AIRFLOW
SPECIAL PRODUCTS LTD

THE X AND UX FLOWGRIDS

Instructions for installation and use

Contents		Page

X FLOW GRIDS	Part No.
X Grid kit 8mm dia Tube – Round and Rectangular Ducts (2.0 Signal Factor)	71827501
X Grid kit 16mm dia Tube – Round and Rectangular Ducts (2.0 Signal Factor)	71827502
UX Grid kit 8mm dia Tube – Round and Rectangular Ducts (1.0 Signal Factor)	71998501
UX Grid kit 16mm dia Tube – Round and Rectangular Ducts (1.0 Signal Factor)	71998502

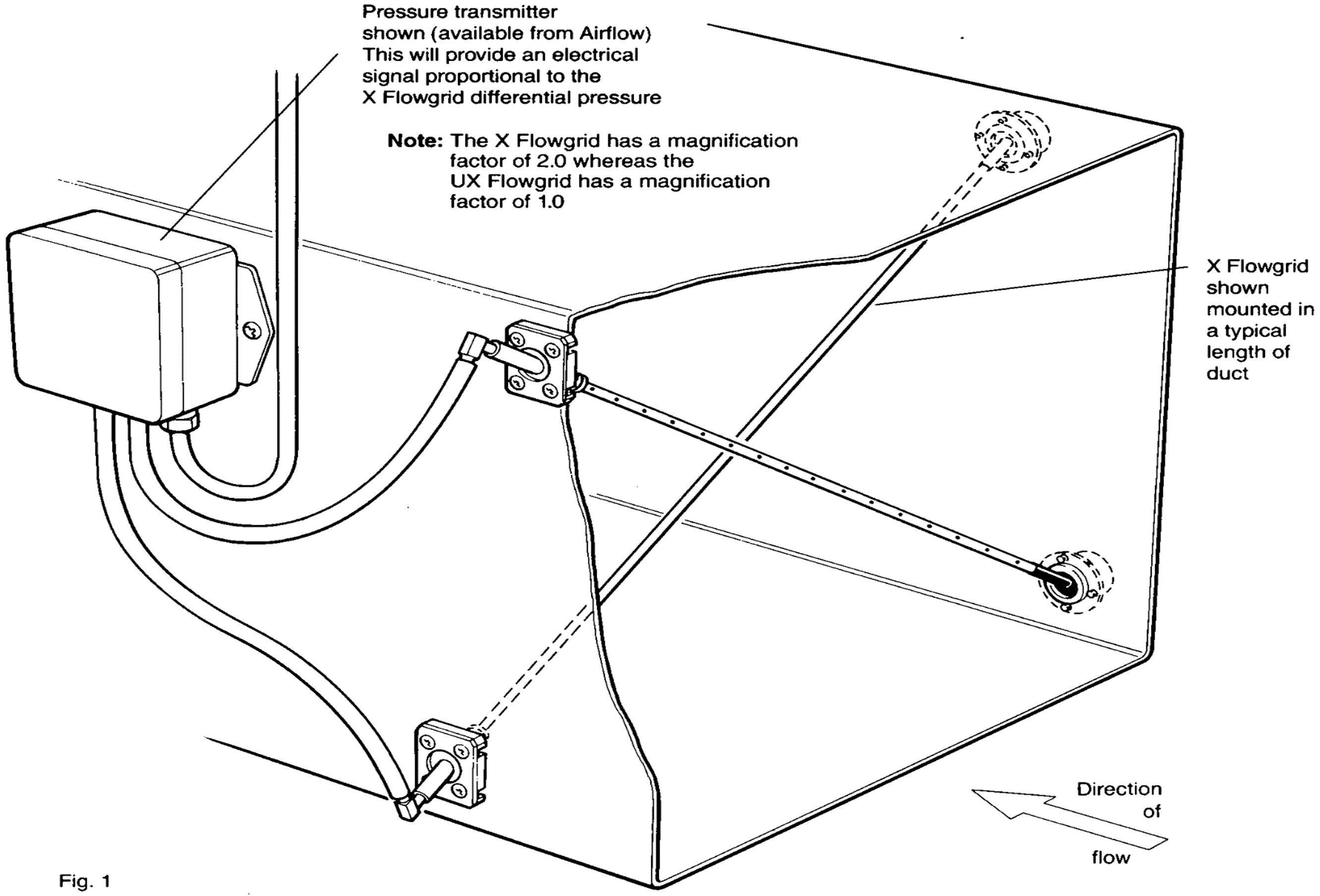


Fig. 1

1 How the X Flowgrid Works

The Flowgrid consists of two tubes mounted diagonally across a square or rectangular duct, or diametrically across a round duct. The tubes are drilled with a series of equi-spaced holes.

For the X Flowgrid the holes in one tube face directly upstream and sense total pressure, whilst those in the second tube face directly downstream sensing sub-static pressure.

In the case of the UX Flowgrid, the pairs of holes in the second tube also face forward but at an included angle of 79 degrees, sensing static pressure.

The total and (sub)static pressures are averaged along the length of each tube and provide pressure signals at connectors outside the duct wall. The pressure differential across these connectors constitute the output signal.

The X Flowgrid arrangement provides a magnification factor of M = 1.8, whilst the UX Flowgrid output is similar to that from a 'standard' pitot-static tube, that is M = 1.0.

2 Construction

The X Flowgrid tubes are made from stainless steel tube to BS 3605 321 S18 and other materials used are PVC, Polyurethane, acetal plastics and neoprene rubber.

The output connectors are 6mm diameter and are intended for use with plastic tube.

X Flowgrids must not be used in air temperatures above 80°C.

3 Applications

X Flowgrids will give useful and reliable readings in a wide variety of 'in duct' locations often where other flow rate measuring devices are found to be unsatisfactory.

However, X Flowgrids should not be used in conditions of high humidity or where material of a sticky nature is present in the airstream as a build-up of deposits on the pressure tubes or in the pressure holes will affect calibration. Where a high dust burden is likely to be encountered, it is advisable to provide access for cleaning when installing an X Flowgrid.

The signal from an X Flowgrid can be used in a variety of ways, for example:

3.1 To display differential pressure, velocity or volume flow using a micromanometer.

3.2 To give a warning of over or under flowrate using a manometer fitted with an alarm.

3.3 To control air supply in a system by connecting the grid to a pressure transmitter with an electrical output which can be used to feed into a control system.

3.4 To display differential pressure on a simple fluid manometer to give visual indication of changes in volume flow rate in the duct.

4 Positioning

X Flowgrids should be positioned in straight lengths of duct and at right angles to the axis of the duct.

The following criteria should be complied with when positioning an X Flowgrid:

4.1 Allow at least 3.5 diameters (3.5D) of duct upstream from 1D bends and minor obstructions.

4.2 Major obstructions such as right angled bends and opposed blade dampers require greater lengths of upstream duct (see section 11.1.).

4.3 Allow at least 1D of duct downstream of the X Flowgrid before any change to the duct cross section or obstruction to the flow. Shorter lengths are likely to increase pressure loss.

4.4 Avoid a sudden expansion immediately before an X Flowgrid (see Fig. 2a).

4.5 A local contraction at the plane of the X Flowgrid is a useful technique to increase pressure differential when velocities are low (see Fig 2b).

4.6 Where persistent swirl is expected it is advisable to install an anti-swirl device at least 1D upstream from the X Flowgrid. A preferred design is shown in BS 848 Part 1 1980 page 50.

An alternative to the above where space is limited is to use honeycomb flow straightener available from Airflow.

Note:
For rectangular ducts $D = \frac{\text{Width + Height of Duct}}{2}$

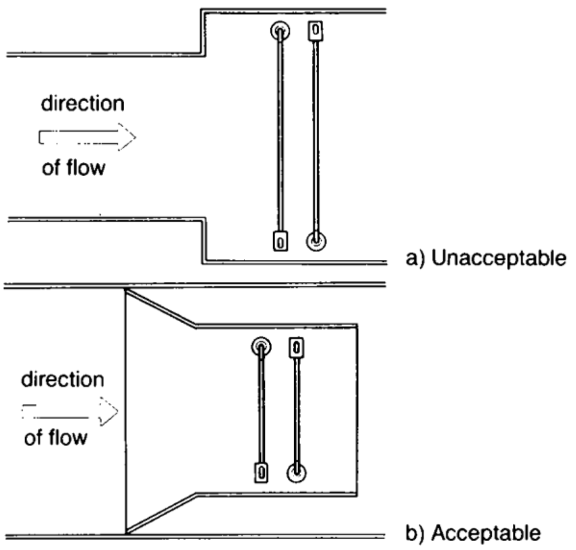


Fig. 2 Effect of local changes in duct section

5 Performance

As X Flowgrids are supplied in kit form and tube lengths are cut to suit the required duct size by the customer, it is only possible for Airflow to supply a typical performance graph with each kit. This should enable an installed X Flowgrid to monitor volume flow/ rate to within the accuracy limits shown in Section 11.1 without site calibration, provided that the criteria in Section 4 are met.

For greater accuracy on site calibration to BS 1042 Section 2.1 is necessary (see Section 10).

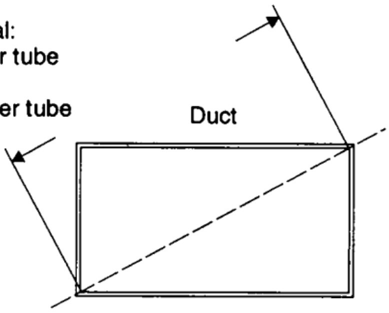
6 Installation

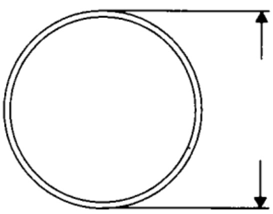
6.1 The two versions of X Flowgrid kits are each available in two tube diameters and lengths, See Table below:

Tube Diameter		Tube & adaptors Supplied Length	
mm	in.	mm	in.
8	0.312	688	27.1
16	0.625	1518	59.8

They may be used in square, rectangular or round ducts.

Maximum duct diagonal:
8 mm (0.312") diameter tube
715 mm (28.15")
16 mm (0.625") diameter tube
1534 mm (60.39")





Maximum duct diameter.
8mm (0.312") diameter tube
680 mm (26.8")
16mm (0.625") diameter tube
1510 mm (59.4")

6.2 Unpack your X Flowgrid. The kit should contain the following parts:

Description	Quantity
Adaptor & pressure tube	2
Adaptor plate	2
Duct cap	2
Cap plate	2
Adaptor drilling template	2
Duct cap drilling template	2
Diaphragm	2
Elbow	2
Tube cap	2
Grommet	2
Cap seal	2
Adaptor seal	2
Screws, self tapping No. 6 x 5/8"	16

6.3 Decide on the best location for your X Flowgrid.

6.4 The X Flowgrid is designed to fit into the shortest duct sides of a rectangular duct or across a duct diameter. Mark out the duct to the dimensions shown in Figs. 3 or 4, attach the self adhesive templates supplied, and produce the holes to the sizes indicated on the templates. DEBURR the 32 mm (1.26") diameter holes.

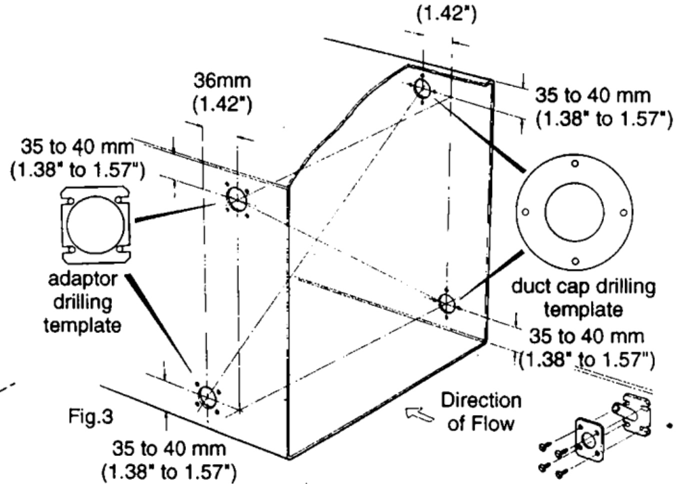


Fig.3

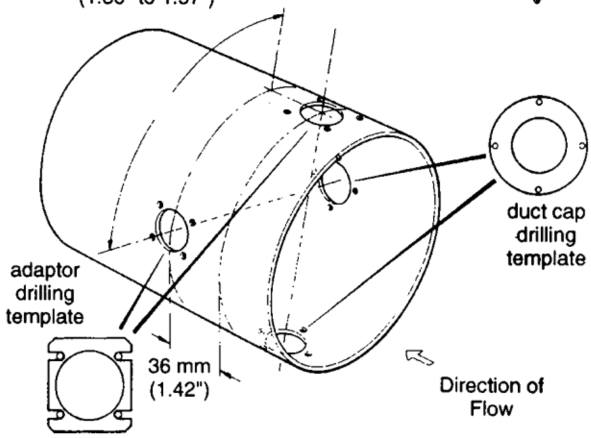


Fig.4

6.5 Introduce tubes into the duct and secure at the adaptor end using the clamping plate and No. 6 self-tapping screws supplied. (see Figs. 5 or 6). Note position of tubes relative to the direction of flow (see Fig.7).

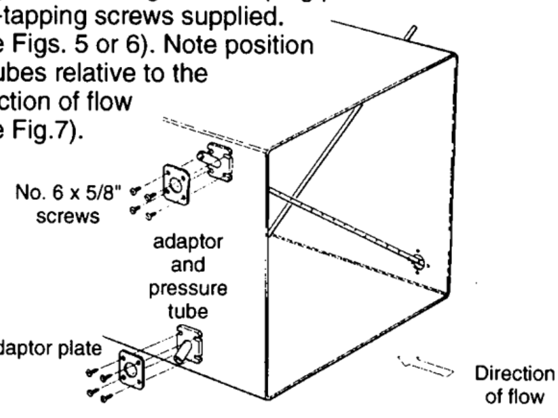


Fig.5

Fig.6

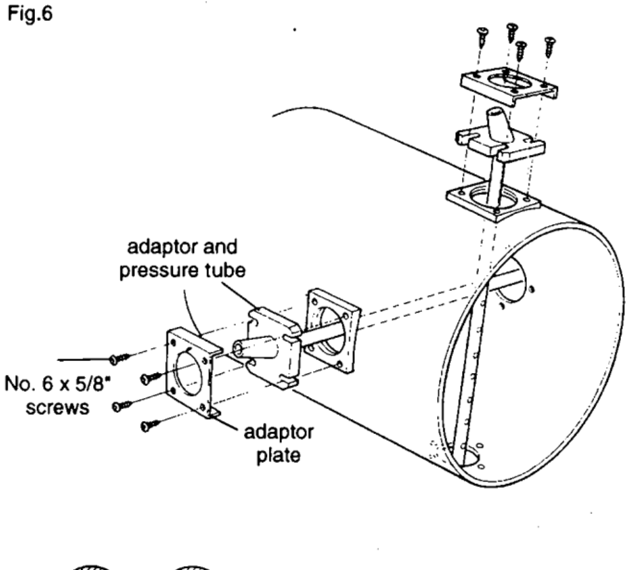


Fig.7.

6.6 Bias protruding ends of tubes towards the edge of the 32 mm (1.26") diameter hole whilst cutting to length, and cut tubes 5 to 7 mm (0.20" to 0.28") from the outside of the duct wall. DEBURR and REMOVE SHARP EDGES from the tube ends and slide tube caps over tubes (see Figs. 8 & 9). Fit grommets as shown.

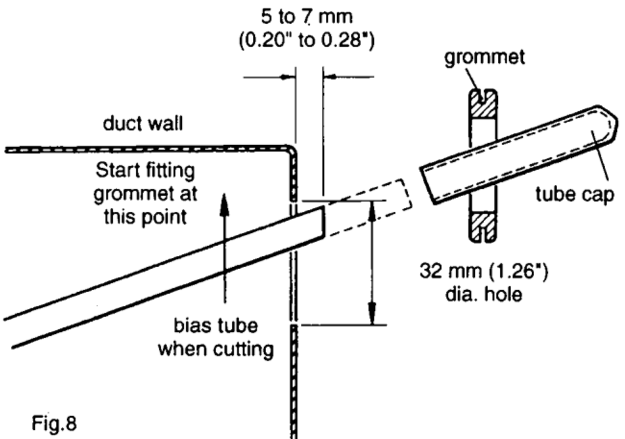


Fig.8

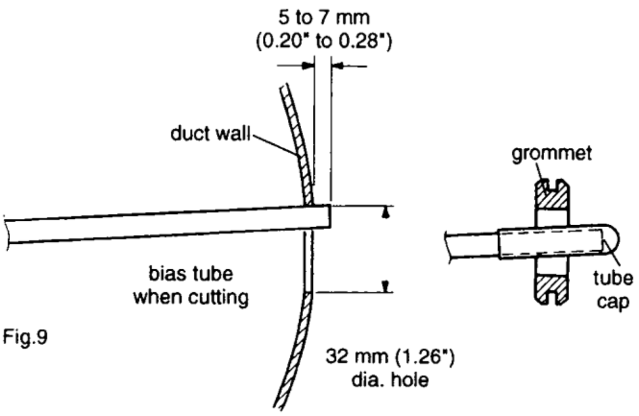


Fig.9

6.7 Position and secure diaphragms and duct caps over protruding tubes using clamping washers and No.6 x 5/8" screws etc. (see Figs. 10 or 11).

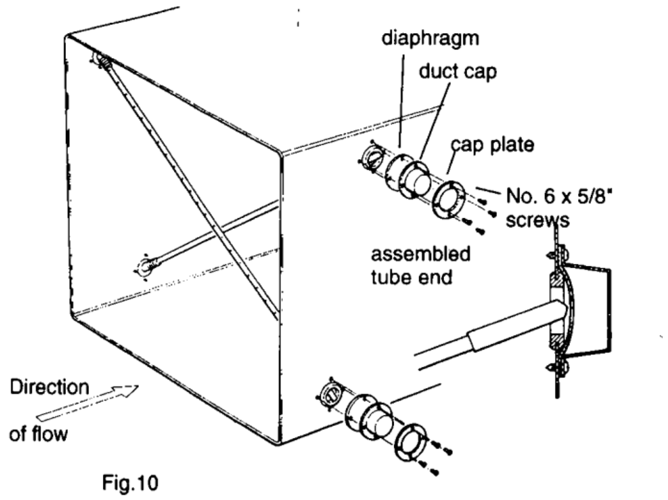


Fig.10

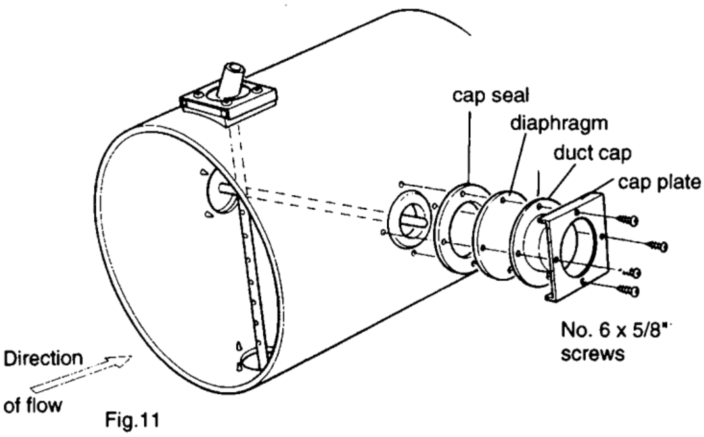


Fig.11

6.8 Push the elbows into the adaptors. These may point in any direction to suit tubing runs to differential pressure measuring instruments. (see Figs. 12 or 13).

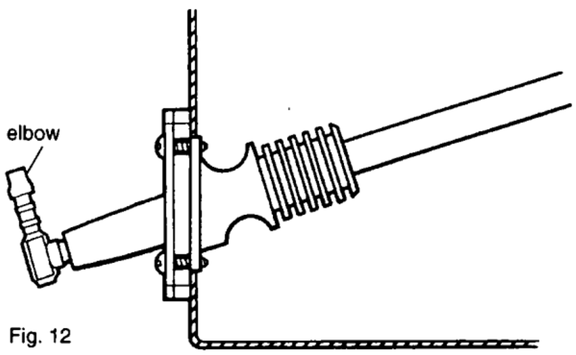


Fig. 12

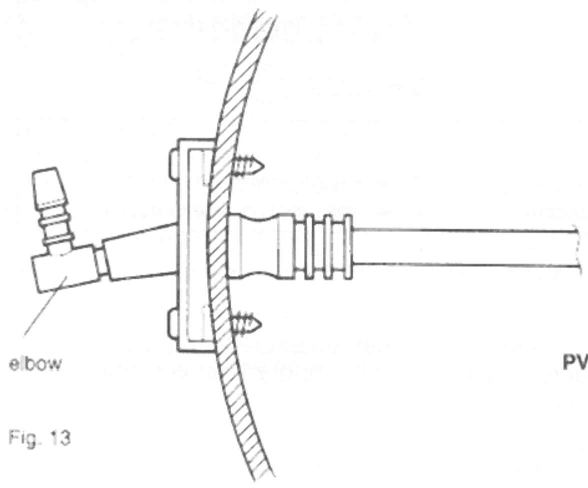


Fig. 13

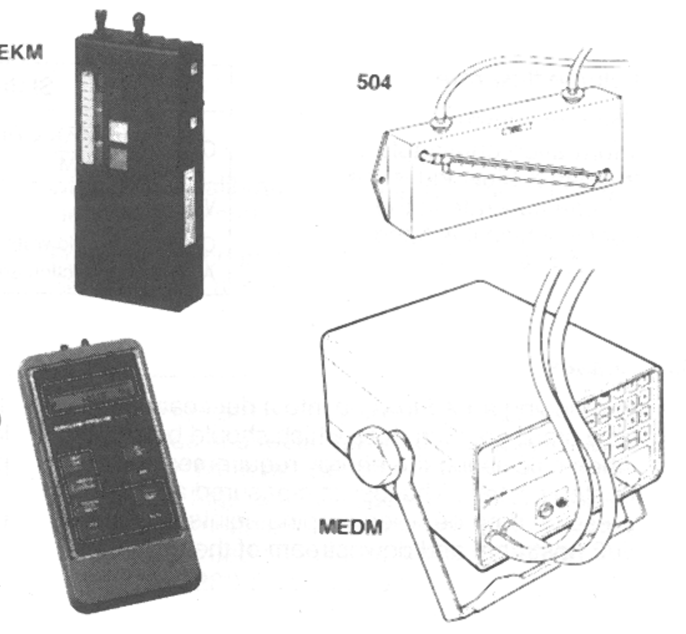


Fig. 14

7 Instrumentation and Completing the System

7.1 The X Flowgrid is not a complete measuring system. To complete the system it is necessary to convert the output signal into a more useful form.

7.1.1 For occasional checking of X Flowgrid differential pressure, portable instruments such as those found in the Airflow PVM or EDM ranges may be used. For immediate indication of grid differential pressure, duct velocity or volume flow rate, the Airflow MEDM is recommended (see Fig. 14).

7.1.2 A pressure transmitter available from Airflow may be used to give an electrical output proportional to the pressure signal or include a square rooting function to indicate velocity direct (see Fig. 1).

7.1.3 If the X Flowgrid is to be used as part of an alarm system, to warn for example, if the volume flow rate drops below a certain limit, manometers fitted with alarm trips, such as the Airflow Type 504 and contact kit may be used, or the EKM pressure alarm manometer (see Fig. 14).

7.2 To complete the installation fit flexible tubing from the elbows at the ends of the X Flowgrid to the chosen instrument. The elbow connector is 6mm outside diameter.

8 Interpretation of Output

8.1 Duct mean velocity

The differential pressure signal obtained across the output tappings of the X Flowgrid is proportional to the duct mean velocity pressure and to the square of the duct mean velocity.

The relationship between the differential pressure and velocity pressure is the magnification factor M.

$$M = \frac{\Delta P}{P\bar{v}}$$

For X Flowgrid M = 1.8
UX Flowgrid M = 1.0

SI Units	Imperial Units
The velocity relationship is:	
$\bar{v} = \sqrt{\frac{2}{\rho} \times P\bar{v}}$	$\bar{v} = 1096.5\sqrt{\frac{P\bar{v}}{\rho}}$
The basic formula for the flowgrid is therefore:	
$\bar{v} = \sqrt{\frac{2}{\rho} \times \frac{\Delta p}{M}}$	$\bar{v} = 1096.5\sqrt{\frac{\Delta p}{\rho M}}$
and allowing for changes in air density the formula becomes:	
$\bar{v} = \sqrt{\frac{2}{\rho} \times \frac{\Delta p}{M} \times CF}$	$\bar{v} = 4005\sqrt{\frac{\Delta p}{\rho M} \times CF}$
Where =	
$\bar{v}$ = mean duct velocity m/s	$\bar{v}$ = mean duct velocity ft/min
Δp = X Flowgrid differential pressure Pa	Δp = X Flowgrid differential pressure in. wg.
M = X Flowgrid magnification factor	M = X Flowgrid magnification factor
ρ = density of air in duct kg/m³	ρ = density of air in duct lbs/ft³
$P\bar{v}$ = duct mean velocity pressure Pa	$P\bar{v}$ = duct mean velocity pressure in. wg.
ρo = standard density of air 1.2 kg/m³	ρo = standard density of air 0.075 lb/ft³
CF = correction factor $= \frac{\rho o}{\rho} = \frac{101350}{B} \times \frac{T}{293}$	CF = correction factor $= \frac{\rho o}{\rho} = \frac{30}{B} \times \frac{T}{528}$
B = barometric pressure Pa	B = barometric pressure in Hg
T = absolute airstream Temperature degrees K = t°C + 273	T = absolute airstream Temperature in °R = t°F + 460

8.2 Volume flow rate

The most useful information obtainable from an X Flowgrid is the volume flow rate in the duct in which it is fitted.
$Q = A \times \bar{v}$

SI Units	Imperial Units
$Q = A\sqrt{\frac{2}{\rho} \times \frac{\Delta p}{M} \times CF}$	$Q = 4005\, A\sqrt{\frac{\Delta p}{\rho M} \times CF}$
Where =	
Q = Volume flowrate in m^3/sec A = Cross section area of duct m^2	Q = Volume flowrate in ft^3/min A = Cross section area of duct ft^2

8.3 Losses

Introducing an X Flowgrid into a duct causes a very small pressure loss which should be known when calculating the energy requirements in a ducted system. The loss is measured as the pressure drop between tapping points situated D/2 upstream and downstream of the grid.

The pressure loss P_L may be expressed as a loss factor L in terms of the duct mean velocity pressure.

$$L = \frac{P_L}{P\bar{v}}$$

9 Typical Performance Graphs

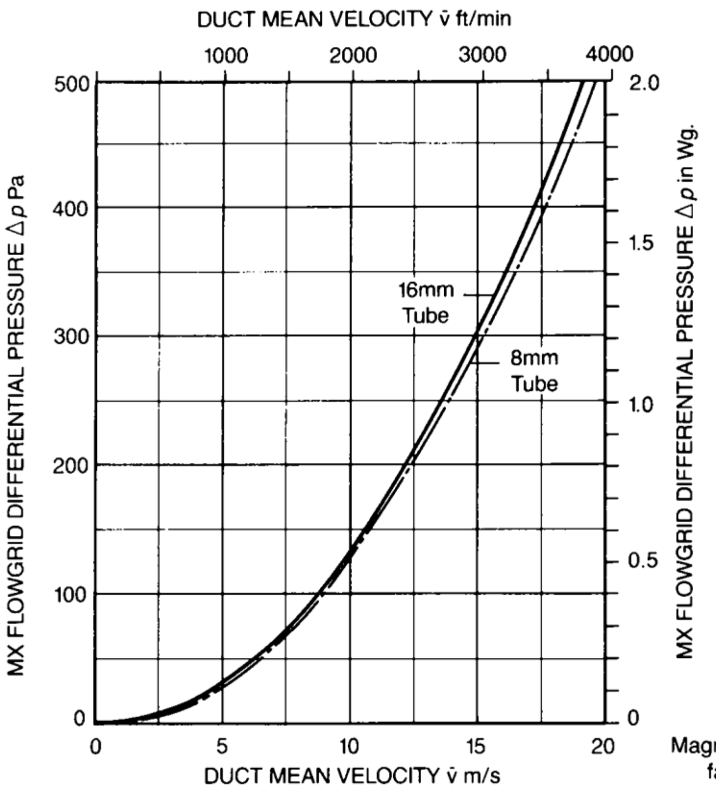


Fig. 15

Fig. 15 shows X Flowgrid differential pressure against duct mean velocity.

This graph is drawn for standard air conditions of 1.2 kgs/m^3 (0.075 lbs/ft^3) and may be used if lower levels of accuracy (see sections 4.3 and 11) are acceptable. If higher levels of accuracy are required on site calibration is essential (see Section 10).

Fig. 16 shows typical values of magnification factor M and pressure loss factor L plotted against mean velocity v̄ for a typical X Flowgrid installation. It will be seen that these values remain sensibly constant over the useful range of the X Flowgrid.

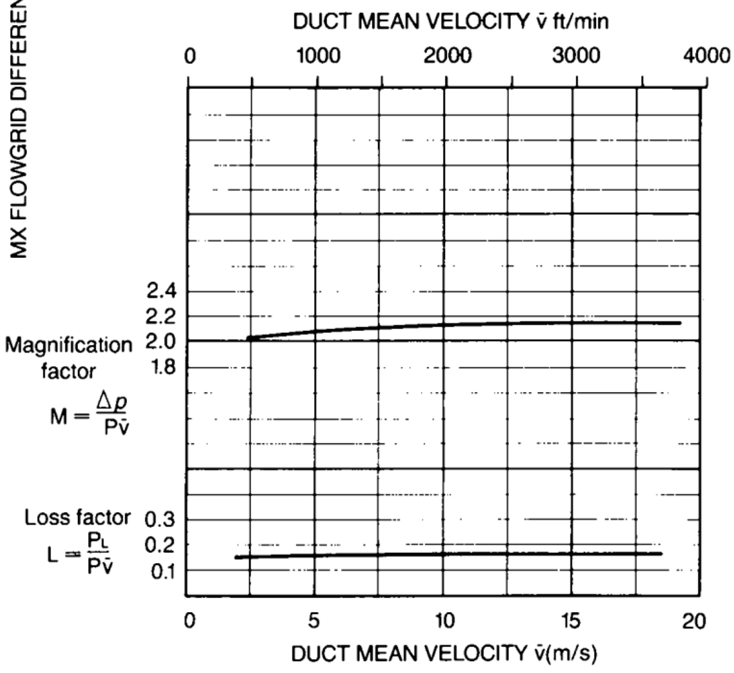


Fig 16

10 Calibration on Site

To achieve the best possible accuracy X Flowgrids must be calibrated on site and the following method of site calibration and subsequent calculation is advised.

Any valid method of determining the volume flow rate may be used in establishing the flow rate to differential pressure characteristic.

The following method and theory applies to the use of pitot static tubes, as the primary means of determining volume flow rate by the velocity traverse technique (see BS1042 Section 2.1). A full range of semi-ellipsoidal pitot static tubes and manometers is available from Airflow.

To calibrate an X Flowgrid.

10.1 Install the X Flowgrid as described (see section 6) and connect to a suitable manometer (Airflow type 4 Test Set – long limb – recommended).

10.2 Prepare holes in the duct wall upstream of the X Flowgrid for the pitot static tube traverse to give an adequate survey of the duct velocity pattern and mean duct velocity. (The pitot static tube may be connected across the short limb of the Type 4 Test Set for example).

10.3 Operate the system to give a typical flow rate through the flowgrid and take records of pitot static tube traverse readings and the flowgrid differential pressure readings.

10.4 If possible, arrange for the system flow rate to be changed to give additional sets of readings covering the range over which the system is intended to be used.

10.5 The theory of the X Flowgrid for normal atmosphere conditions is shown in Section 8.

$$\frac{\Delta p}{P\bar{v}} = M \text{ (See Section 8.1)}$$

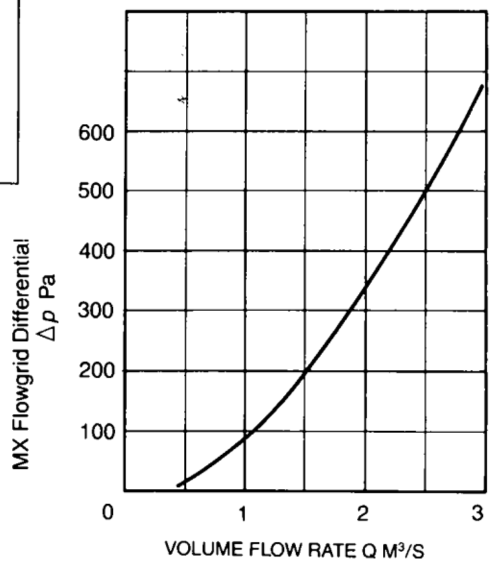
Hence calculate the flow constant K′ for each set of readings taken; allowing for an Airflow pitot static tube which has a coefficient of 0.997.

SI Units	**Imperial Units**
$K' = A \times \frac{1.291}{\sqrt{M}}$	$K' = A \times \frac{4005}{\sqrt{M}}$
Where	
Δp = X Flowgrid differential pressure	Δp = X Flowgrid differential pressure in wg
M = X Flowgrid magnification factor	M = X Flowgrid magnification factor
$P\bar{v}$ = duct mean velocity pressure Pa	$P\bar{v}$ = duct mean velocity pressure in wg
A = cross sectional area of duct m^2	A = cross sectional area of duct ft^2
Take the average K′ and plot the curve of Q v Δp	
Where	
$Q = K'\sqrt{\Delta p}$	
Q = volume flowrate m^3/s	Q = volume flowrate ft^3/min

10.6 Suggested format for results using worked examples:

10.6.1 Metric units (example – using X Flowgrid in duct size 250mm × 500mm)

PITOT STATIC TUBE TRAVERSE DATA										
	Pitot Tube Traverse Readings $P\bar{v}$ Pa & $\sqrt{P\bar{v}}$					Average of $\sqrt{P\bar{v}}$	Average of $P\bar{v}$	Flow-grid Diff Δp	Mag-Factor $\frac{\Delta p}{P\bar{v}} = M$	Flow Constant $K' = A \times \frac{1.28}{\sqrt{M}}$
Reading No	1	2	3	4	5					
$P\bar{v}$	250	230	260	240	212		238.08	514.2	2.160	0.1095
$\sqrt{P\bar{v}}$	15.81	15.17	16.12	15.49	14.56	15.43				
$P\bar{v}$	96	92	99	96	90		94.67	199.8	2.110	0.1108
$\sqrt{P\bar{v}}$	9.80	9.59	9.95	9.80	9.49	9.73				
$P\bar{v}$	48	46	47	51	45		47.33	98.1	2.072	0.1118
$\sqrt{P\bar{v}}$	6.93	6.78	6.86	7.14	6.71	6.88				
DUCT AREA A = 250 × 500mm = 0.125m^2								Average K′ =		0.1107



GRAPH PLOTTING INFORMATION DERIVED FROM TRAVERSE DATA.

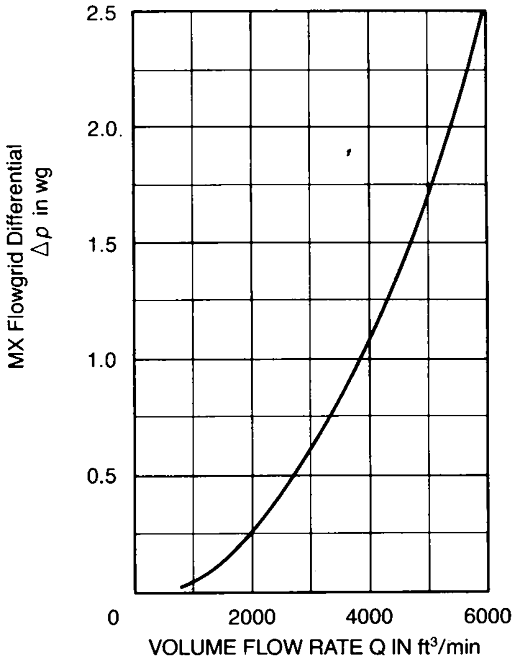
MX Flow Grid Diff Δp Pa	25	50	100	200	300	400	500	600
$\sqrt{\Delta p}$	5	7.07	10	14.14	17.32	20.0	22.36	24.43
Vol Flow Rate $Q = K'\sqrt{\Delta p}$ M^3/s	0.553	0.783	1.107	1.565	1.917	2.214	2.475	2.704

10.6.1 Metric units (example – using X Flowgrid in duct size 250mm × 500mm)

PITOT STATIC TUBE TRAVERSE DATA										
	Pitot Tube Traverse Readings Pv Pa & $\sqrt{Pv}$					Average of $\sqrt{Pv}$	Average of Pv	Flow-grid Diff Δp	Mag-Factor $\frac{\Delta p}{Pv} = M$	Flow Constant $K' = A \times \frac{1.28}{\sqrt{M}}$
Reading No	1	2	3	4	5					
Pv	250	230	260	240	212		238.08	514.2	2.160	0.1095
$\sqrt{Pv}$	15.81	15.17	16.12	15.49	14.56	15.43				
Pv	96	92	99	96	90		94.67	199.8	2.110	0.1108
$\sqrt{Pv}$	9.80	9.59	9.95	9.80	9.49	9.73				
Pv	48	46	47	51	45		47.33	98.1	2.072	0.1118
$\sqrt{Pv}$	6.93	6.78	6.86	7.14	6.71	6.88				
DUCT AREA A = 250 × 500mm = 0.125m²								Average K' =		0.1107

GRAPH PLOTTING INFORMATION DERIVED FROM TRAVERSE DATA.

X Flow Grid Diff Δp Pa	25	50	100	200	300	400	500	600
$\sqrt{\Delta p}$	5	7.07	10	14.14	17.32	20.0	22.36	24.43
Vol Flow Rate $Q = K' \sqrt{\Delta p}$ M³/s	0.553	0.783	1.107	1.565	1.917	2.214	2.475	2.704



11 Uncertainty and repeatability of measurement

11.1 Expected uncertainty of measurement with typical system obstructions:

Obstruction	Straight upstream length required to maintain:	
	±10%	±15%
right angle bend	10.0D	3.5D
radius bend r = 1D or less	10.0D	3.5D
opposed blade damper	10.0D	3.5D
30° bend	3.5D	2.0D
tapered contraction	3.5D	2.0D
sudden contraction	3.5D	2.0D

Note:
For rectangular ducts $D = \frac{\text{Width} + \text{Height of Duct}}{2}$

11.2 On any particular installation repeatability of signal output is likely to be better than ±5%.

11.3 When calibrated on site (see section 10) uncertainty of measurement is likely to be better than ±5%.

12 Maintenance

No maintenance is normally required except where a high dust burden is likely to be encountered in the airstream. Deposits in the pressure holes will affect calibration and it is advisable to provide some means of access for cleaning when installing the X Flowgrid.

AIRFLOW SPECIAL PRODUCTS LTD

Airflow-SP Ltd
C. R. Bated Industrial Estate
StokenchurchBucks
HP14 3PD
Tel: +44(0)845 1771775
Fax: +44(0)845 1771775
enquiries@airflow-sp
www.airflow-sp.com