AF106

Flat Plate Boundary Layer Model

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.

TecQuipment

MB/AD/DB/0509

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Introduction

Figure 1 The AF106 Flat Plate Boundary Layer Model

The AF106

The AF106 Flat Plate Boundary Layer Model works with the AF100 Subsonic Wind Tunnel. It shows boundary layer development and separation.

The Flat Plate Boundary Layer Model is just one of a range of models that TecQuipment manufacture to accompany our range of wind tunnels. Each model allows a wide variety of experiments and demonstrations to be conducted.

The Flat Plate Boundary Layer model is made of two hinged stainless steel plates. When fitted inside the working section of a wind tunnel, the angle of the plates can be adjusted to set the optimum conditions for the experiment. Fine filament tufts are provided to aid visualisation of the flow over the plate.

On the upper surface of the model are five small aerofoils set at right angles to the surface. Each aerofoil is drilled with five tiny pitot holes on the leading edge. Each hole is connected to a separate tube (25 tubes in total). All the tubes are routed together and emerge at the side of the model. The aerofoils are staggered so that their wakes do not interfere with each other.

When the model is fitted in the wind tunnel, the tubes may be connected to the AFA1 Multi-tube manometer (or the AFA6 32-way Pressure System) for pressure measurements.

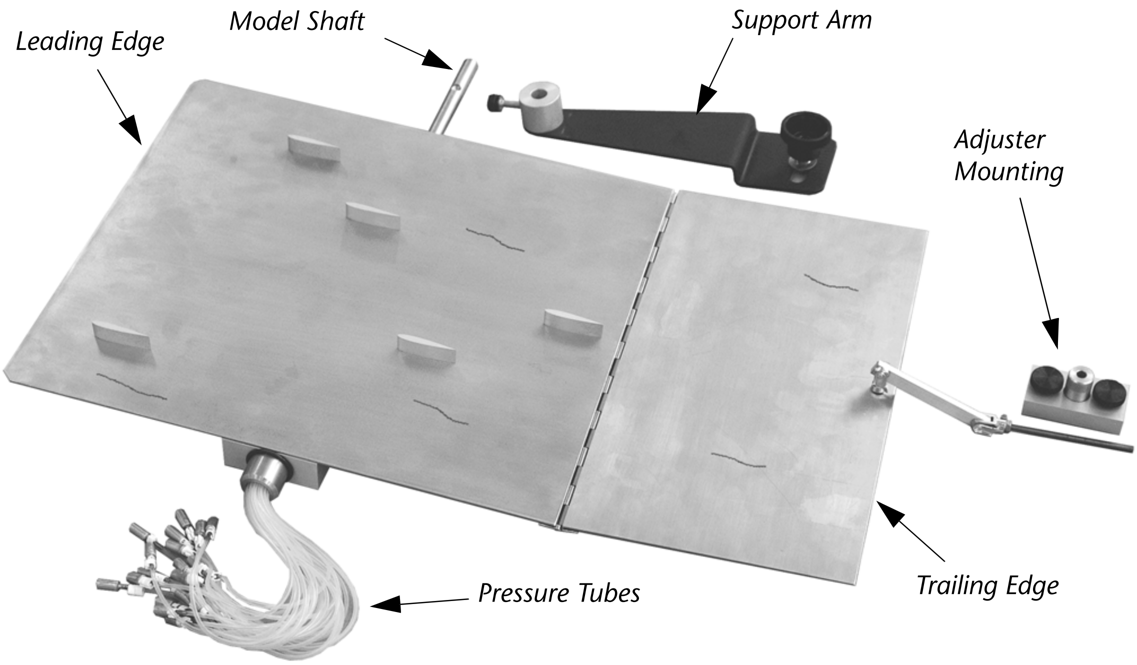


Figure 2 The Main Parts of the Flat Plate Boundary Layer Model

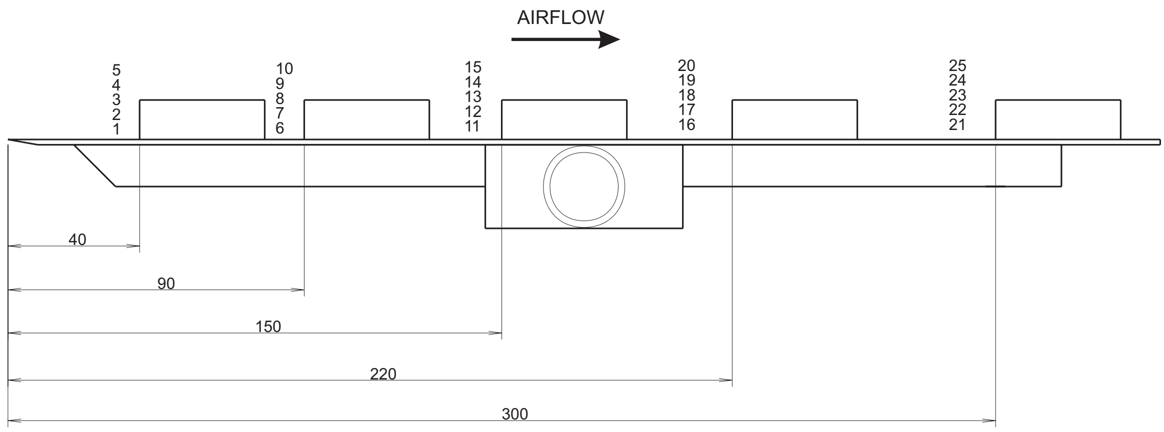


Figure 3 Distances from the Leading Edge of Each Aerofoil with the Numbers of Each Pitot hole

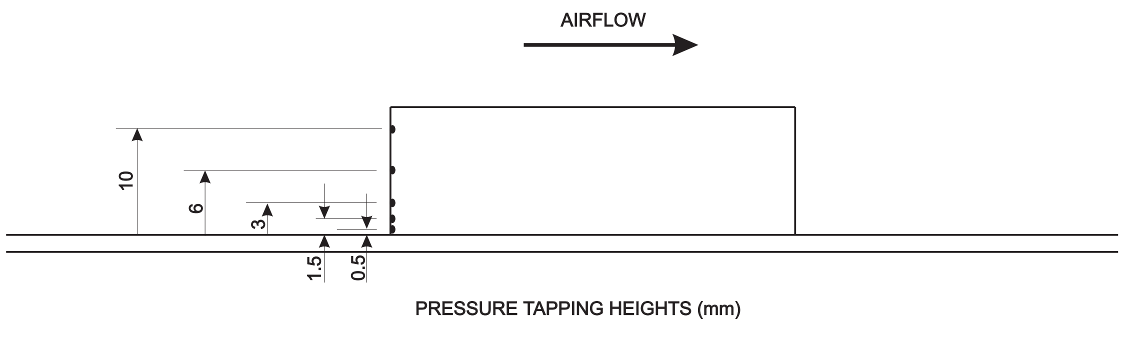


Figure 4 Distance of Pitot Holes from Baseplate

Installation

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.*

Assembly

Nett Weight: 5 kg

WARNING ***This model has a sharp leading edge. Take care when handling.***

Procedure

1. Make sure the electrical supply to the wind tunnel is disconnected.

2. One of the side windows in the working section has a large model holder with three locking screws. Leave this panel in place, but remove the other window.

3. Make sure that the rear pitot tube of the working section is removed and fit the adjuster mounting in its place (see Figure 5).

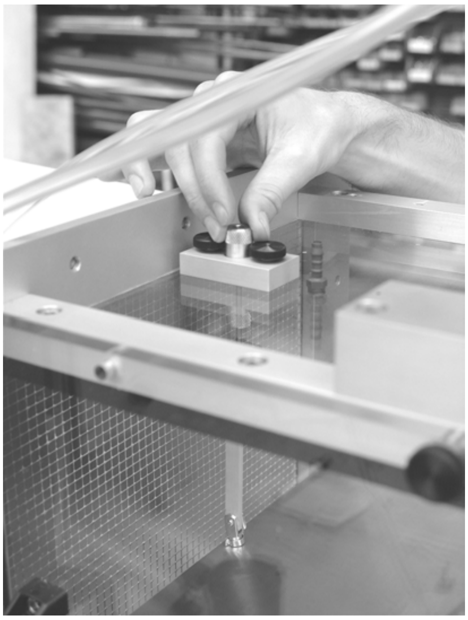


Figure 5 Fit the Adjuster Mounting in Place of the Rear Pitot Tube.

4. Locate the model shaft into the model holder in the other side panel (see Figure 6). Make sure that the small aerofoils are uppermost.

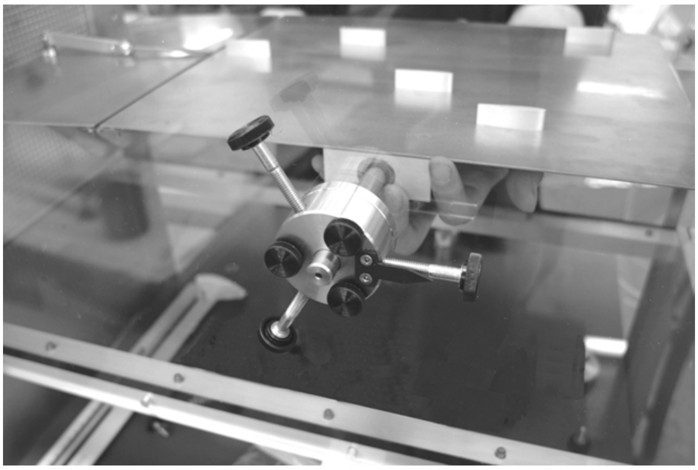


Figure 6 Slide the Model Shaft (other side of the model) Into the Holder on the Other Panel

5. On the trailing edge of the model is a threaded bar. Pass this bar up into the adjuster mounting and level the model (see Figure 5).

6. Pass the 25 tubes through the hole in the loose side panel and refit it (see Figure 7).

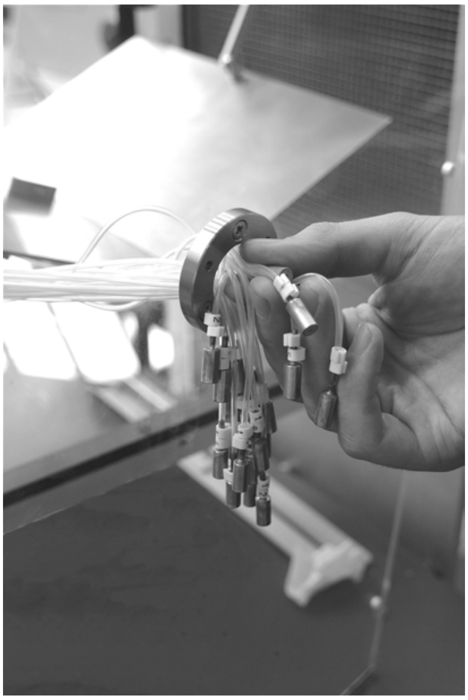


Figure 7 Pass the Tubes Through the Hole in the Side Panel

7. Make sure that the bottom mounting is turned around (see Figure 8) and fit the model support arm to the model shaft and tighten in place (see Figure 9).

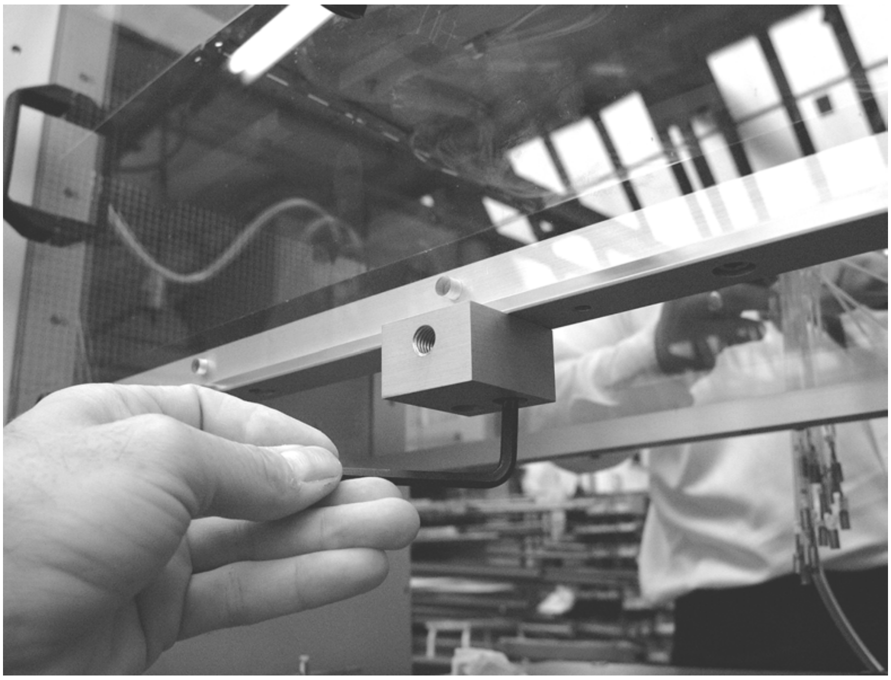


Figure 8 Make Sure Bottom Mounting is turned around so that the Hole is Visible

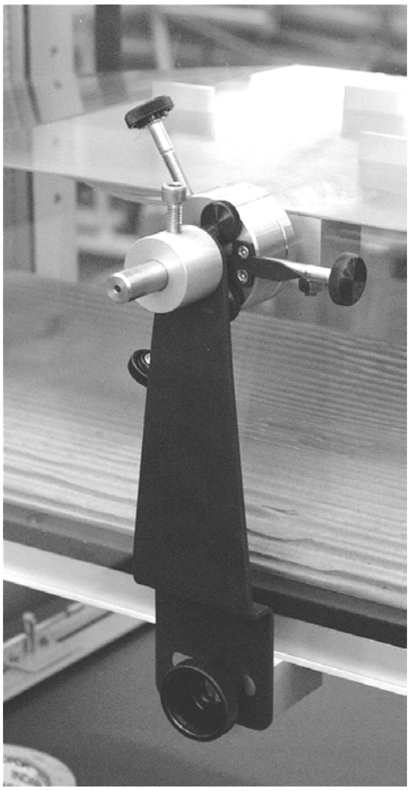


Figure 9 Fit the Support Arm

8. Use the three long mounting screws (supplied) to fit the manifold plate to the bottom of the Working Section and connect the 25 tubes to the front connections (see Figure 10). Each tube (tapping) has a number to make this easier.

9. Use the clear tubing (supplied) to connect the pressure connections at the back of the manifold to a suitable manometer or multi-way pressure display (see Figure 11).

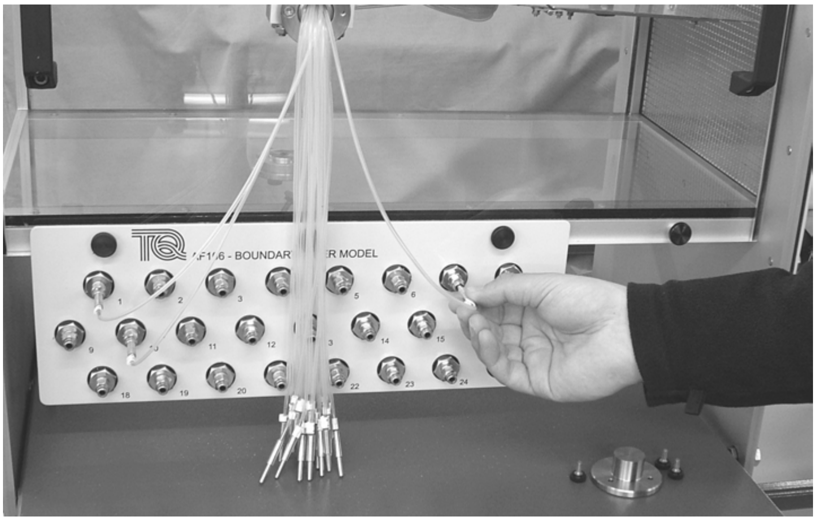


Figure 10 Fit the Manifold Plate and Connect the Tappings

Figure 11 Use the Clear Pipe Supplied to Connect to the Back Sockets

Test Procedure

The model must be adjusted very carefully to give the ideal conditions to achieve a satisfactory boundary layer. It must be adjusted to give a good pressure gradient with no separation. The best conditions occur when the plate and trailing edge is set to +/- 5° from the horizontal position (see Figure 12).

CAUTION

Strong turning forces are generated on the model even at low tunnel speeds.

Never remove the support arm screw. Grip the support arm tightly when making adjustments.

The procedure is as follows:

1. Adjust the angle of attack and the trailing edge

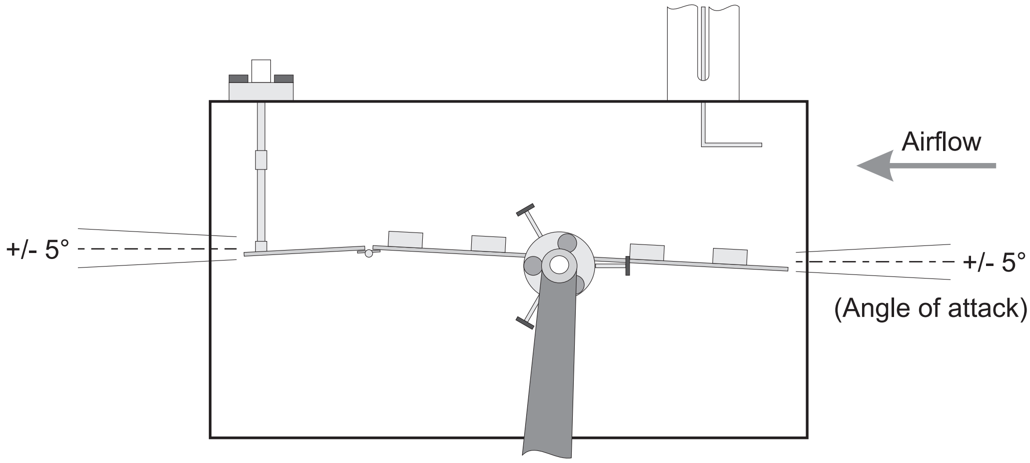


Figure 12 Adjust the Angles of the Leading and Trailing Edges.

2. Make sure all fixings are tight.

3. Start the Wind Tunnel at a velocity of 20 $m.s^{-1}$. Observe the tufts on the surface of the plate to ensure that the flow is laminar.

NOTE

Use a smoke generator (not supplied) to see the flow more clearly and to improve the results. Contact TecQuipment for a suitable smoke generator for your wind tunnel.

4. Record the two wall pressures upstream and downstream of the wind tunnel and average the two figures to give h_o (in mm) (see Table 1). When converted into pressure (Pascals), this gives an approximate figure for the working section static pressure (P_o). For a more accurate reading, interpolate between the two to give a local static pressure for each point.

5. The local velocity (V) is a function of the difference between the total pressure measured at each tapping (P_T) and the local static pressure (P_o). To calculate the local velocities, use the formula:

$$P_T = P_o + \frac{1}{2}\rho V^2$$

This re-arranges to give

$$V = \sqrt{2 \times \frac{P_T - P_o}{\rho}}$$

Where: $\rho = \frac{P_a}{RT_a}$

6. Record all pressure readings and calculate the local velocities in a table similar to Table 1.

7. Plot a graph of local velocity against the tapping number to give the curves for boundary layer growth around each aerofoil.

8. Repeat the test at wind tunnel velocities of 25 and 35 $m.s^{-1}$.

Tapping No	Reading of tapping manometer (mm H_2O)	Difference between average wall and the tapping manometer readings h_t - h_o (mm H_2O)	Difference in Pascals P_T - P_O (Pa)	Local Velocity (m.s^{-1})
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
Wall Pressure Upstream = mm		**Wall Pressure Downstream = mm**		**Average (P_o) =**
Wind Tunnel Velocity = m.s^{-1}		**Test Date =**		

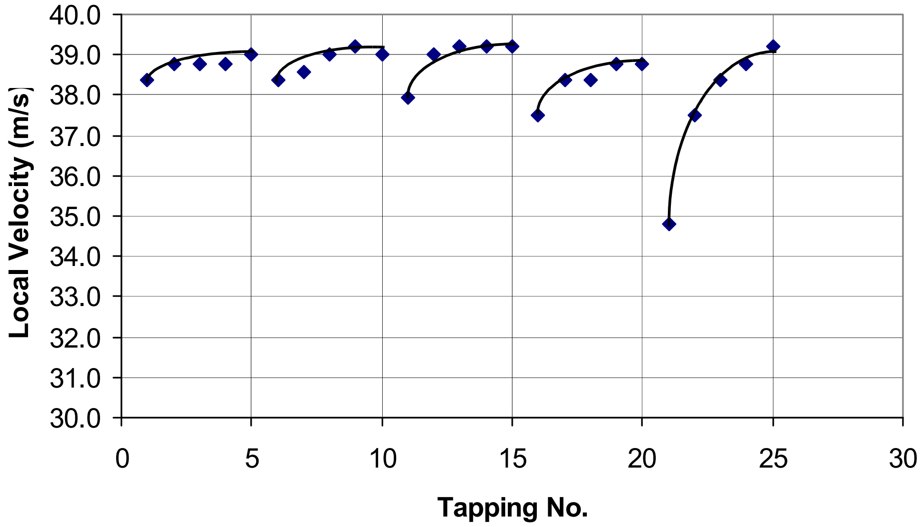
Table 1 Blank Results Table

Results

The following results show how the boundary develops along the plate. For a more detailed account of boundary layer growth, refer to text books as described in the '**References**' section.

Tapping No	Reading of tapping manometer (mm H_2O)	Difference between average wall and the tapping manometer readings h_t - h_o (mm H_2O)	Difference in Pascals P_T - P_O (Pa)	Local Velocity (m.s^{-1})
1	404	90	882.9	38.4
2	402	92	902.52	38.8
3	402	92	902.52	38.8
4	402	92	902.52	38.8
5	401	93	912.33	39.0
6	404	90	882.9	38.4
7	403	91	892.71	38.6
8	401	93	912.33	39.0
9	400	94	922.14	39.2
10	401	93	912.33	39.0
11	406	88	863.28	37.9
12	401	93	912.33	39.0
13	400	94	922.14	39.2
14	400	94	922.14	39.2
15	400	94	922.14	39.2
16	408	86	843.66	37.5
17	404	90	882.9	38.4
18	404	90	882.9	38.4
19	402	92	902.52	38.8
20	402	92	902.52	38.8
21	420	74	725.94	34.8
22	408	86	843.66	37.5
23	404	90	882.9	38.4
24	402	92	902.52	38.8
25	400	94	922.14	39.2
Wall Pressure Upstream = 502 mm		**Wall Pressure Downstream = 486 mm**		**Average (P_o) = 494**
Wind Tunnel Velocity = 35 m.s^{-1}		**Test Date =**		

Table 2 Results from Test at 35 m.s^{-1}



Graph 1 Results From Test at 35 m.s^{-1}

References

Aerodynamics

by LJ Clancy

Published in 1991 by Longman Scientific &Technical

ISBN 0582 988802

Maintenance, Spares and Customer Care

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

Store the model in a dry and dust free area suitably covered.

Regularly check the small pitot holes for dust. remove any blockages with a dry air line.

CAUTION

Never try to force any objects (pins or wire) into the pitot holes. They are precision drilled and any damage will affect the readings.

Do not blow into the pitot holes, human saliva will block them.

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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Fax: +44 115 973 1520

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