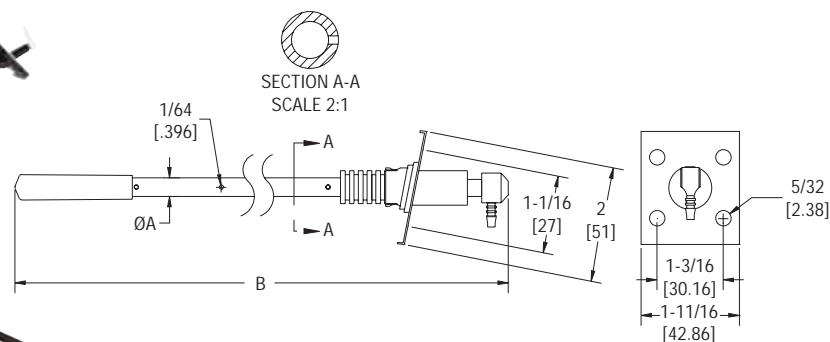




Series AFG Averaging Flow Grid

Specifications - Installation and Operating Instructions



The **Series AFG Flow Grid** is an outstandingly simple yet accurate and cost effective alternative to other duct mounted pressure sensors. Once installed and connected to a suitable measuring instrument, the device will provide years of trouble free monitoring of both air and gas flow. Fitting the AFG Flow Grid is simple, with the unit supplied in kit form to allow both workshop and on-site installation into a wide range of square and circular ducts.

The AFG Flow Grid is a fundamental pressure-sensing device designed to transmit a continuous differential pressure signal. When this output is connected to a suitable measuring instrument (i.e. manometer, pressure transducer, etc.) it may be used to determine air velocity and volume flow rate.

HOW THE AFG FLOW GRID WORKS

The AFG Flow Grid 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.

The holes in one tube face directly upstream and sense total pressure, while 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 differentials across these connectors constitute the output signal.

CONSTRUCTION

The AFG Flow Grid tubes are stainless, steel, PVC, Polyurethane, acetyl plastics, and neoprene rubber.

The output connectors are 1/4" diameter and are intended for use with plastic tube.

The AFG Flow Grids must not be used in air temperatures above 176°F (80°C).

SPECIFICATIONS

Service: Monitor air or compatible gas flow.

Wetted Materials: 304 SS, PVC, Polyurethane, acetyl plastics, and neoprene rubber.

Accuracy: ±5%.

Maximum Temperature: 176°F (80°C).

Velocity Range: 295.2 ft/min to 5904 ft/min (1.5 to 30 m/sec).

Diameter of Tubes: 5/16" (8 mm) or 5/8" (16 mm).

Max Duct Diagonal: 60.4" (153.4 cm).

Max Duct Diameter: 59.4" (150.9 cm).

Process Connections: 5/16" barbed.

Weight: AFG-1: 1 lb (454 g); AFG-2: 3 lb (1361 g).

APPLICATIONS

The AFG Flow Grids 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, AFG Flow Grids should not be used in conditions of high humidity or where material of a sticky nature is present in the air stream, 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 AFG Flow Grid.

Positioning in Ducts:

The AFG Flow Grids 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 AFG Flow Grid:

1. Allow at least 3.5 diameters (3.5D) of duct upstream from 1D bends and minor obstructions.
2. Major obstructions such as right angled bends and opposed blade dampers require greater lengths of upstream duct (See the last page).
3. Allow at least 1D of duct downstream of the AFG Flow Grid before any change to the duct cross section or obstruction to the flow. Shorter lengths are likely to increase pressure loss.

4. Avoid a sudden expansion immediately before an AFG Flow Grid (See Fig. 2a).
5. A local contraction at the plane of the AFG Flow Grid is a useful technique to increase pressure differential when velocities are low (See Fig. 2b).
6. Where persistent swirl is expected it is advisable to install an anti-swirl device at least 1D upstream from the the AFG Flow Grid.

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

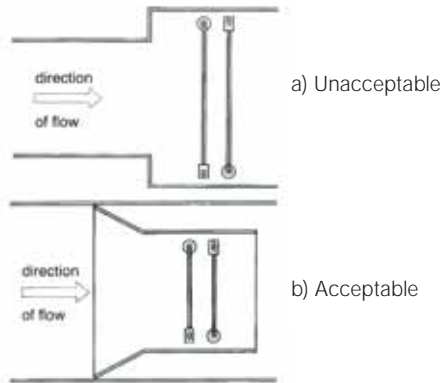


Fig. 2

INSTALLATION

The AFG Flow Grids are supplied in kit form, and tube lengths are cut to suit the required duct size by the customer.

The AFG Flow Grid is available in two tube diameters and lengths (See Table 1).

Table 1: Dimensions

Tube Diameter "A"	Tube & Adapters Supplied Length Size "B"
5/16" (8 mm)	27" (688 mm)
5/8" (16 mm)	59-4/5" (1518 mm)

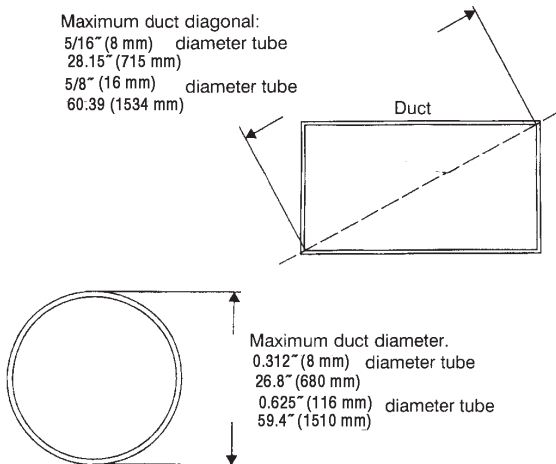


Fig. 3

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

Unpack your AFG Flow Grid. The kit should contain the following parts:

Table 2: Included Parts

Description	Quantity
Adapter & Pressure Tube	2
Adapter Plate	2
Duct Cap	2
Cap Plate	2
Adapter Drilling Template	2
Duct Cap Drilling Template	2
Diaphragm	2
Elbow	2
Tube Cap	2
Grommet	2
Cap Seal	2
Adapter Seal	2
Screws, Self Tapping No. 6 x 5/8"	16

Decide on the best location for your AFG Flow Grid.

The AFG Flow Grid 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 Fig. 4 and 5. Attach the self-adhesive templates supplied, and produce the holes to the sizes indicated on the templates. DEBURR the 1.26" (32 mm) diameter holes.

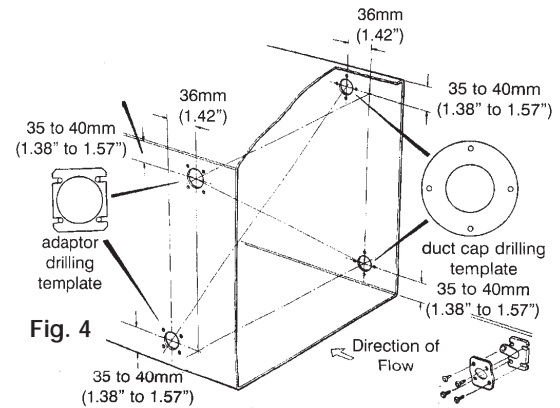


Fig. 4

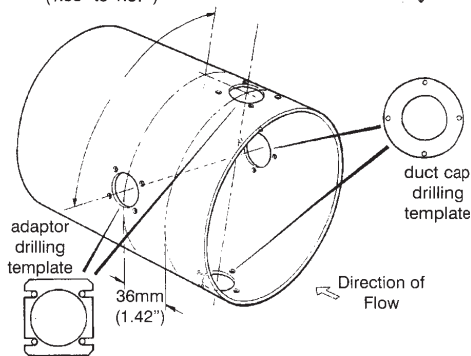


Fig. 5

Introduce tubes into the duct and secure at the adapter end using the clamping plate and No. 6 self-tapping screws supplied (See Fig. 6 and 7). Note position of tubes relative to the direction of flow (See Fig. 7).

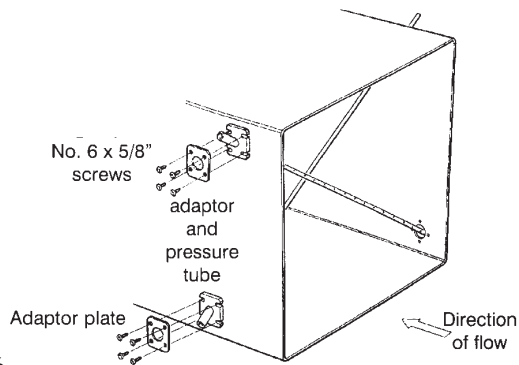


Fig. 6

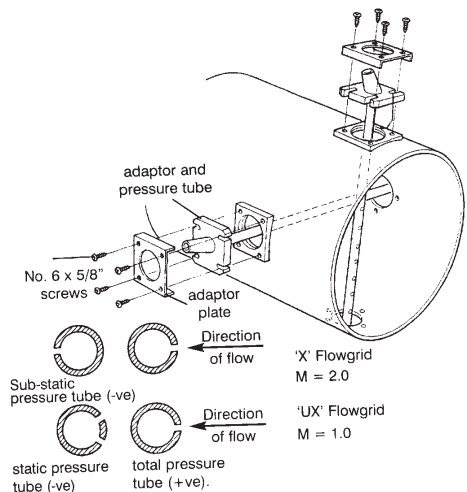


Fig. 7

Position and secure diaphragms and duct caps over protruding tubes using clamping washers and No. 6 x 5/8" screws, etc. (See Fig. 10 & 11).

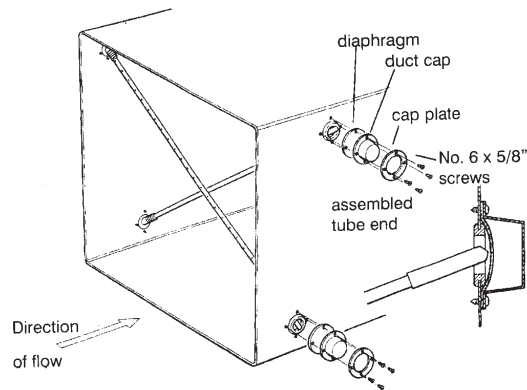


Fig. 10

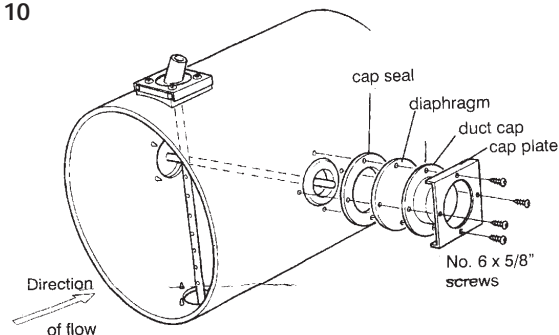


Fig. 11

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

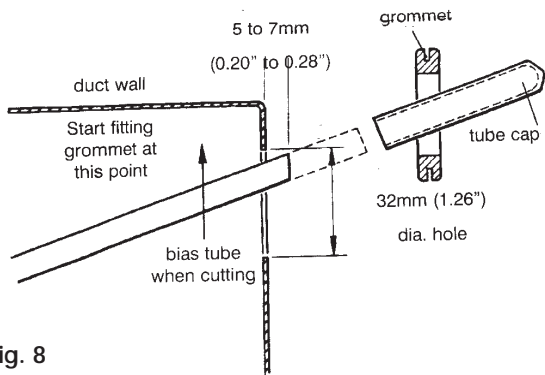


Fig. 8

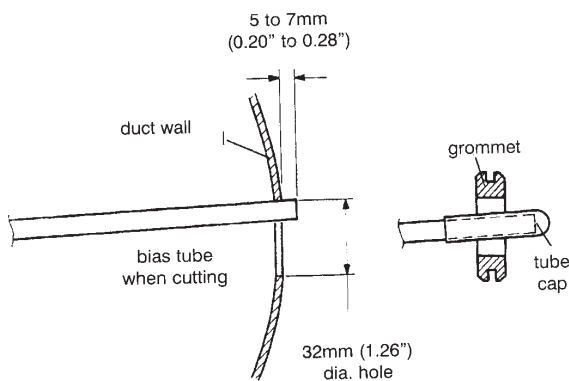


Fig. 9

Push the elbows into the adapters. These may point in any direction to suit tubing runs to differential pressure measuring instruments (See Fig. 12 & 13).

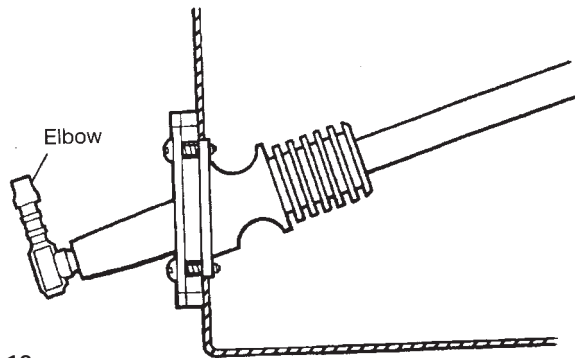


Fig. 12

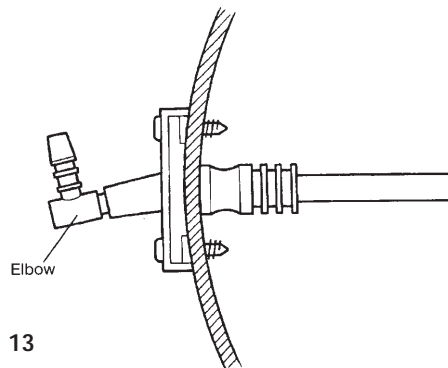


Fig. 13

Instrumentation and Completing the System:

The AFG Flow Grid is not a complete measuring system. To complete the system it is necessary to convert the output signal into a more useful form.

For occasional checking of the AFG Flow Grid, differential pressure portable instruments may be used.

A pressure transmitter may be used to give an electrical output proportional to the pressure signal or include a square rooting function to indicate velocity directly.

If the AFG Flow Grid is to be used as part of an alarm system, to warn for example, if the volume flow rate drops below a certain limit, a manometer fitted with alarm trips may be used.

To complete the installation, fit flexible tubing from the elbows at the ends of the AFG Flow Grid to the chosen instrument. The elbow connector is 6 mm outside diameter.

Interpretation of Output:

Duct mean velocity:

The differential pressure signal obtained across the output tapings of the AFG Flow Grid is proportional to the duct mean velocity pressure and to the square of the duct mean velocity.

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

$$M = (\Delta P) / (P_v)$$

AFG Flow Grid: M=1.0

Table 3: Calculating Velocity from Differential Pressure

SI Units	Imperial Units
The velocity relationship is:	
$\bar{v} = \sqrt{\frac{2}{\rho} \times P_v}$	$\bar{v} = 1096.5 \sqrt{\frac{P_v}{\rho}}$
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	
$\bar{v} = \sqrt{\frac{2}{\rho_0} \times \frac{\Delta P}{M} \times CF} = 1.291 \sqrt{\frac{\Delta P}{M} \times CF}$	$\bar{v} = 1096.5 \sqrt{\frac{\Delta P}{\rho_0 M} \times CF} = 4005 \sqrt{\frac{\Delta P}{M} \times CF}$
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/m ³	ρ = density of air in duct lbs/ft ³
P_v = duct mean velocity pressure Pa	P_v = duct mean velocity pressure in. wg.
ρ_0 = standard density of air 1.2kg/m ³	ρ_0 = standard density of air 0.075lb/ft ³
CF = correction factor	CF = correction factor
$\frac{\rho_0}{\rho} = \frac{101350}{B} \times \frac{T}{293} \times \frac{101,350}{101,350 + Ps}$	$\frac{\rho_0}{\rho} = \frac{30}{B} \times \frac{T}{528} \times \frac{408}{408 + Ps}$
B = barometric pressure Pa	B = barometric pressure in Hg
T = absolute airstream Temperature degrees K	T = absolute airstream Temperature in °R
$= t°C + 273$	$= t°F + 460$
Ps = duct static pressure Pa	Ps = duct static pressure in. wg.

Volume Flow Rate:

The most useful information obtainable from an AFG Flow Grid is the volume flow rate in the duct in which it is fitted.

Table 4: Calculating Volumetric Flow from Differential Pressure

SI Units	Imperial Units
$Q = 1.291 A \sqrt{\frac{\Delta P}{M} \times CF}$	$Q = 4005 A \sqrt{\frac{\Delta P}{M} \times CF}$
Where =	
Q = Volume flowrate in m ³ /sec	Q = Volume flowrate in ft ³ /min
A = Cross section area of duct m ²	A = Cross section area of duct ft ²

Fig. 14: Typical Performance Graphs

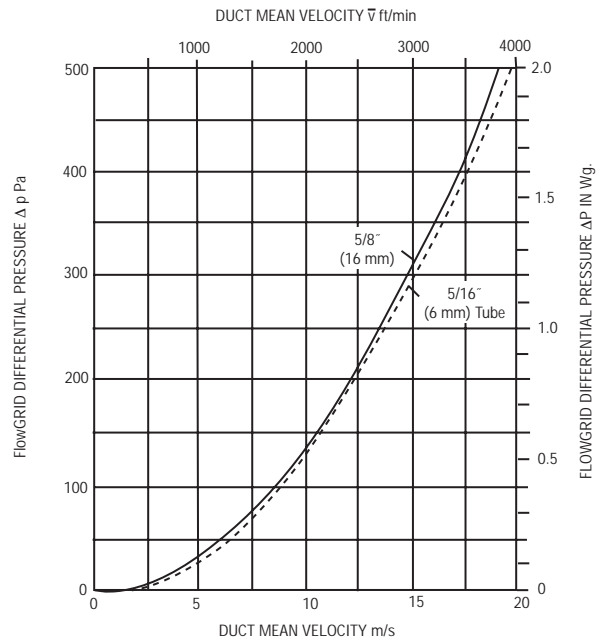


Fig. 14 (above) shows AFG Flow Grid differential pressure against duct mean velocity.

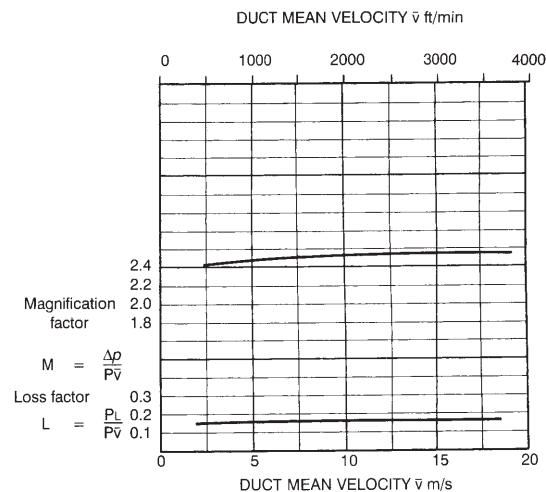
This graph is drawn for standard air conditions of 1.2 kgs/m³ (0.075 lbs/ft³) and may be used if lower levels of accuracy (See page 1 & 3) are acceptable. If higher levels of accuracy are required on site calibration is essential (See next page).

Losses:

Introducing an AFG Flow Grid 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.

Fig. 15 shows magnification factor M and pressure loss factor L plotted against mean velocity for a typical AFG Flow Grid installation. It will be seen that these values remain sensibly constant over the useful range of the AFG Flow Grid.

Fig. 15: Magnification and Pressure Loss Factors



Calibration on Site:

To achieve the best possible accuracy, the AFG Flow Grids 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.

To calibrate an AFG Flow Grid:

1. Install the AFG Flow Grid as described (See installation pages 2 & 3) and connect to a suitable manometer.

2. Prepare holes in the duct wall upstream of the AFG Flow Grid for the Pitot static tube traverse to give an adequate survey of the duct velocity pattern and mean duct velocity.

3. Operate the system to give a typical flow rate through the Flow Grid and take records of Pitot static tube traverse readings and the Flow Grid differential pressure readings.

4. If possible, arrange 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.

5. The theory of the AFG Flow Grid for normal atmosphere conditions is shown on page 4.

$(\Delta p)/(P\bar{v}) = M$ (See page 4).

Measure the ambient temperature 't', the ambient barometric pressure 'B' and the duct static pressure Ps. Calculate the correction factor CF in the appropriate units.

Hence calculate the flow constant 'K' for each set of readings taken.

Table 5: Calculating Flow Constant K

SI Units	Imperial Units
$K' = A \times 1.291 \sqrt{\frac{CF}{M}}$	$K' = A \times 4005 \sqrt{\frac{CF}{M}}$
<p>Where = Δp = X Flowgrid differential pressure M = X Flow grid magnification factor Pv = duct mean velocity pressure Pa A = cross section area of duct m² CF = correction factor Take the average K' and plot the curve of Q v Δp</p>	<p>Δp = X Flowgrid differential pressure in. wg. M = X Flowgrid magnification factor Pv = duct mean velocity pressure wg A = cross section area of duct ft² CF = correction factor</p>
<p>Where $Q = K' \sqrt{\Delta p}$ Q = volume flowrate m³/s</p>	<p>$Q = K' \sqrt{\Delta p}$ Q = volume flowrate ft³/min</p>

6. Suggested format for results using worked examples:

Metric Units (example- using AFG Flow Grid in duct size 250 mm x 500 mm)

Table 6: Example: K Factor Calculation (Metric)

PITOT STATIC TUBE TRAVERSE DATA										
Reading No.	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 $K_1 = A \times 1.291 \sqrt{\frac{CF}{M}}$
	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 X 500 mm = 0.125 m ²									AVERAGE k' = 0.1107	

Table 7: Graph Plotting Information Derived from Traverse Data (metric)

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'	0.553	0.783	1.107	1.565	1.917	2.214	2.475	2.704
$\sqrt{\Delta p}$ M ³ /s								

Imperial Units (example- using AFG Flow Grid in duct size 10" x 20")

Table 8: Example: K Factor Calculation (Imperial)

PITOT STATIC TUBE TRAVERSE DATA										
Reading No.	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 $K_1 = A \times 4005 \sqrt{\frac{CF}{M}}$
	1	2	3	4	5					
P \bar{v}	0.95	0.99	1.03	1.06	0.99		1.004	2.169	2.160	3781
$\sqrt{P\bar{v}}$	0.975	0.995	1.015	1.030	0.996	1.002				
P \bar{v}	0.48	0.50	0.52	0.53	0.49		0.504	1.063	2.110	3828
$\sqrt{P\bar{v}}$	0.693	0.707	0.721	0.728	0.70	0.710				
P \bar{v}	0.23	0.25	0.25	0.24	0.22		0.238	0.493	2.072	3863
$\sqrt{P\bar{v}}$	0.480	0.50	0.50	0.49	0.469	0.488				
DUCT AREA A = 10" X 20" = 1.388 ft ²									AVERAGE k' = 3824	

Table 9: Graph Plotting Information Derived from Traverse Data (Imperial)

MX Flow Grid Diff Δp Pa	0.5	1.0	1.5	2.0	2.5
$\sqrt{\Delta p}$	0.707	1.0	1.225	1.414	1.581
Vol Flow Rate Q = K'	2703	3824	4684	5408	6046
$\sqrt{\Delta p}$ ft ³ /min					

(see Fig. 17 for Graph)

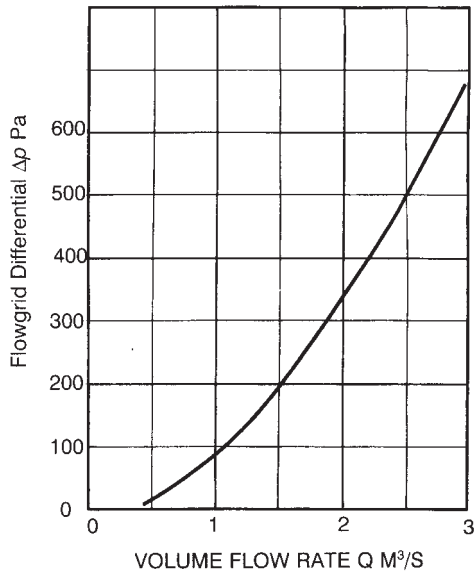


Fig. 16

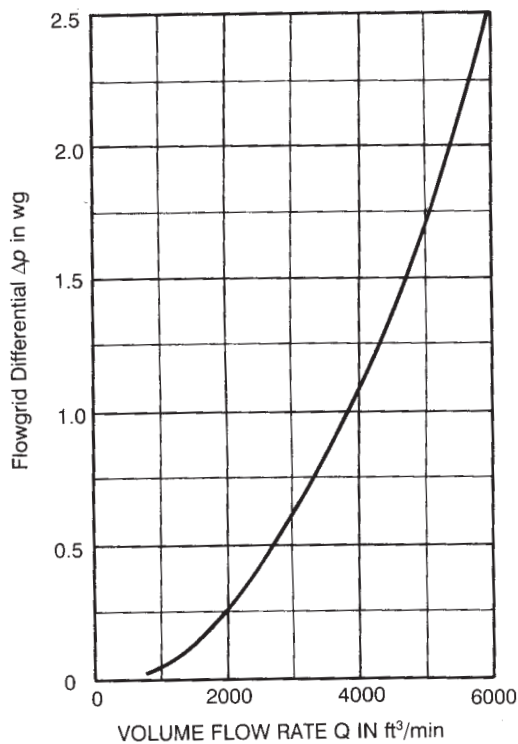


Fig. 17

Table 10: Uncertainty and Repeatability of Measurement

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 Angle 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= Width + Height of Duct/2

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

When calibrated on site (See Previous Page) uncertainty of measurement is likely to be better than ±5%.

MAINTENANCE

No maintenance is normally required except where a high dust burden is likely to be encountered in the air stream. Deposits in the pressure holes will affect calibration and it is advisable to provide some means of access for cleaning when installing the AFG Flow Grid. The Series AFG Flow Grid is not field serviceable and should be returned if repair is needed (field repair should not be attempted and may void warranty). Be sure to include a brief description of the problem plus any relevant application notes. Contact customer service to receive a return goods authorization number before shipping.