AF101

Cylinder 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.

MB/DB/bs/1208

TecQuipment

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Figure 1 The AF101 Cylinder Model

The AF101

The AF101 Cylinder Model is designed for use with the AF100 Subsonic Wind Tunnel. It shows the pressure distribution around a cylinder and can be used with the Single Component Balance (AFA2) or Three Component Balance (AFA3) (not supplied) to give direct readings of drag.

The Cylinder Model is just one of a range of models that TecQuipment manufactures to accompany our range of wind tunnels. Each model allows a wide variety of experiments and demonstrations to be conducted.

The Cylinder Model is made from a tube with one end sealed and the other end fixed to a hollow model support shaft with a pressure connection. A small hole is drilled through the wall of the cylinder, this is the pressure measurement point. When fitted inside the working section of a wind tunnel, and connected to a suitable pressure measurement device, the cylinder can be rotated to measure the static pressure at any point and give the pressure distribution around the cylinder. TecQuipment manufactures a selection of suitable manometers for use with this model.

When used with the AFA10 Smoke Generator, the flow round a cylinder can be visualised. If the cylinder model is used with the AF100 Wind Tunnel, the working section pitot tube can be used to perform a wake traverse to find the pressure distribution downstream of the cylinder. From this, the drag can be calculated and compared to direct measurements from the balance.

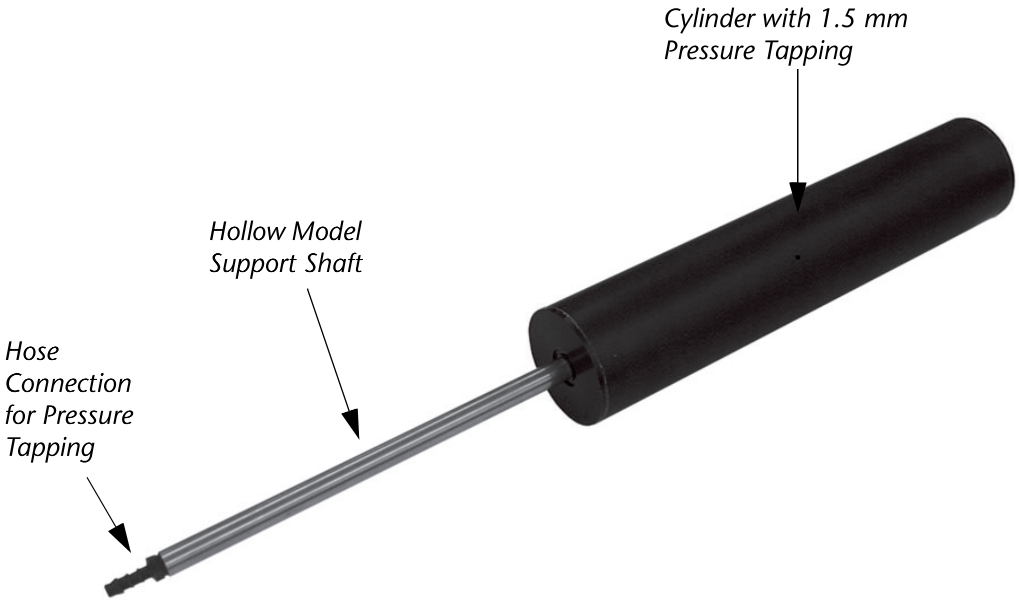


Figure 2 The Main Parts of the Cylinder Model

Technical Details

Item	Details
Dimensions	63.5 mm Diameter (Nominal) 300 mm Length (Nominal) 1.5 mm hole
Weight	1 kg

Assembly and Installation

Refer to the test procedures for full details.

Notation

Symbol	Description	Units
D	Drag	Newton (N)
C_D	Coefficient of Drag	-
d	Diameter	m
V	Air Velocity	$m.s^{-1}$
ρ	Air Density	$kg.m^{-3}$
p	Pressure	Pascal (Pa)
b	Length	m

Test Procedures

Pressure Distribution Test

Aim

To determine the pressure distribution around the cylinder

Assembly 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 any pitot tubes in the working section are out of the way.

4. Slide the hollow model support shaft into the model holder in the other side panel. Rotate the model so that you can see the pressure measurement hole. It must face into the air flow (towards the inlet of the wind tunnel). Rotate the model so that the hole 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).

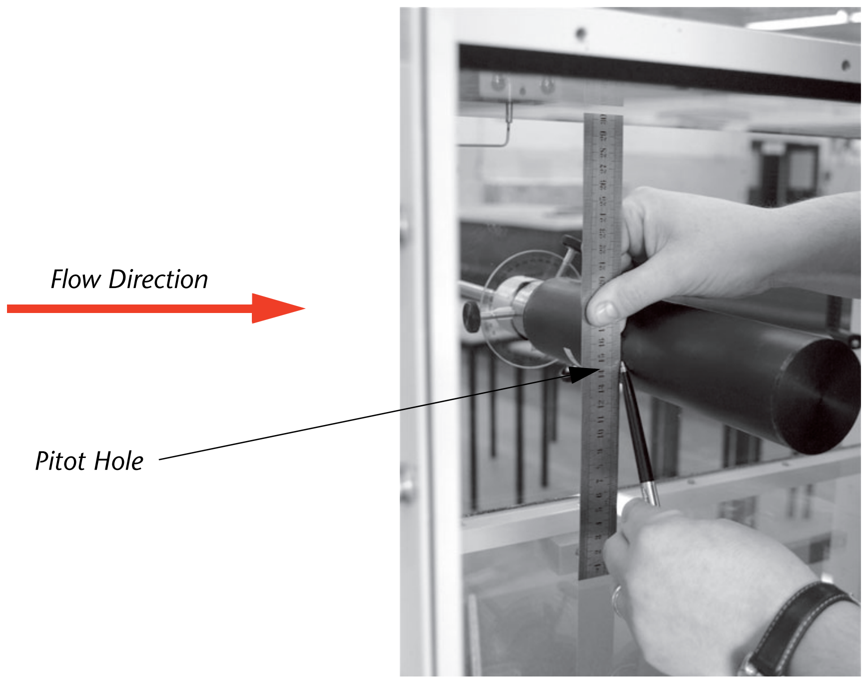


Figure 3 Rotate the Model so that the Pitot Hole is at the Same Height as the Model Centre Line

Figure 4 Tighten the Three Lock Screws of the Model Holder

5. Place the protractor onto the hollow 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. Use the pipe supplied with the cylinder model to connect its hose connector to a suitable manometer.

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

Test Procedure

1. Create a blank table of results similar to Table 1. Record the ambient temperature and pressure.
2. Start the Wind Tunnel at a velocity of 25 $m.s^{-1}$. Record the upstream (static) wall pressure (p_w) of the working section.
3. Record the manometer reading of the pressure at the cylinder pitot hole (p).
4. Rotate the cylinder model in 10 degree increments and record the manometer reading each time.
5. Repeat the experiment at a tunnel velocity of 33 $m.s^{-1}$.
6. Refer to the **Analysis** to calculate the last two columns of your table.

Wind Tunnel Speed, V		**$m.s^{-1}$**		
Wall static pressure, $p_w = p_\infty$		**mm H_20**		
Atmospheric Pressure, p_a		**mbar**		
Ambient Temperature, T_a		**°C**		
Calculated Air Density, ρ		**kg/m^3**		
Angle θ	p **(mm H_2O)**	p-p_∞ **(mm H_2O)**	**Actual Pressure Coefficient** C_p	**Ideal Pressure Coefficient** **$1\text{-}4\sin^2\theta$**
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
100				
110				
120				
130				
140				
150				
160				
170				
180				

Table 1 Blank Results Table

Analysis

For a more detailed account of pressure distribution, refer to text books as described in the '**References**' section.

$$\text{Air Density } \rho = \frac{p_a}{RT_a}$$

and

$$\text{Actual Pressure Coefficient } C_p = \frac{p - p\infty}{\frac{1}{2}\rho V^2}$$

and Ideal fluid theory shows that:

$$p = p\infty + \frac{1}{2}\rho V^2 - 2\rho V^2 \sin^2\theta$$

So

$$\text{Ideal Pressure Coefficient } C_p = 1 - 4\sin^2\theta$$

Where:

p_a = Atmospheric Pressure
T_a = Ambient Temperature
R = Universal Molar Gas Constant (= 287 J/kgK)
p = Measured Pressure
$p\infty$ = Free stream static pressure

Calculate the Actual and Ideal Pressure Coefficients at each angle of the cylinder and enter your figures into your results table.

Plot a graph of Ideal Pressure Coefficient and the Actual Pressure Coefficient against the angle (0 to 180 degrees).

Wake Traverse Test

Aim

To determine the pressure distribution downstream of the cylinder (in its wake) and use the results to calculate profile drag.

Procedure

1. Create a blank table of results similar to Table 2.

2. Fit the ***pitot-static*** tube to the ***upstream*** (free stream) position and the ***basic pitot*** tube to the ***downstream*** position on the working section (see Figure 6). Connect the pitot and pitot-static tubes to manometers as shown in Figure 6.

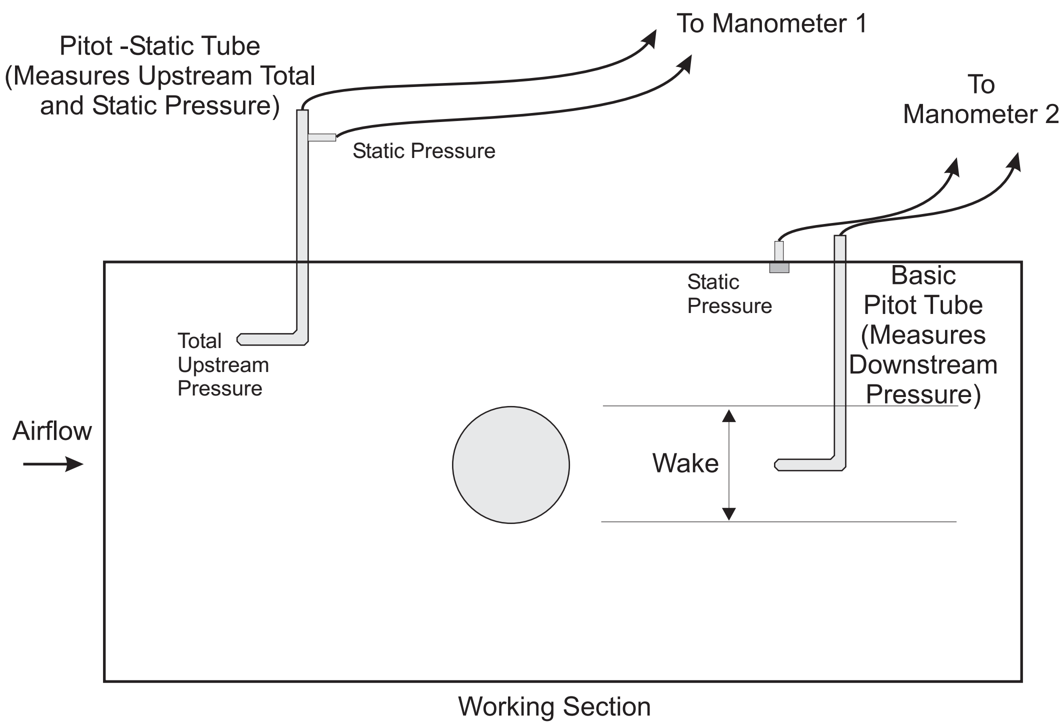


Figure 6 Wake Traverse Experiment Set Up

3. From inside the Working Section, fit the cylinder into the model holder and tighten the model holder.

4. Make a note of the ambient conditions and set the tunnel air speed to 25 $m.s^{-1}$.

5. Position the pitot-static tube (upstream) in the free stream approximately ¼ distance down the Working Section. Use both its connections, connected to a manometer to measure and record the difference between upstream static and total pressure.

6. Connect the basic pitot tube (downstream) to a second manometer, connect the downstream wall tapping of the Working section to the other port of this manometer. The manometer will measure the difference between downstream total and static pressure.

7. Make a note of the width (height) of the wake. To do this:
   - Move the basic tube slowly downwards until the manometer reading just begins to change, this is one edge of the wake. Make a note of this position from the scale of the basic pitot tube.
   - Move the basic pitot tube further down until its manometer readings return their original 'out of the wake' value. Make a note of this position from the scale of the basic pitot tube.
   - Use your measurements to determine the width (height) of the wake
8. Now use the basic pitot tube to measure the pressures in the wake at suitable distance increments, between 2 mm and 10 mm (depending on the width of the wake). Also record the pressures just above and just below the wake. Record your results in your Results Table.
9. Refer to the **Analysis** to calculate the last two columns of your table.

Analysis

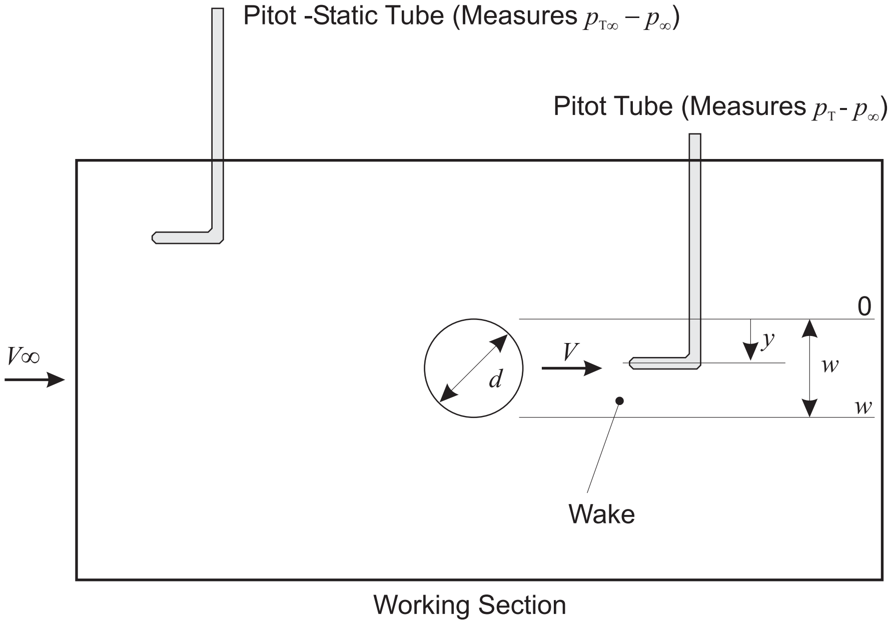


Figure 7 The Wake Traverse Experiment

The profile drag of the cylinder is equal to the loss of momentum of the air due to the cylinder.

Generally,

$$\text{Mass Flow } \dot{m}(V\infty - V) = \text{Drag}$$

So, by integrating across the wake:

$$\text{Drag} = \int_0^w \rho V(V\infty - V)\delta y \qquad (1)$$

It is convienient to express drag as the non-dimensional coefficient:

$$C_D = \frac{Drag}{\frac{1}{2}\rho V\infty^2 db} \tag{2}$$

So

$$C_D = 2\int_0^{w/d} \frac{V}{V\infty}\left(1 - \frac{V}{V\infty}\right)\delta\left(\frac{y}{d}\right) \tag{3}$$

Where

$$\frac{V}{V\infty} = \sqrt{\frac{p_T - p\infty}{p_{T\infty} - p\infty}} \tag{4}$$

Calculate $\sqrt{\frac{p_T - p\infty}{p_{T\infty} - p\infty}}$ and $\frac{V}{V\infty}\left(1 - \frac{V}{V\infty}\right)$ from your results and plot a graph of $\frac{V}{V\infty}\left(1 - \frac{V}{V\infty}\right)$ against y/d. As shown Equation 3, the area under the graph is equal to 1/2 C_D.

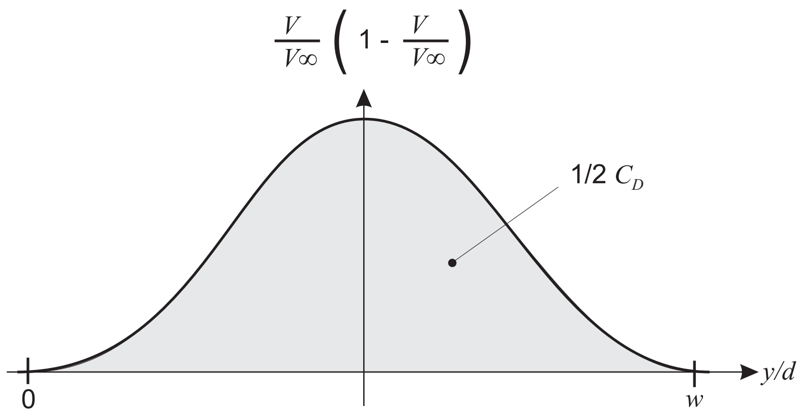


Figure 8 Ideal Graph of Calculated Drag

If the Single Component Balance (AFA2) or the Three Component Balance (AFA3) is available, the calculated drag coefficient can be compared to the direct measurement.

Free Stream Total - Static Pressure $p_{T\infty} - p_{\infty}$ **: ___ mm** H_2O	
Ambient Pressure: ____ mbar	**Ambient Temperature:__°C**
Air Velocity: _____ m.s^{-1}	

Pitot Scale Reading (mm)	**IN/OUT of Wake**	**Downstream Total - Static Pressure** $p_T - p_{\infty}$ **(mm** H_2O**)**	$\sqrt{\frac{p_T - p_{\infty}}{p_{T\infty} - p_{\infty}}}$	$\frac{V}{V_{\infty}}\left(1 - \frac{V}{V_{\infty}}\right)$

Table 2 Blank Results Table for Wake Traverse Experiment

Drag Test

If you have TecQuipment's optional Two or Three Component Balances (AFA2 and AFA3), use one of them with the Cylinder Model to determine the cylinder drag coefficient and compare it with your results from the wake traverse.

Refer to the Two or Three Component Balance User Guides for details.

NOTE *You must compare the drag coefficient for the same air speed*

Sample Results and Conclusions

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

Pressure Distribution Test

Wind Tunnel Speed, V		**25 m.s^{-1}**		
Wall static pressure, $p_w = p\infty$		**-39 mm H_20**		
Atmospheric Pressure, p_a		**1035 mbar**		
Ambient Temperature, T_a		**17 °C**		
Calculated Air Density, ρ		**1.244 kg/m^3**		
Angle θ	p **(mm H_2O)**	p-$p\infty$ **(mm H_2O)**	**Actual Pressure Coefficient** C_p	**Ideal Pressure Coefficient** **1- 4sin$^2\theta$**
0	0	39	0.985	1.000
10	-2	37	0.934	0.879
20	-12	27	0.682	0.532
30	-30	9	0.227	0.000
40	-52.5	-13.5	-0.341	-0.653
50	-75	-36	-0.909	-1.347
60	-92	-53	-1.338	-2.000
70	-101	-62	-1.565	-2.532
80	-100	-61	-1.540	-2.879
90	-95	-56	-1.414	-3.000
100	-92.5	-53.5	-1.351	-2.879
110	-92.5	-53.5	-1.351	-2.532
120	-92.5	-53.5	-1.351	-2.000
130	-92.5	-53.5	-1.351	-1.347
140	-92.5	-53.5	-1.351	-0.653
150	-91	-52	-1.313	0.000
160	-92.5	-53.5	-1.351	0.532
170	-91	-52	-1.313	0.879
180	-90	-51	-1.287	1.000

Table 3 Results For Pressure Distribution Experiment at 25 m.s^{-1}

Wind Tunnel Speed, V	**33 m.s^{-1}**
Wall static pressure, $p_w = p\infty$	**-71 mm H_20**
Atmospheric Pressure, p_a	**1035 mbar**
Ambient Temperature, T_a	**17 °C**
Calculated Air Density, ρ	**1.244 kg/m^3**

Angle θ	p **(mm H_2O)**	p-$p\infty$ **(mm H_2O)**	**Actual Pressure Coefficient** Cp	**Ideal Pressure Coefficient** **1-4sin$^2\theta$**
0	0	71	1.029	1.000
10	-3	68	0.985	0.879
20	-21	50	0.724	0.532
30	-51	20	0.290	0.000
40	-91	-20	-0.290	-0.653
50	-126	-55	-0.797	-1.347
60	-166	-95	-1.376	-2.000
70	-182	-111	-1.608	-2.532
80	-176	-105	-1.521	-2.879
90	-161	-90	-1.304	-3.000
100	-163	-92	-1.333	-2.879
110	-161	-90	-1.304	-2.532
120	-161	-90	-1.304	-2.000
130	-162	-91	-1.318	-1.347
140	-163	-92	-1.333	-0.653
150	-163	-92	-1.333	0.000
160	-163	-92	-1.333	0.532
170	-163	-92	-1.333	0.879
180	-164	-93	-1.347	1.000

Table 4 Results For Pressure Distribution Experiment at 33 m.s^{-1}

Conclusions

Ideal fluid flow assumes that the flow remains attached all round the cylinder. In reality, viscous effects cause the flow to separate from the downstream surface of the cylinder. This is shown by the example results. The flow separation and turbulent wake can be clearly seen if the optional AFA10 Smoke Generator is used.

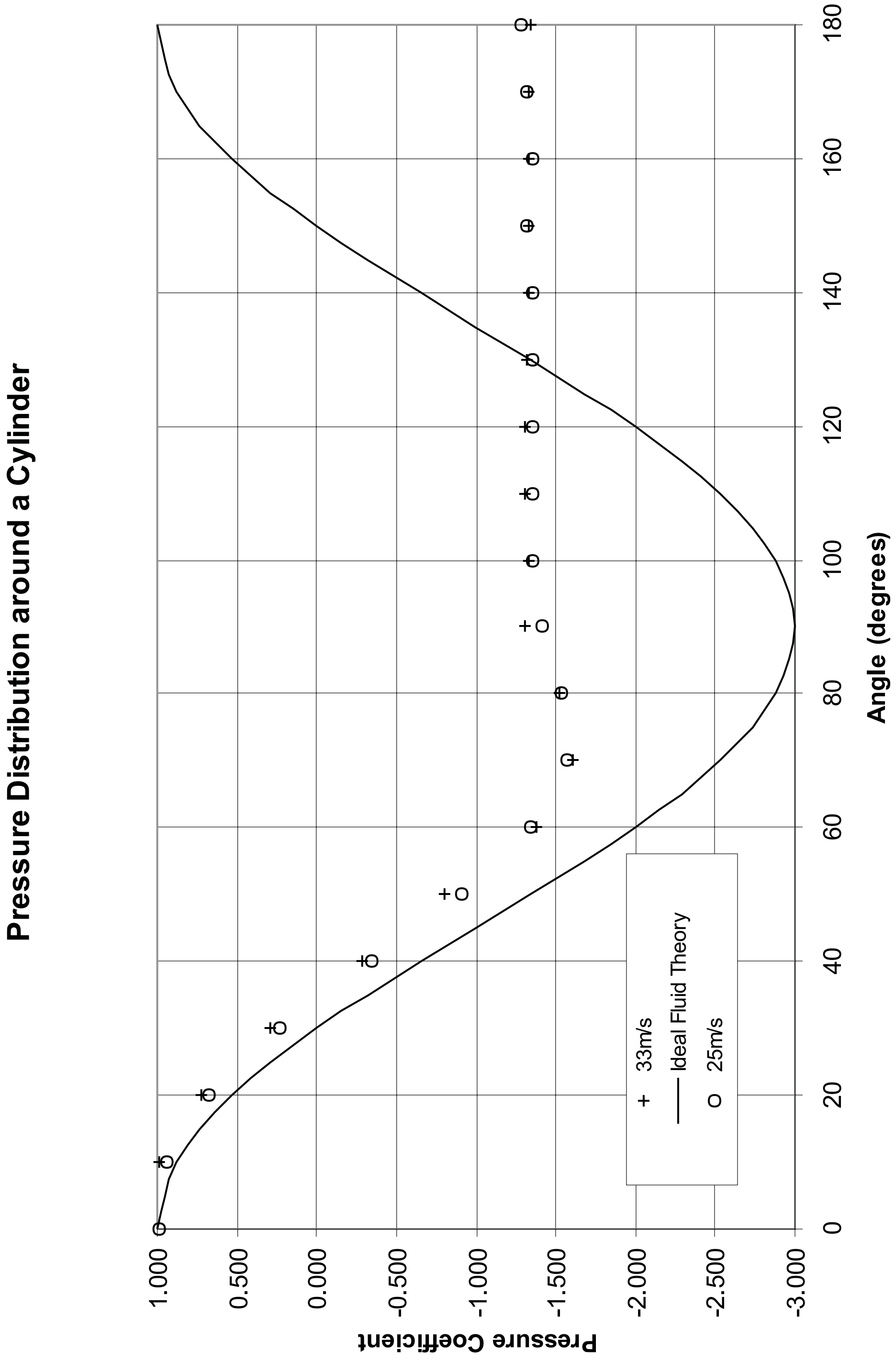
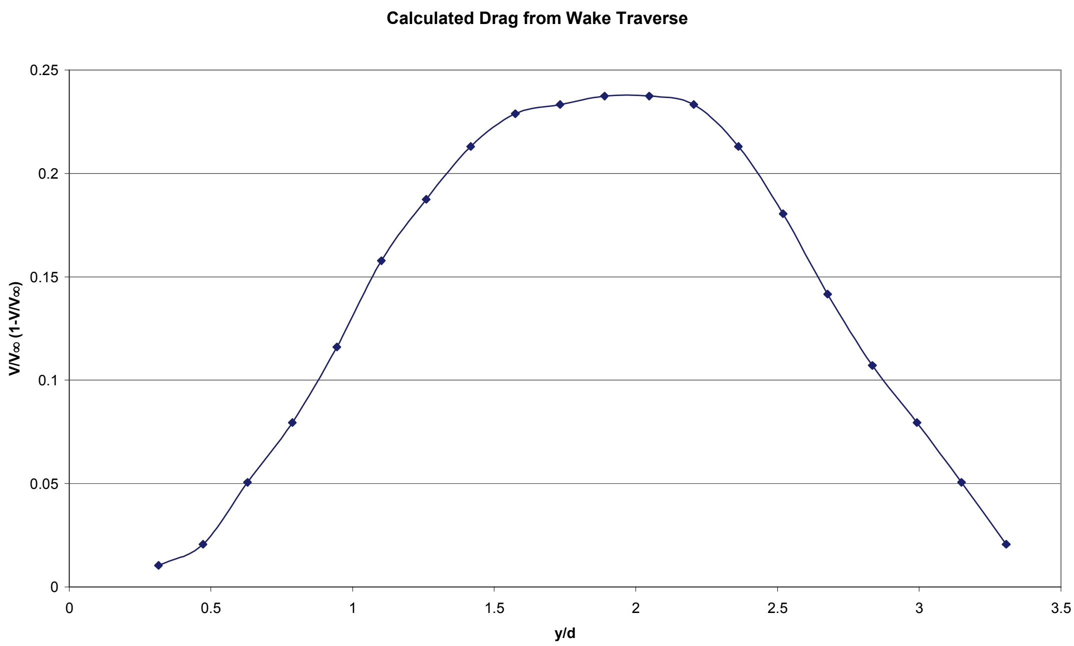


Figure 9 Chart of Ideal and Actual Pressure Distribution Around the Cylinder at Both Test Speeds.

Wake Traverse Test

Free Stream Total - Static Pressure $p_{T\infty} - p_\infty$: 48 mm H_2O				
Ambient Pressure: 1021 mbar		Ambient Temperature:22°C		
Air Velocity: 27.94 $m.s^{-1}$				
Pitot Scale Reading (mm)	**IN/OUT of Wake**	**Downstream Total - Static Pressure $p_T - p_\infty$ (mm H_2O)**	$\sqrt{\frac{p_T - p_\infty}{p_{T\infty} - p_\infty}}$	$\frac{V}{V_\infty}\left(1 - \frac{V}{V_\infty}\right)$
260	out	48	0.31927542	0
250	out	48	0.31927542	0
240	in	46	0.31255308	0.02061167
230	in	46	0.31255308	0.02061167
220	in	43	0.30218931	0.05065139
210	in	40	0.29145725	0.07953759
200	in	37	0.28031461	0.10713781
190	in	33	0.2647292	0.14165619
180	in	28	0.24385063	0.18042928
170	in	23	0.22100840	0.21305198
160	in	19	0.20087305	0.23331953
150	in	18	0.19551547	0.23737243
140	in	18	0.19551547	0.23737243
130	in	19	0.20087305	0.23331953
120	in	20	0.20609140	0.22883055
110	in	23	0.22100840	0.21305198
100	in	27	0.23945657	0.1875
90	in	31	0.25658172	0.15780423
80	in	36	0.27650063	0.11602540
70	in	40	0.29145725	0.07953759
60	in	43	0.30218931	0.05065139
50	in	46	0.31255308	0.02061167
40	in	47	0.31593213	0.01036184
30	out	48	0.31927542	0
20	out	48	0.31927542	0

Table 5 Results for Wake Traverse Test



Graph 1 Results for Wake Traverse Test

The area under the graph was found by division into strips to give a total area of 0.408. As shown in the results analysis, the area is equal to half the coefficient of drag, so actual C_D is calculated as 0.816.

Drag Test

These results were found by use of TecQuipment's Three Component Balance (AFA3) with the Cylinder Model at the same air speed and ambient conditions as the wake traverse test.

Ambient Pressure	1021 mbar
Ambient Temperature	22°C
Lift	-0.1 N
Drag	8.8 N
Pitching Moment	-0.01 Nm
C_L	-0.011
C_D	0.981
C_M	-0.001

Conclusion

The drag coefficient results from both the wake and the balance are very similar. What do you think could be the cause of any errors? How could the wake traverse be made more accurate?

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 hole for dust. remove any blockages with a dry air line.

CAUTION

Never try to force any objects (pins or wire) into the pitot hole. It is precision drilled and any damage will affect the readings.

Do not blow into the pitot hole, human saliva will block it.

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.

Customer Care

We hope you find our products and manuals satisfactory. If you have any questions, do not hesitate to contact our Customer Care department immediately:

Tel: +44 115 954 0155

Fax: +44 115 973 1520

Email: **customercare@tecquipment.com**

TecQuipment

AF101

Cylinder Model

User Guide

Introduction

Figure 1 The AF101 Cylinder Model

The AF101

The AF101 Cylinder Model is designed for use with the AF100 Subsonic Wind Tunnel. It shows the pressure distribution around a cylinder and can be used with the Single Component Balance (AFA2) or Three Component Balance (AFA3) (not supplied) to give direct readings of drag.

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The Cylinder Model is made from a tube with one end sealed and the other end fixed to a hollow model support shaft with a pressure connection. A small hole is drilled through the wall of the cylinder, this is the pressure measurement point. When fitted inside the working section of a wind tunnel, and connected to a suitable pressure measurement device, the cylinder can be rotated to measure the static pressure at any point and give the pressure distribution around the cylinder. TecQuipment manufactures a selection of suitable manometers for use with this model.

When used with the AFA10 Smoke Generator, the flow round a cylinder can be visualised. If the cylinder model is used with the AF100 Wind Tunnel, the working section pitot tube can be used to perform a wake traverse to find the pressure distribution downstream of the cylinder. From this, the drag can be calculated and compared to direct measurements from the balance.

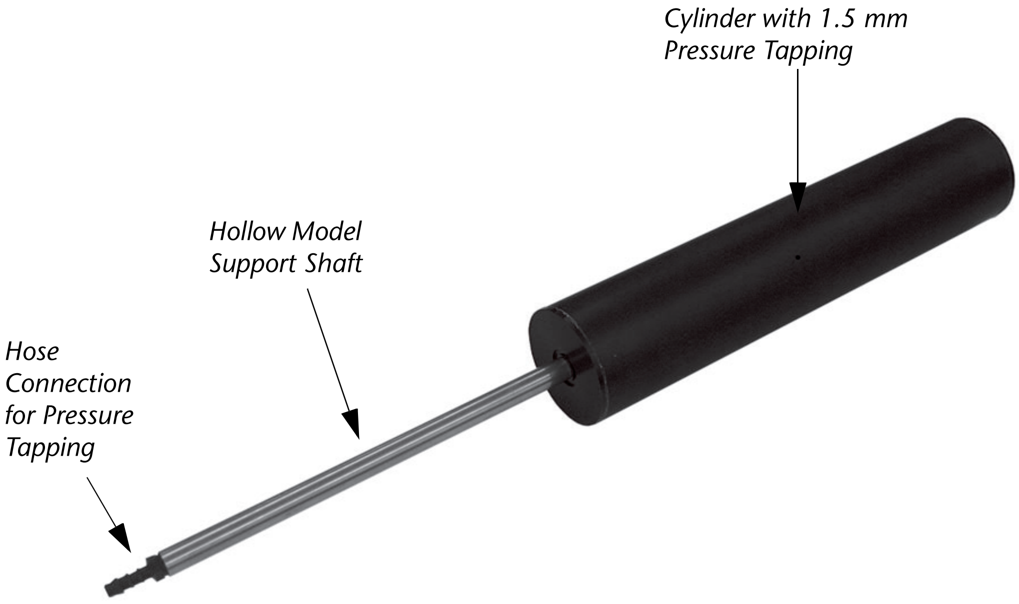

Figure 2 The Main Parts of the Cylinder Model

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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 any pitot tubes in the working section are out of the way.

4. Slide the hollow model support shaft into the model holder in the other side panel. Rotate the model so that you can see the pressure measurement hole. It must face into the air flow (towards the inlet of the wind tunnel). Rotate the model so that the hole 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).

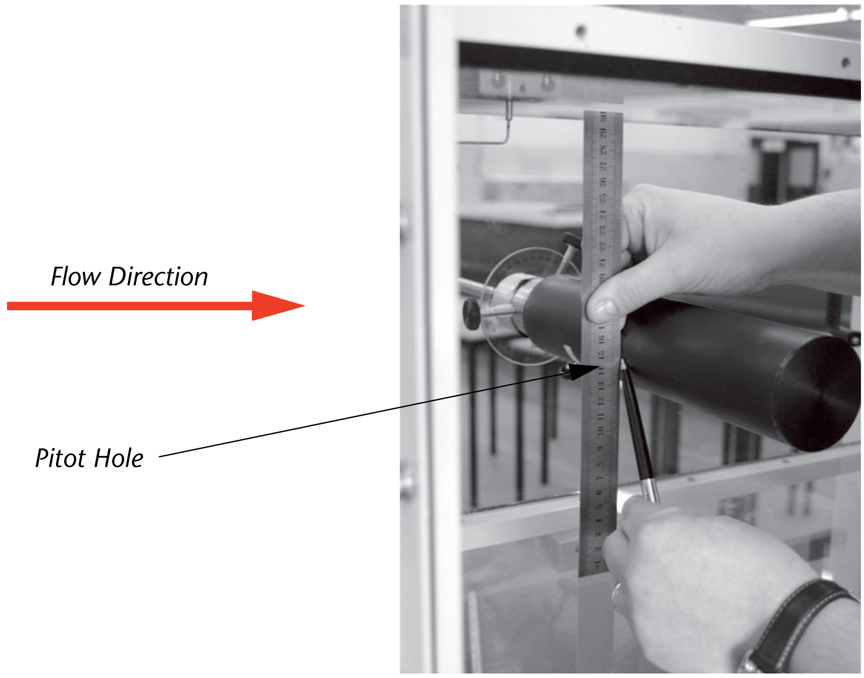

Figure 3 Rotate the Model so that the Pitot Hole is at the Same Height as the Model Centre Line

Figure 4 Tighten the Three Lock Screws of the Model Holder

5. Place the protractor onto the hollow 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. Use the pipe supplied with the cylinder model to connect its hose connector to a suitable manometer.

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

Test Procedure

1. Create a blank table of results similar to Table 1. Record the ambient temperature and pressure.
2. Start the Wind Tunnel at a velocity of 25 m.s^{-1}. Record the upstream (static) wall pressure (p_w) of the working section.
3. Record the manometer reading of the pressure at the cylinder pitot hole (p).
4. Rotate the cylinder model in 10 degree increments and record the manometer reading each time.
5. Repeat the experiment at a tunnel velocity of 33 m.s^{-1}.
6. Refer to the **Analysis** to calculate the last two columns of your table.

Wind Tunnel Speed, V	**m.s^{-1}**
Wall static pressure, $p_w = p\infty$	**mm H_20**
Atmospheric Pressure, p_a	**mbar**
Ambient Temperature, T_a	**°C**
Calculated Air Density, ρ	**kg/m^3**

Angle θ	p **(mm H_2O)**	p-$p\infty$ **(mm H_2O)**	**Actual Pressure Coefficient** C_p	**Ideal Pressure Coefficient** **1-4sin$^2\theta$**
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
100				
110				
120				
130				
140				
150				
160				
170				
180				

Table 1 Blank Results Table

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and Ideal fluid theory shows that:

$$p = p\infty + \frac{1}{2}\rho V^2 - 2\rho V^2 \sin^2\theta$$

So

$$\text{Ideal Pressure Coefficient } C_p = 1 - 4\sin^2\theta$$

Where:

p_a = Atmospheric Pressure
T_a = Ambient Temperature
R = Universal Molar Gas Constant (= 287 J/kgK)
p = Measured Pressure
$p\infty$ = Free stream static pressure

Calculate the Actual and Ideal Pressure Coefficients at each angle of the cylinder and enter your figures into your results table.

Plot a graph of Ideal Pressure Coefficient and the Actual Pressure Coefficient against the angle (0 to 180 degrees).

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Aim

To determine the pressure distribution downstream of the cylinder (in its wake) and use the results to calculate profile drag.

Procedure

1. Create a blank table of results similar to Table 2.

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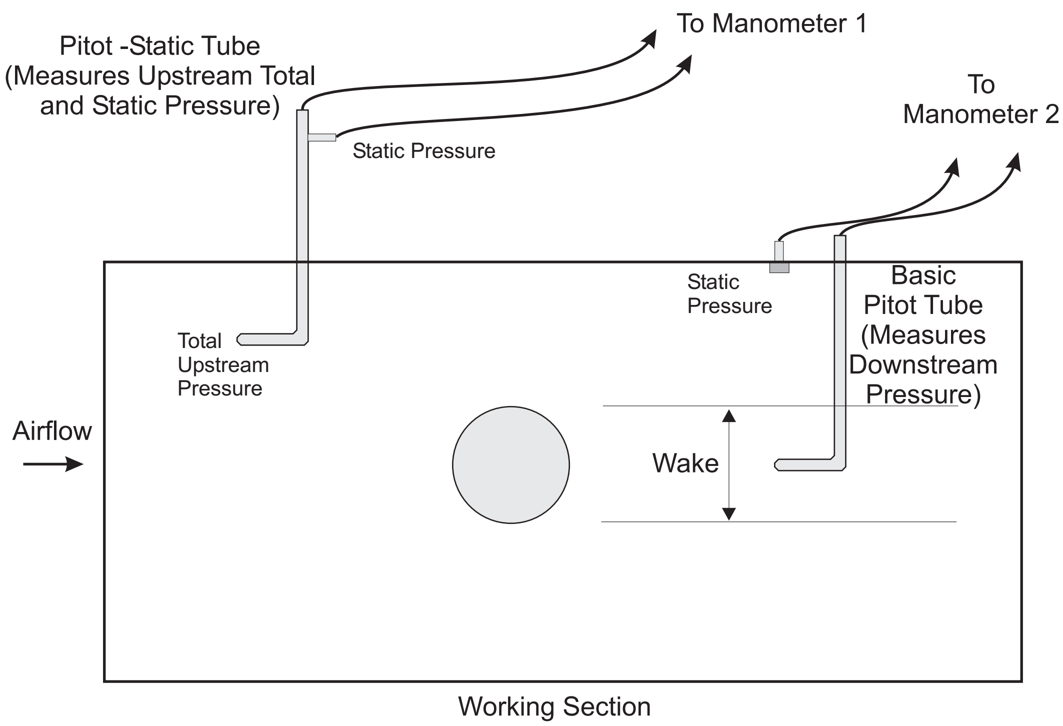

Figure 6 Wake Traverse Experiment Set Up

3. From inside the Working Section, fit the cylinder into the model holder and tighten the model holder.

4. Make a note of the ambient conditions and set the tunnel air speed to 25 m.s^{-1}.

5. Position the pitot-static tube (upstream) in the free stream approximately ¼ distance down the Working Section. Use both its connections, connected to a manometer to measure and record the difference between upstream static and total pressure.

6. Connect the basic pitot tube (downstream) to a second manometer, connect the downstream wall tapping of the Working section to the other port of this manometer. The manometer will measure the difference between downstream total and static pressure.

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   - Move the basic tube slowly downwards until the manometer reading just begins to change, this is one edge of the wake. Make a note of this position from the scale of the basic pitot tube.
   - Move the basic pitot tube further down until its manometer readings return their original 'out of the wake' value. Make a note of this position from the scale of the basic pitot tube.
   - Use your measurements to determine the width (height) of the wake

8. Now use the basic pitot tube to measure the pressures in the wake at suitable distance increments, between 2 mm and 10 mm (depending on the width of the wake). Also record the pressures just above and just below the wake. Record your results in your Results Table.

9. Refer to the **Analysis** to calculate the last two columns of your table.

Analysis

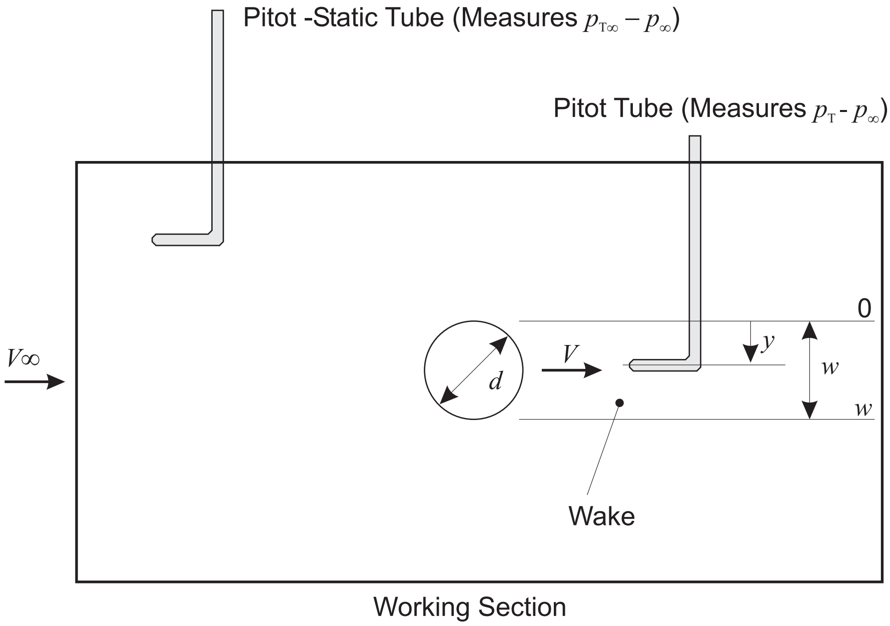


Figure 7 The Wake Traverse Experiment

The profile drag of the cylinder is equal to the loss of momentum of the air due to the cylinder.

Generally,

$$\text{Mass Flow } \dot{m}(V\infty - V) = \text{Drag}$$

So, by integrating across the wake:

$$\text{Drag} = \int_0^w \rho V(V\infty - V)\delta y \qquad (1)$$

It is convienient to express drag as the non-dimensional coefficient:

$$C_D = \frac{Drag}{\frac{1}{2}\rho V\infty^2 db} \tag{2}$$

So

$$C_D = 2\int_0^{w/d} \frac{V}{V\infty}\left(1 - \frac{V}{V\infty}\right)\delta\left(\frac{y}{d}\right) \tag{3}$$

Where

$$\frac{V}{V\infty} = \sqrt{\frac{p_T - p\infty}{p_{T\infty} - p\infty}} \tag{4}$$

Calculate $\sqrt{\frac{p_T - p\infty}{p_{T\infty} - p\infty}}$ and $\frac{V}{V\infty}\left(1 - \frac{V}{V\infty}\right)$ from your results and plot a graph of $\frac{V}{V\infty}\left(1 - \frac{V}{V\infty}\right)$ against y/d. As shown Equation 3, the area under the graph is equal to 1/2 C_D.

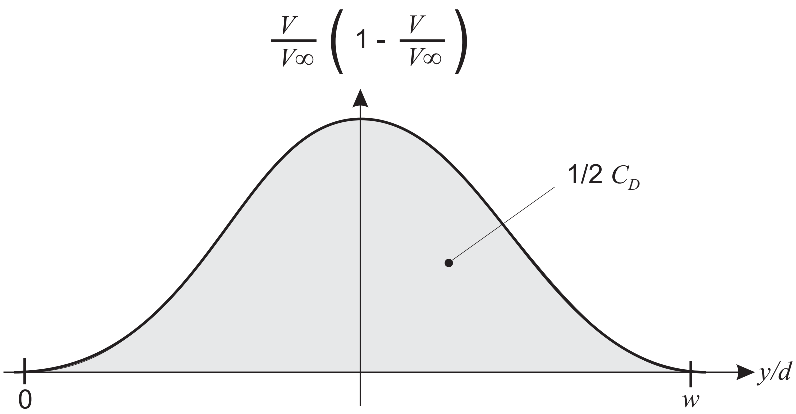


Figure 8 Ideal Graph of Calculated Drag

If the Single Component Balance (AFA2) or the Three Component Balance (AFA3) is available, the calculated drag coefficient can be compared to the direct measurement.

Free Stream Total - Static Pressure $p_{T\infty} - p_{\infty}$ **: ___ mm** H_2O				
Ambient Pressure: ____ mbar		**Ambient Temperature:__°C**		
Air Velocity: _____ m.s^{-1}				
Pitot Scale Reading (mm)	**IN/OUT of Wake**	**Downstream Total - Static Pressure** $p_T - p_{\infty}$ **(mm** H_2O**)**	$\sqrt{\dfrac{p_T - p_{\infty}}{p_{T\infty} - p_{\infty}}}$	$\dfrac{V}{V_{\infty}}\left(1 - \dfrac{V}{V_{\infty}}\right)$

Table 2 Blank Results Table for Wake Traverse Experiment

Drag Test

If you have TecQuipment's optional Two or Three Component Balances (AFA2 and AFA3), use one of them with the Cylinder Model to determine the cylinder drag coefficient and compare it with your results from the wake traverse.

Refer to the Two or Three Component Balance User Guides for details.

NOTE *You must compare the drag coefficient for the same air speed*

Sample Results and Conclusions

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

Pressure Distribution Test

Wind Tunnel Speed, V		**25 m.s^{-1}**		
Wall static pressure, $p_w = p_\infty$		**-39 mm H_20**		
Atmospheric Pressure, p_a		**1035 mbar**		
Ambient Temperature, T_a		**17 °C**		
Calculated Air Density, ρ		**1.244 kg/m^3**		
Angle θ	p **(mm H_2O)**	p-p_∞ **(mm H_2O)**	**Actual Pressure Coefficient** C_p	**Ideal Pressure Coefficient** **1- 4sin$^2\theta$**
0	0	39	0.985	1.000
10	-2	37	0.934	0.879
20	-12	27	0.682	0.532
30	-30	9	0.227	0.000
40	-52.5	-13.5	-0.341	-0.653
50	-75	-36	-0.909	-1.347
60	-92	-53	-1.338	-2.000
70	-101	-62	-1.565	-2.532
80	-100	-61	-1.540	-2.879
90	-95	-56	-1.414	-3.000
100	-92.5	-53.5	-1.351	-2.879
110	-92.5	-53.5	-1.351	-2.532
120	-92.5	-53.5	-1.351	-2.000
130	-92.5	-53.5	-1.351	-1.347
140	-92.5	-53.5	-1.351	-0.653
150	-91	-52	-1.313	0.000
160	-92.5	-53.5	-1.351	0.532
170	-91	-52	-1.313	0.879
180	-90	-51	-1.287	1.000

Table 3 Results For Pressure Distribution Experiment at 25 m.s^{-1}

Wind Tunnel Speed, V	$33\ m.s^{-1}$
Wall static pressure, $p_w = p\infty$	-71 mm H_20
Atmospheric Pressure, p_a	1035 mbar
Ambient Temperature, T_a	17 °C
Calculated Air Density, ρ	1.244 kg/m^3

Angle θ	p (mm H_2O)	p-$p\infty$ (mm H_2O)	Actual Pressure Coefficient Cp	Ideal Pressure Coefficient $1\text{-}4\sin^2\theta$
0	0	71	1.029	1.000
10	-3	68	0.985	0.879
20	-21	50	0.724	0.532
30	-51	20	0.290	0.000
40	-91	-20	-0.290	-0.653
50	-126	-55	-0.797	-1.347
60	-166	-95	-1.376	-2.000
70	-182	-111	-1.608	-2.532
80	-176	-105	-1.521	-2.879
90	-161	-90	-1.304	-3.000
100	-163	-92	-1.333	-2.879
110	-161	-90	-1.304	-2.532
120	-161	-90	-1.304	-2.000
130	-162	-91	-1.318	-1.347
140	-163	-92	-1.333	-0.653
150	-163	-92	-1.333	0.000
160	-163	-92	-1.333	0.532
170	-163	-92	-1.333	0.879
180	-164	-93	-1.347	1.000

Table 4 Results For Pressure Distribution Experiment at 33 $m.s^{-1}$

Conclusions

Ideal fluid flow assumes that the flow remains attached all round the cylinder. In reality, viscous effects cause the flow to separate from the downstream surface of the cylinder. This is shown by the example results. The flow separation and turbulent wake can be clearly seen if the optional AFA10 Smoke Generator is used.

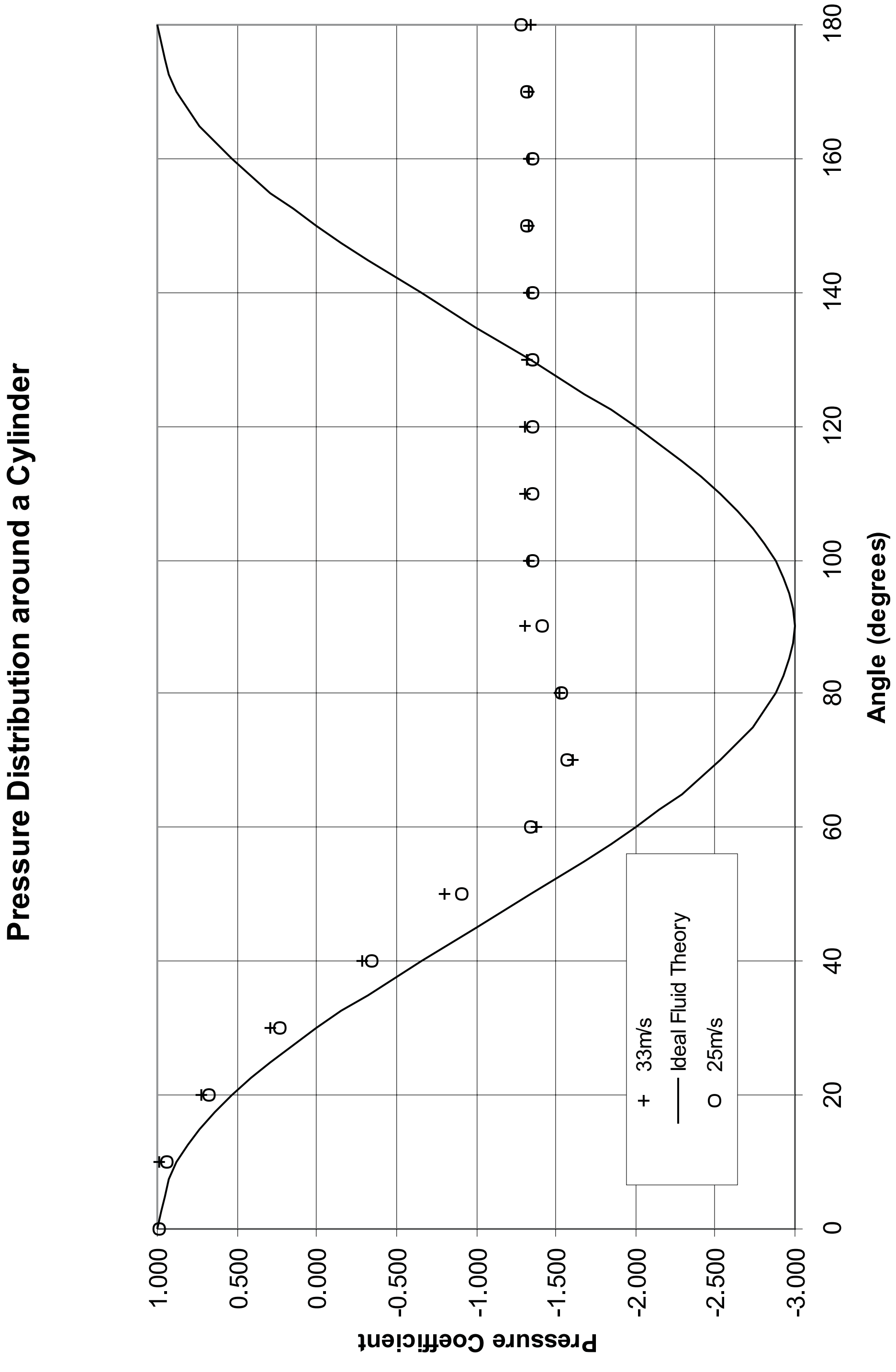
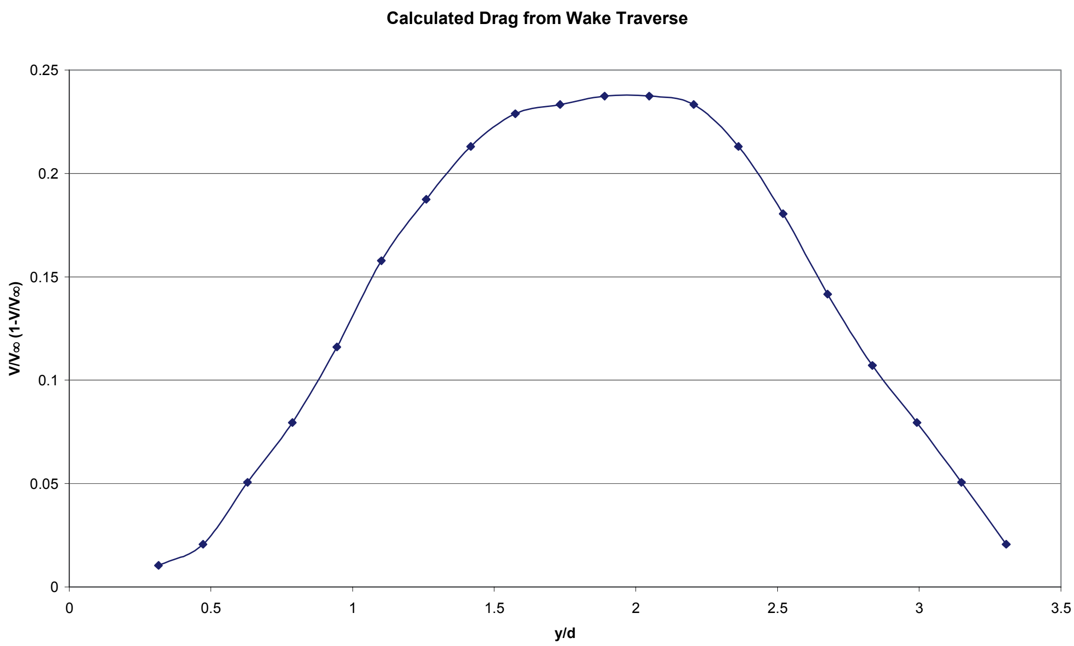


Figure 9 Chart of Ideal and Actual Pressure Distribution Around the Cylinder at Both Test Speeds.

Wake Traverse Test

Free Stream Total - Static Pressure $p_{T\infty} - p_\infty$: 48 mm H_2O				
Ambient Pressure: 1021 mbar		Ambient Temperature:22°C		
Air Velocity: 27.94 m.s^{-1}				
Pitot Scale Reading (mm)	**IN/OUT of Wake**	**Downstream Total - Static Pressure $p_T - p_\infty$ (mm H_2O)**	$\sqrt{\frac{p_T - p_\infty}{p_{T\infty} - p_\infty}}$	$\frac{V}{V_\infty}\left(1 - \frac{V}{V_\infty}\right)$
260	out	48	0.31927542	0
250	out	48	0.31927542	0
240	in	46	0.31255308	0.02061167
230	in	46	0.31255308	0.02061167
220	in	43	0.30218931	0.05065139
210	in	40	0.29145725	0.07953759
200	in	37	0.28031461	0.10713781
190	in	33	0.2647292	0.14165619
180	in	28	0.24385063	0.18042928
170	in	23	0.22100840	0.21305198
160	in	19	0.20087305	0.23331953
150	in	18	0.19551547	0.23737243
140	in	18	0.19551547	0.23737243
130	in	19	0.20087305	0.23331953
120	in	20	0.20609140	0.22883055
110	in	23	0.22100840	0.21305198
100	in	27	0.23945657	0.1875
90	in	31	0.25658172	0.15780423
80	in	36	0.27650063	0.11602540
70	in	40	0.29145725	0.07953759
60	in	43	0.30218931	0.05065139
50	in	46	0.31255308	0.02061167
40	in	47	0.31593213	0.01036184
30	out	48	0.31927542	0
20	out	48	0.31927542	0

Table 5 Results for Wake Traverse Test



Graph 1 Results for Wake Traverse Test

The area under the graph was found by division into strips to give a total area of 0.408. As shown in the results analysis, the area is equal to half the coefficient of drag, so actual C_D is calculated as 0.816.

Drag Test

These results were found by use of TecQuipment's Three Component Balance (AFA3) with the Cylinder Model at the same air speed and ambient conditions as the wake traverse test.

Ambient Pressure	1021 mbar
Ambient Temperature	22°C
Lift	-0.1 N
Drag	8.8 N
Pitching Moment	-0.01 Nm
C_L	-0.011
C_D	0.981
C_M	-0.001

Conclusion

The drag coefficient results from both the wake and the balance are very similar. What do you think could be the cause of any errors? How could the wake traverse be made more accurate?

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 hole for dust. remove any blockages with a dry air line.

CAUTION

Never try to force any objects (pins or wire) into the pitot hole. It is precision drilled and any damage will affect the readings.

Do not blow into the pitot hole, human saliva will block it.

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.

Customer Care

We hope you find our products and manuals satisfactory. If you have any questions, do not hesitate to contact our Customer Care department immediately:

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Fax: +44 115 973 1520

Email: **customercare@tecquipment.com**