed end of the cord.
5. Read the DRAG value, subtract the zero reading from earlier. The result should be 49.10 N.

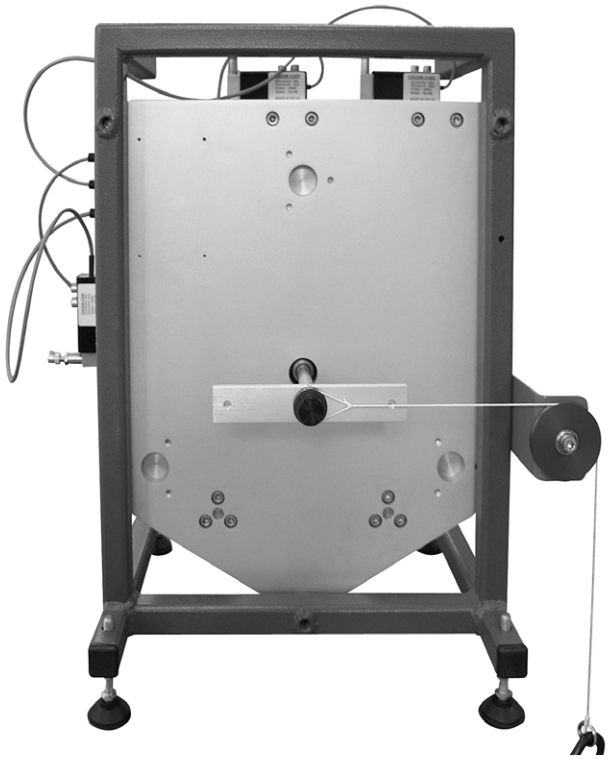

Figure 15 Drag Calibration

Fore/Aft Calibration

Referring to figure 16

1. Allow the cord to hang straight down from the small pulley.
2. Attach a 10 kg mass
3. Read the FORE and AFT values. Subtract the ‘zero’ readings from earlier. The result should be 49.10 N

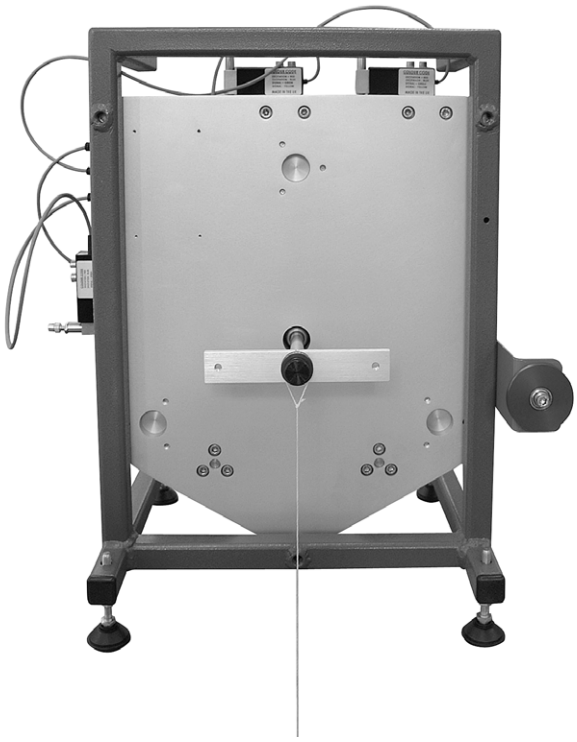

Figure 16 Fore/Aft Calibration

Moment Calibration

Referring to figure 17:

1. Move the small pulley to the left hand hole of the calibration arm, use a spirit level to ensure it is level.

2. Attach a 4 kg mass to the cord.

3. Read the FORE and AFT readings. Subtract the 'zero' readings from earlier. The results should be 39.2 N for the 'FORE' load cell and 0 N for the 'AFT' load cell.

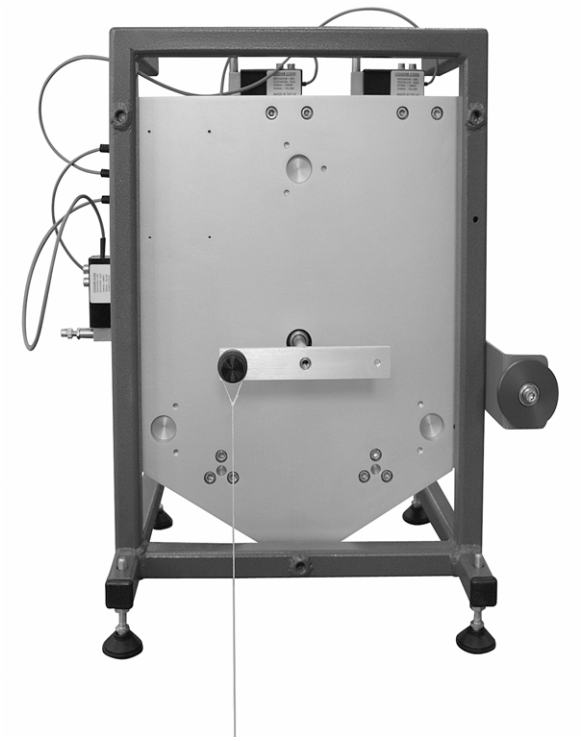

Figure 17 Moment Calibration

Remove the mass. Tap the frame and check that the readings return to zero +/- 0.2 N. If the readings are much greater or smaller than +/- 0.2 N, then contact TecQuipment or your local agent for instructions.

Maintenance

General

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

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.***

Store the apparatus in a clean dry place which is free from dust. When not in use keep the AFA3 balance on its storage/calibration frame.

Occasionally apply one or two drops of thin oil (sewing machine oil or clock lubricant) to the universal joints of the force plate supporting legs.

Periodically check the calibration of the AFA3 balance as described earlier in this guide.

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

- Isolate the apparatus from the electrical supply.
- Renew the fuse.
- 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.*

The fuse at the back of the AFA3display unit is part of the IEC socket, use a small flat bladed screwdriver to remove the fuse and its cover.

Glossary

This guide uses some terms which are in common use in aviation but need clarifying because they could be misunderstood.

Aerofoil	A structure with curved surfaces (e.g. a wing, fin, or tailplane) designed to give lift in flight.
Aft	The rear section of the aircraft.
Angle of attack	The angle at which the aerofoil is inclined, relative to the airflow. - Some British textbooks use the word 'incidence', but this can be confused with the American definition of 'the angle of the wing relative to the fuselage'.
Attitude	The position of an aircraft in relation to a given point or direction.
Fore	The front or forward part of the aircraft.
NACA	National Advisory Committee for Aeronautics - predecessor to NASA
NASA	National Aeronautics and Space Administration

Spare Parts

Check the Packing Contents List to see what spare parts we send with the apparatus.

If you need technical help or spares, please contact your local TecQuipment Agent, or contact TecQuipment direct.

When you ask for spares, please tell us:

- 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 you know it)
- The serial number
- The year it was bought (if you know it)

Please give us as much detail as possible about the parts you need and check the details carefully before you contact us.

If the product is out of warranty, TecQuipment will let you know the price of the spare parts.

Customer Care

We hope you like our products and manuals. If you have any questions, please contact our Customer Care department:

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email: customer.care@tecquipment.com

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