AF102

150 mm Chord NACA0012 Aerofoil with Tappings

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/DB/bs/0509

Contents

AF102

NACA0012 Aerofoil with Tappings

User Guide

Introduction

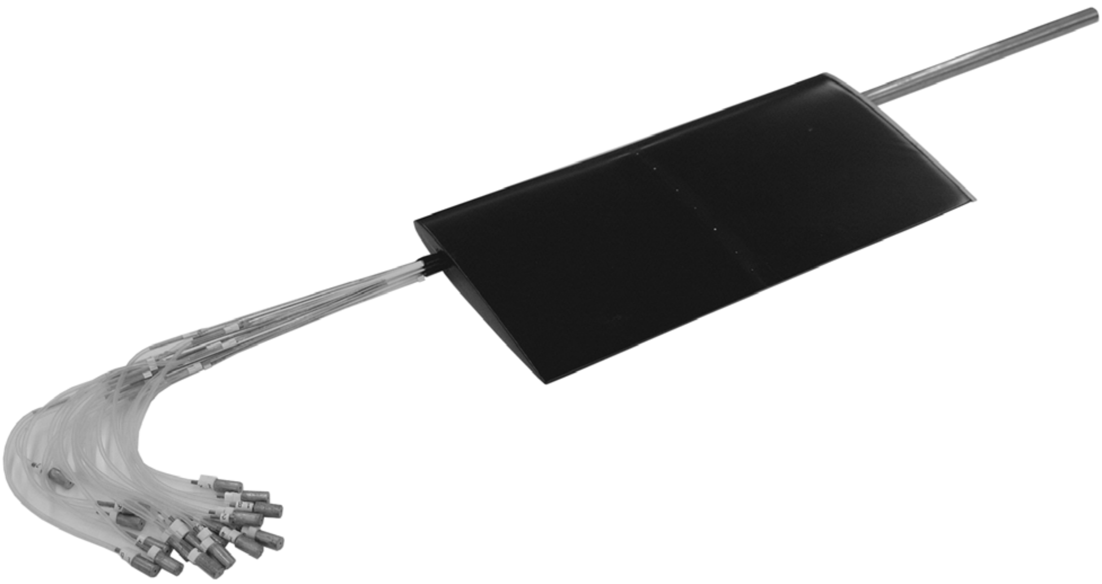

Figure 1 The AF102 Aerofoil with Tappings

The AF102

The AF102 Aerofoil Model is designed for use with the AF100 Subsonic Wind Tunnel. It illustrates:

- the pressure distribution around a symmetrical NACA0012 aerofoil
- characteristics of lift
- drag on an aerofoil (when used with the pitot devices supplied with the AF100)

The Aerofoil 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 Aerofoil Model is a symmetrical NACA0012 section aerofoil of 300 mm span and 150 mm chord. 20 pressure tappings are located on the chord of the aerofoil. They are routed to a set of small diameter tubes that emerge from the end of the aerofoil and connect to small labelled flexible pipes with adaptors (tappings) for connection to a larger diameter pipe.

When fitted inside the working section of a wind tunnel, the angle of incidence of the aerofoil can be adjusted and the resulting pressure distribution around the aerofoil can be measured.

When the model is fitted in the wind tunnel, the pressure tappings may be connected to manometers for pressure measurement. TecQuipment manufacture a selection of suitable multi-tube manometers (such as the AFA1) for use with this model. Alternatively you may use the AFA6 32 - Way pressure display.

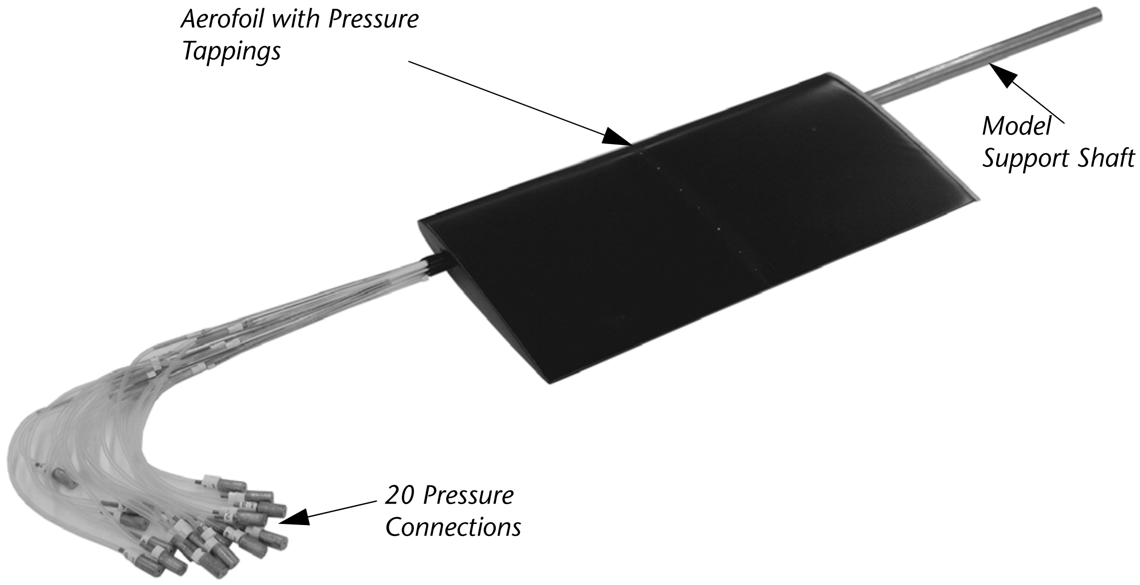

Figure 2 The Main Parts of the Aerofoil Model

Upper Surface Tapping	Distance From Leading Edge
1	0.76
3	3.81
5	11.43
7	19.05
9	38.00
11	62.0
13	80.77
15	101.35
17	121.92
19	137.16

Lower Surface Tapping	Distance From Leading Edge
2	1.52
4	7.62
6	15.24
8	22.86
10	41.15
12	59.44
14	77.73
16	96.02
18	114.30
20	129.54

Table 1 Tapping Positions on the NACA 0012 Aerofoil

Installation

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

NOTE 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: 2 kg

Procedure

1. Make sure the electrical supply to the wind tunnel is disconnected.
2. One of the side panels in the working section has a large model holder with three locking screws. Leave this panel in place, but remove the other panel.
3. Make sure that any pitot tubes in the working section are out of the way.
4. Slide the model support shaft into the model holder in the other side panel. Rotate the model so that the leading edge faces into the air flow (towards the inlet of the wind tunnel). Rotate the model so that the trailing edge is at the same height as the centre line of the model, this is nominally 153 mm (see Figure 3). Tighten the three lock screws of the model holder (see Figure 4).

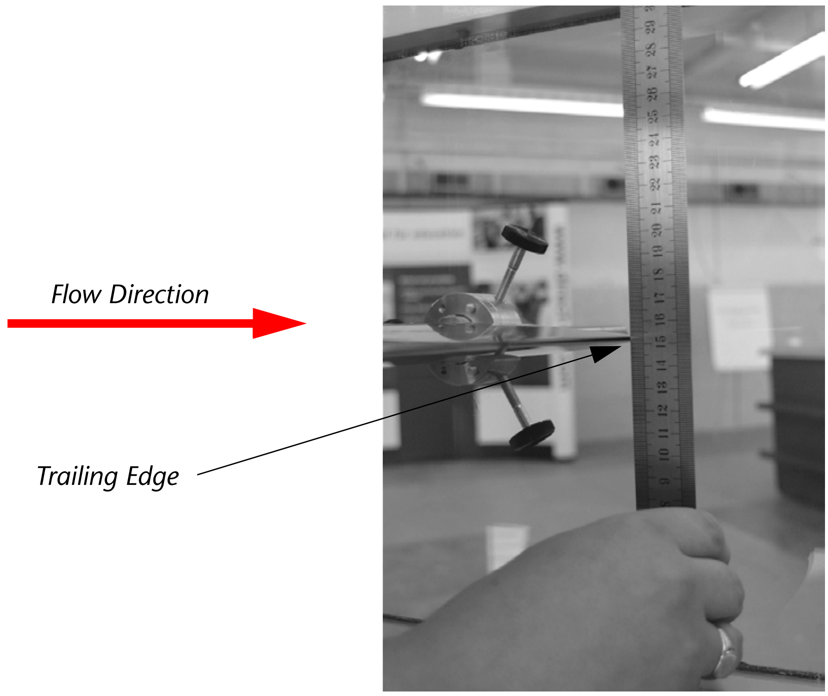

Figure 3 Set the Trailing Edge to the Same Height as the Centre Line

Figure 4 Tighten the Three Lock Screws of the Model Holder

5. Place the protractor onto the support shaft and rotate it so that the model holder pointer is at zero (see figure 5).

6. Tighten the lock screw of the protractor.

7. Remove the blanking plug from the panel you removed in step 2.

8. Carefully feed the flexible tappings through the hole in the panel and refit the side panel (see Figure 6).

Figure 5 Slide Protractor onto Hollow Support Shaft and Set to Zero.

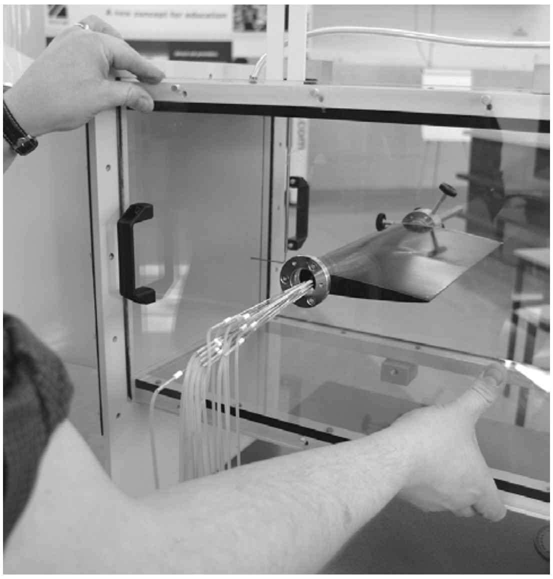

Figure 6 Carefully Feed the Flexible Tapping Pipes through the Hole and Refit the Panel

9. Use the long screws (supplied) to fit the manifold plate to the bottom of the Working Section and Connect the tapping pipes to the front sockets (see Figure 7). Each pipe has a number to make this easier.

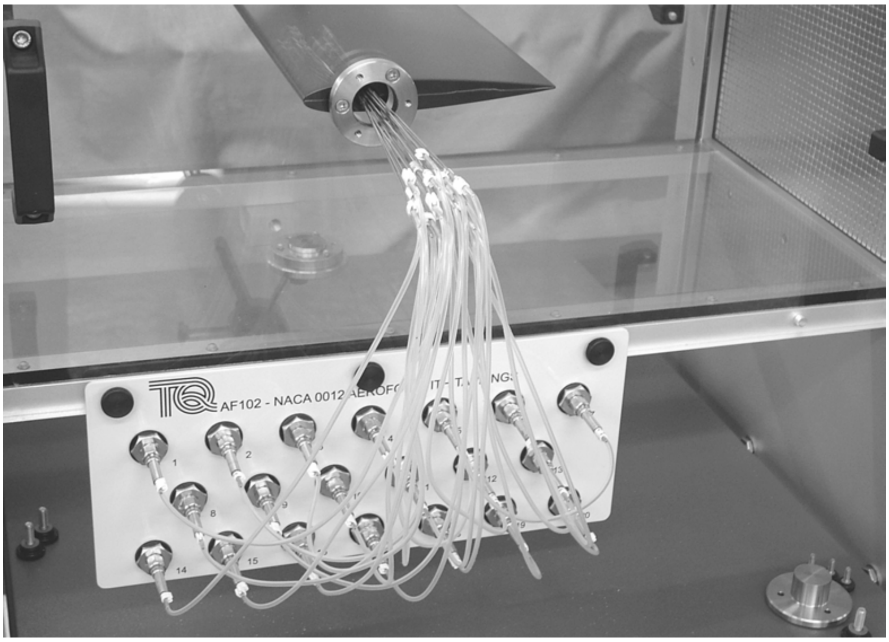

Figure 7 Fit the Manifold Plate and Connect the Pipes

10. Use the pipe supplied with the aerofoil model to connect the outlets at the back of the manifold to a suitable manometer or pressure measurement device (see Figure 8). If you are using the AFA1 Multi-tube manometer, connect the pressure tapping in numerical order or odd ones first then even ones. This gives a clear representation of the pressure distribution round the aerofoil.

Figure 8 Use Pipe Supplied to Connect Back Connections to a Suitable Pressure Measurement Device

Test Procedure

1. Create a blank table of results similar to Table 2. Record the ambient temperature and pressure.

2. Start the Wind Tunnel at a velocity of 33 $m.s^{-1}$. Record the upstream wall pressure of the working section.

3. Set the aerofoil to your chosen angle of incidence (8° gives a good unstalled pressure distribution).

4. Record the manometer reading for each pressure tapping.

5. Repeat the experiment at different angles of incidence. The wing will stall at approximately 12° to 13°, so a post stall result at about 15° will be important.

NOTE *The upper and lower surface tappings are staggered, so that you can obtain results from 40 tapping positions. To do this, remove the aerofoil and re-fit it the opposite way around in the working section. The pressure connections will be on the opposite side of the working section.*

Wall Pressure Upstream, h_w**=** **mm** H_2O

Angle of Aerofoil, α **=**

Ambient Temperature, T_a **=**

Wind Tunnel Velocity, V **=** **m.s**$^{-1}$

	Tapping Number n	Distance From Leading Edge x (mm)	Reading of manometer h_n (mm H_2O)	Local Relative Static Head h_w-h_n (mm H_2O)	Local Relative Static Pressure p_w-p_n (Pa)	Trapezoidal Area (N/m)
Upper Surface	1	0.76				
	3	3.81				
	5	11.43				
	7	19.05				
	9	38.00				
	11	62.00				
	13	80.77				
	15	101.35				
	17	121.92				
	19	137.16				
	END	150				
Lower Surface	2	1.52				
	4	7.62				
	6	15.24				
	8	22.86				
	10	41.15				
	12	59.44				
	14	77.73				
	16	96.02				
	18	114.30				
	20	129.54				
	END	150				
					Total Area Under Graph	

Wing Span = 0.3 m
Wing Area, S **= 0.3 m x 0.15 m = 0.045 m**^{2}

Lift, L **=**

Lift Coefficient, C_L **=**

Table 2 Blank Results Table

Results Analysis

These results show the pressure distribution around the aerofoil. For a more detailed account of pressure distribution around an aerofoil, refer to text books as described in the '**References**' section.

Lift Per Unit Span

A wing creates lift by producing a positive pressure under the aerofoil, and a negative pressure above it. So if the pressure distribution is plotted against the distance from the leading edge, the area under the graph will be equal to the lift per unit span.

Calculate the difference between the local static pressure (p_n) and the wall reference static pressure (p_w) at each tapping point to give the local relative static pressure and enter your results into your table. Plot a graph of local relative static pressure against the distance from the leading edge. The area under the curve will be the lift per unit span.

Tapezoidal Rule

One way of finding the area under a curve is the Trapezoidal rule. This involves dividing the graph up into trapezium shaped strips, calculating the area of each trapezium and summing them to give the total area under the curve (see Figure 9).

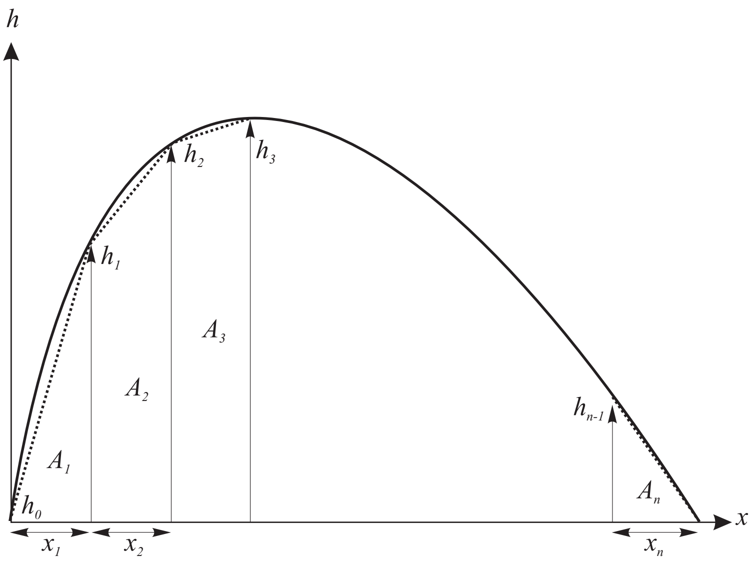

Figure 9 The Trapezoidal Rule

$$A_{total} = A_1 + A_2 + A_3 ....A_n$$

$$= \frac{(h_0 - h_1)}{2} x_1 + \frac{(h_1 + h_2)}{2} x_2 + ... + \left(\frac{h_n - 1 + h_n}{2}\right) x_n$$

If you use strips of equal width and the total number of strips is x_n

$$A_{total} = \frac{x_n}{2}\{(h_0 + h_1) + (h_1 + h_2) + ... + (h_n - 1 + h_n)\}$$

Remember the area under the graph for the lower surface will be opposite in sign to the area under the graph for the upper surface. The two areas must be added to give total lift. Take care when you calculate the total area.

From the lift per unit span, the Lift can be easily calculated. This can be compared to the lift measured using the AFA2 single component balance (or the AFA3 Three component balance) and AF104 Aerofoil Model.

NOTE *The AF102 Tapped aerofoil model cannot be used for direct measurement of lift as the pressure connections would interfere with the measurement. The 300mm Aerofoil from the AF104 is identical in section and span to the AF102 aerofoil and can be used for comparison.*

Coefficient of Lift

Lift is commonly expessed as the non-dimensionalised Lift Coefficient C_L

$$C_L = \frac{L}{\left(\frac{1}{2}\rho V^2 S\right)}$$

Where:

L = Lift
V = Air Velocity
S = Wing Area

Calculate the C_L for each angle of incidence and, and plot a graph of C_L against α. This graph can be compared to the equivalent graph from the AF104 300 mm aerofoil.

Visualisation

Using the AFA1 Multi-tube manometer, connect the pressure tapping in numerical order or odd ones first then even ones. This gives a clear representation of the pressure distribution round the aerofoil. As the speed of the tunnel, or the angle of incidence is altered, the manometer will show the changing pressure distribution. See Figures 10 and 11.

If the AFA10 Smoke Generator is used with the model at the same time as a multi-tube manometer, it gives an excellent visual demonstration. The smoke trace can be used to show how the flow separates from the aerofoil during the stall while the manometer shows the associated deterioration of the pressure distribution.

Figure 10 Example of Levels with Alternate Odd and Even Tapping Connections on the TecQuipment AFA1 Multi-tube Manometer

Figure 11 Example of Levels with Odd then Even Tapping Connections on the TecQuipment AFA1 Multi-tube Manometer

Sample Results

Note: These results are for guidance only, actual results may differ slightly.

	Tapping Number n	Distance From Leading Edge x (mm)	Local Relative Static Head h_w-h_n (mm H_2O)	Local Relative Static Pressure p_w-p_n (Pa)	Trapezoidal Area (N/m)
Angle of Aerofoil, α = 8°					
Ambient Temperature, T_a = 17°C					
Wind Tunnel Velocity, V = 33 m.s^{-1}					
Upper Surface	1	0.76	-184.0	-1805	-0.69
	3	3.81	-164.0	-1609	-5.21
	5	11.43	-114.0	-1118	-10.39
	7	19.05	-94.0	-922	-7.77
	9	38.00	-60.0	-589	-14.31
	11	62.00	-40.0	-392	-11.77
	13	80.77	-32.0	-314	-6.63
	15	101.35	-19.0	-186	-5.15
	17	121.92	-10.0	-98	-2.93
	19	137.16	-3.0	-29	-0.97
	END	150		0	-0.19
Lower Surface	2	1.52	68.0	667	0.51
	4	7.62	46.0	451	3.41
	6	15.24	26.0	255	2.69
	8	22.86	16.0	157	1.57
	10	41.15	6.0	59	1.97
	12	59.44	2.0	20	0.72
	14	77.73	0.0	0	0.18
	16	96.02	2.0	20	0.18
	18	114.30	0.0	0	0.18
	20	129.54	2.0	20	0.15
	END	150		0	
				Total Area Under Graph	77.77
Wing Span = 0.3 m **Wing Area, S = 0.3 m x 0.15 m = 0.045 m^2**					
Lift, L = 77.77 N					
Lift Coefficient, C_L = 23.33					

Table 3 Sample Results at 33 m.s^{-1} and 8° Angle of Incidence

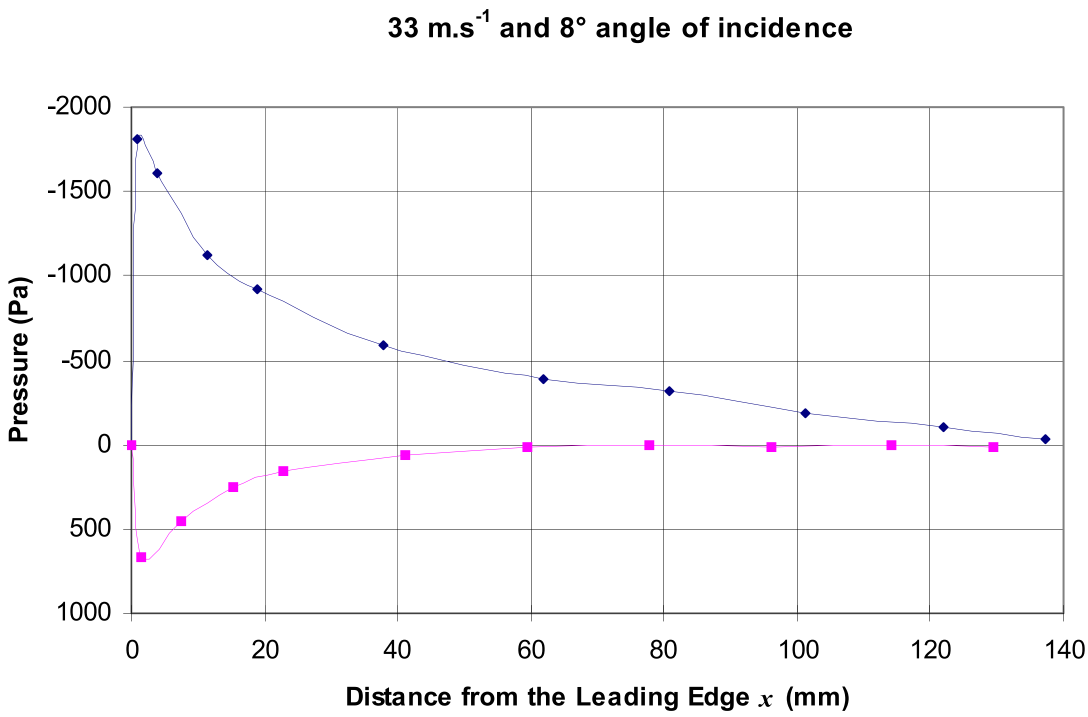

Figure 12 Graph of Local Relative Static Pressure against Distance from Leading Edge

References

Aerodynamics

by LJ Clancy

Published in 1991 by Longman Scientific &Technical

ISBN 0582 988802

Maintenance

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:

Telephone: +44 115 972 2611

Fax: +44 115 973 1520

email: **customer.care@tecquipment.com**

For information about all TecQuipment Products and Services, visit:

www.tecquipment.com