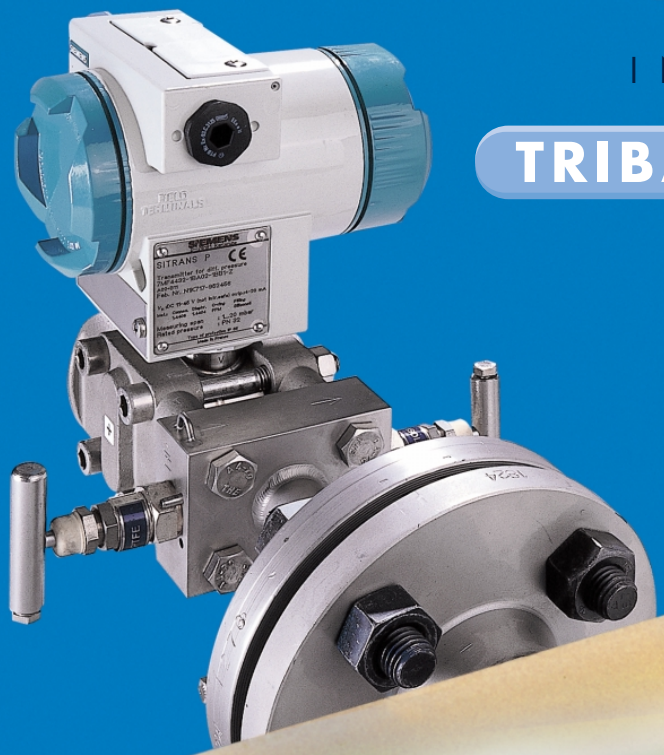
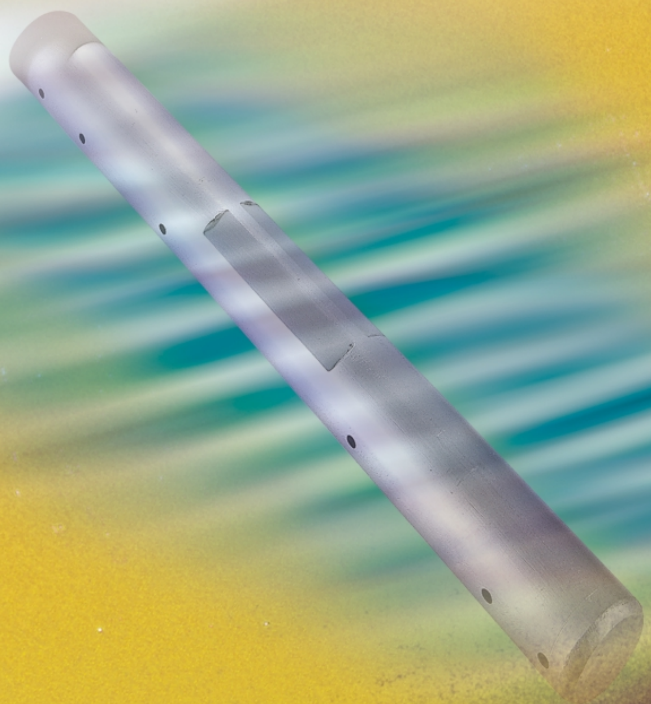
TORBAR®

INCORPORATING

TRIBAR & MASS TRIBAR





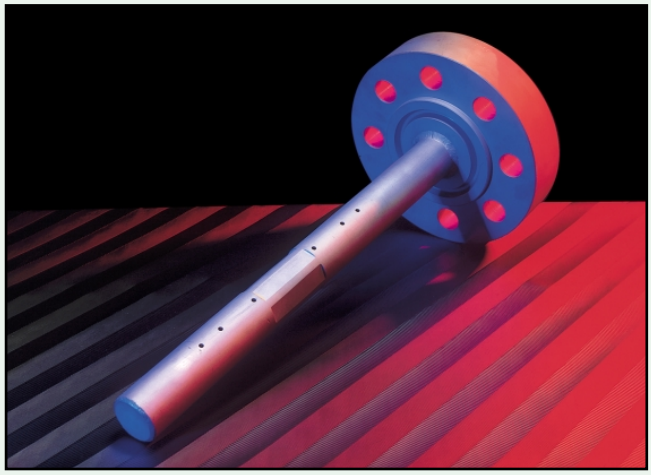
FOR DEPENDABLE FLOW MEASUREMENT

WHAT IS A TORBAR?

The **TORBAR** is a multiport self-averaging flow meter with a design based on the classical pitot tube concept of fluid flow measurement.

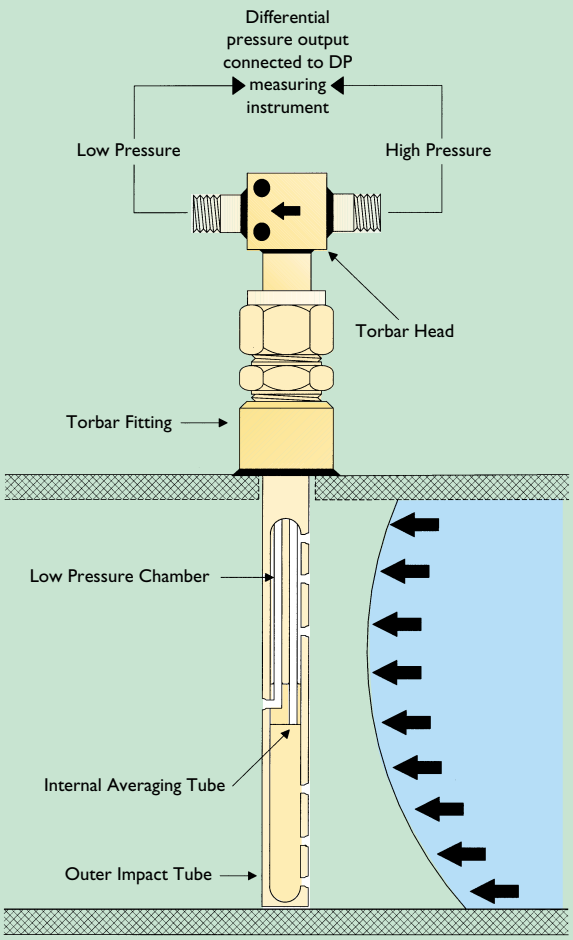
Since the introduction of the **TORBAR** in 1985, thousands have been installed into a wide variety of industries world wide. Refer to page 14 for details of typical applications where Torbars have been successfully used.

A comprehensive list of major projects and letters of reference from international companies are available on request.



HOW TORBAR WORKS

TORBAR produces an averaged differential pressure (DP) signal proportional to the square of the flow rate, (see Differential Pressure Calculations on page 11).



The DP output is normally piped to a Differential Pressure Transmitter in order to generate an electrical signal proportional to the flow rate. A D.P. gauge or switch can be used to provide local mechanical indication or flow rate switching. For certain applications, the DP Transmitter can be directly mounted on to the **TORBAR** via an integral 3 valve manifold. The total flowmeter package is called a **TRIBAR**. Full details are given on pages 16 & 17.

Each **TORBAR** is designed to span the process pipe diameter and comprises four basic components:

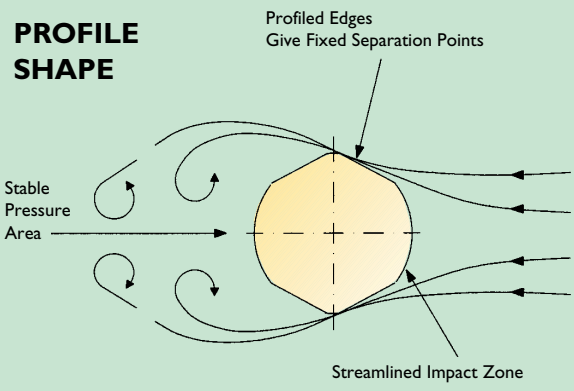
- **Outer impact tube -** ONE PIECE CONSTRUCTION
- **Internal averaging tube**
- **Low pressure chamber**
- **Head**

The outer impact tube has a number of pressure sensing holes facing upstream which are positioned at equal annular points in accordance with a log-linear distribution.

The "total pressures" developed at each upstream hole by the impact of the flowing medium are firstly averaged within the outer impact tube and then to a second order (and more accurately) averaged within the internal averaging tube. This pressure is represented at the head as the high pressure component of the DP output.

The low pressure component is generated from a single sensing hole located on the downstream side of the outer impact tube. For bi-directional flow measurement, the **TORBAR** can be supplied with the same number of downstream ports as upstream. Bi-directional sensors have an inherently lower mechanical strength than the standard **TORBAR** and the figures given for Maximum Allowable DP on page 11 should be reduced by 50%.

PROFILE SHAPE - The **TORBAR** is an improvement on the round sensor design due to the unique profiled flats which are positioned around the downsteam hole in order to define the separation point at which the flow lines "break-off" as the fluid passes around the outer impact tube. This feature creates a stable pressure area at the downstream pressure sensing hole thereby maintaining a more constant flow co-efficient K at high velocities enabling a very wide range of flow measurement (turndown).



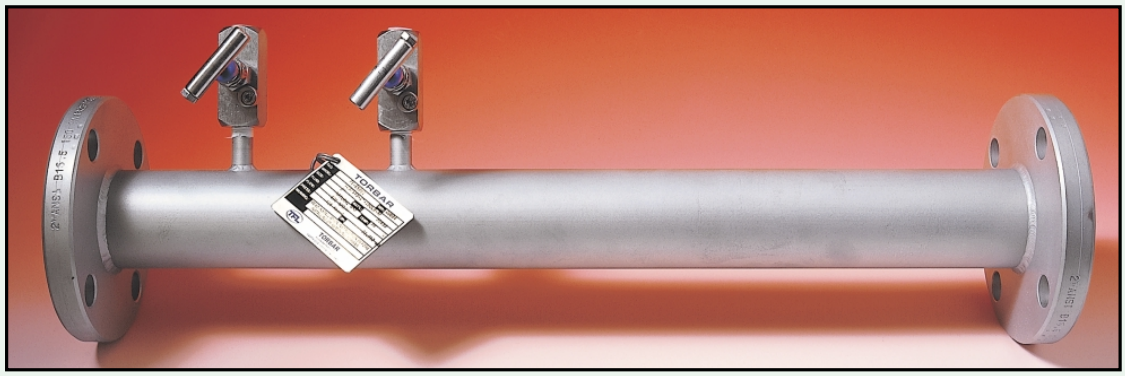
PROBLEM FLUIDS

The **TORBAR** is NOT suitable for the measurement of 2 phase fluids or when the fluid does not completely fill the cross section of the pipe.

Satisfactory flow measurement can be achieved for certain contaminated gas flows (such as flue gas) by using an air purging system. See page 15. For water flows which may contain a small amount of air, an air-venting package is recommended.

FEATURES

- Unique profile shape enables high flow turndown
- Dual averaging for better accuracy
- One-piece outer tube for optimum strength
- Suitable for pipe sizes from 10mm to 5000mm (and larger with a special 2 piece construction)
- Suitable for square or rectangular section ducts
- Available as hot-tap for insertion into pressurised pipes
- Optional direct mounting transmitter arrangement (see TRIBAR on pages 16 & 17)
- Zero co-efficient drift ensures long term stability
- Low permanent pressure loss means low energy consumption - and significant cost benefits



GENERAL SPECIFICATIONS

- TORBAR is suitable for liquid, gas, and steam flow measurement
- Accuracy ± 1% of actual flow rate - verified by independent flow laboratories
- Repeatability of measurement ± 0.1%
- Reynolds number. Minimum Re:1.2x10^4
- Flow rate turndown typically 10:1 (100:1 of DP)
- Maximum working pressure up to 600 bar
- Maximum working temperature up to 1300 deg. C with selected materials and fittings
- Maximum viscosity 200 cp (mPas)
- Short upstream and downstream straight pipe lengths
- Long term accuracy unaffected by wear

CONSTRUCTION

- TORBARs are engineered and manufactured to stringent routines including BS, ANSI, ASME, ISO and DIN standards
- Welding is carried out by Lloyds qualified welders to ASME IX and European standards.
- Quality control system is approved to BS EN ISO 9002-1994
- TORBARs are leak tested before dispatch.
- Hydrostatic pressure testing and NDE is available by request for all models.
- Standard material of construction is 316L stainless steel but many other materials are available on request.
- All TORBARs have full material traceability.
- Material test certificates to EN 10204 (DIN 50049) and certificates of conformity are available for each component part of every TORBAR
- Stainless steel data plate as standard.

APPROVAL NO: 926227

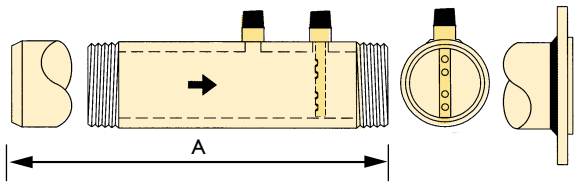
INDEPENDENT FLOW TESTS

The **TORBAR** accuracy and repeatability of measurement has been verified by independent testing laboratories in the United Kingdom. Refer to page 10 for more details.

PERMANENTLY INSTALLED TYPES

MODEL SPECIFICATION

IN LINE FITTING



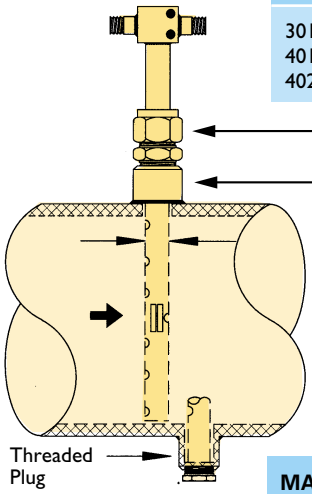
BASIC MODEL	END FITTINGS	FITS PIPE SIZES (mm)
121 122 123	Butt Weld Threaded Flanged	13 - 50

All models are supplied with a pipe section in the same material as **TORBAR** probe

PIPE SIZE (INS.SCH80)	'A' (mm)	MODEL	MAXIMUM PRESSURE/ TEMPERATURE
½" 1" 1½", 2"	200 225 250	121 122 123	200BAR/450°C 70BAR/200°C As flange rating

THREADED FITTING

BASIC MODEL	D (mm)	FITS PIPE SIZES (mm)
301 401† 402*	13 25 25	50 - 150 100 - 1800 100 - 5000



End Support Model 402

All Models are supplied with carbon steel pipe weld fitting and stainless steel compression gland as standard.

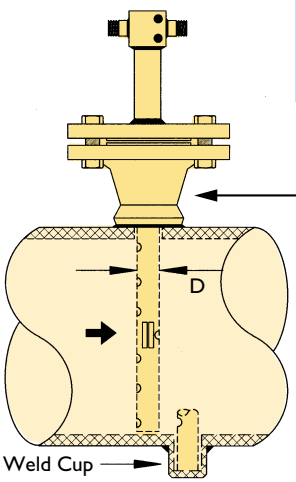
MAXIMUM PRESSURE/ TEMPERATURE	
Model 301	70 Bar @ 500°C
Model 401, 402	70 Bar @ 500°C

† *For liquid flow applications where there is a possibility of process pulsations or intermittent excessive flow velocity, the end-support model should always be selected for pipe sizes over 250mm internal diameter.*
* *With end support*

FLANGED FITTING

Standard

BASIC MODEL	D (mm)	FITS PIPE SIZES (mm)
311 411† 412*	13 25 25	50 - 150 100 - 1800 100 - 5000



End Support Model 412

All Models are standardly supplied without flanged pipe fitting or stud bolts and gaskets. These are available as accessories

STANDARD FLANGE SIZE	
Model 311	1 inch (DN 25)
Model 411, 412 (Other sizes available)	1½ inch (DN 40)

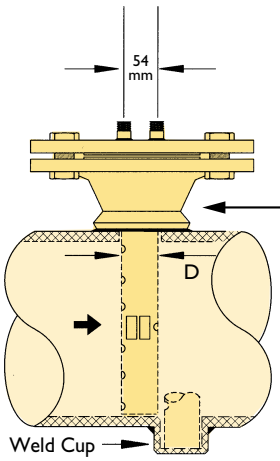
MAXIMUM PRESSURE/ TEMPERATURE
ALL MODELS AS FLANGE RATING TO 450°C FOR MATERIAL 316LSS

† *For liquid flow applications where there is a possibility of process pulsations or intermittent excessive flow velocity, the end-support model should always be selected for pipe sizes over 250mm internal diameter.*
* *With end support*

FLANGED FITTING

Extra Strength

BASIC MODEL	D (mm)	FITS PIPE SIZES (mm)
511† 512*	60 60	250 - 1800 400 - 8000



End Support Model 512

All Models are standardly supplied without flanged pipe fitting or stud bolts and gaskets. These are available as accessories

STANDARD FLANGE SIZE	
Model 511, 512 Other sizes available)	3 inch (DN 80)

MAXIMUM PRESSURE/ TEMPERATURE
ALL MODELS AS FLANGE RATING TO 450°C FOR 316L SS

† *For liquid flow applications where there is a possibility of process pulsations or intermittent excessive flow velocity, the end-support model should always be selected for pipe sizes over 600mm internal diameter.*
* *With end support*

FOR VERTICAL PIPE INSTALLATIONS, SPECIFY OPTION 'VS' - SEE PAGE 12

PERMANENTLY INSTALLED TYPES

MODEL CODING

XXX - XXX - XX - 00 - XX - XXX - XXX - XXX

BASIC MODEL
(See opposite page)

NOMINAL PIPE SIZE

TORBAR PROBE MATERIAL
(see OPTIONS below)

ACCESSORIES
(see page 8)

FLANGE SIZE & RATING
(Models 123, 311, 411, 412, 511, 512)

DP OUTPUT CONNECTION
(see below)

PIPE FITTING MATERIAL
(see OPTIONS below)

OPTIONS

PROBE MATERIAL	CODE
316L Stainless steel	SS
304 Stainless steel	4S
Monel 400	ML
Hastelloy	HC
6MO	6M
Duplex	DX
Super Duplex	SDX
Plastic	PC
Titanium GR2	TI
Other	Specify

PIPE FITTINGS MATERIAL	CODE
A105 Carbon steel	CS
316L Stainless steel	SS
304L Stainless steel	4S
Monel 400	ML
Hastelloy	HC
6MO	6M
Duplex	DX
Super Duplex	SDX
Other	Specify
Purchaser Supply	XX

DP OUTPUT CONNECTIONS

X X X

VALVE MATERIAL	CODE
No valves	O
DM or DM3V HEAD	O
Brass	B
Carbon Steel	C
316L Stainless Steel	S
Monel 400 (Or Alloy 400)	ML
UNS 31254 (6MO)	6M
Hastelloy (C276)	HC
Other	SPECIFY

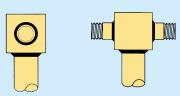
VALVE TYPE	CODE
No valves	O
DM or DM3V HEAD	O
Ball	B
Needle	V
Needle (High Temp)	VH
Gate	G
Globe	L
Double Block/Bleed	VD

SIZE	CODE
DM or DM3V HEAD (See Accessories page 8)	0
¼" NPT (M)	3
¼" BSPT (M)	4
½" NPT (M)	7
½" BSPT (M)	8
½" WELD (MALE)	6
½" FLANGED	9
OTHER	SPECIFY

NOTE: For a female output connection WITHOUT valves, add 'F' to size-code. eg: ¼" NPT female connection without valves, code is 003F.

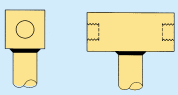
MALE WITHOUT VALVES

Code Example:
007 (½" NPT)



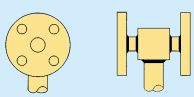
FEMALE WITHOUT VALVES

Code Example:
006F (½" Weld Socket)



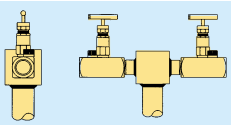
FLANGED WITHOUT VALVES

Code Example:
009 (½")



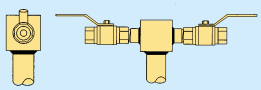
WITH NEEDLE VALVES

Code Example:
SV4
(ST. ST. ¼" BSPT)



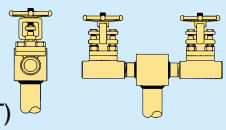
WITH BALL VALVES

Code Example:
BB3
(BRASS. ¼" NPT)



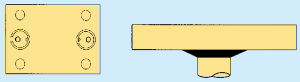
WITH GATE VALVES

Code Example:
CG8
(Carbon ST. ¼" BSPT)



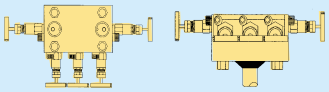
DIRECT MOUNT HEAD

Code: 000
Specify
Accessory: DM



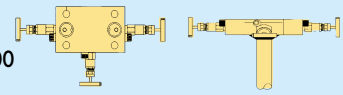
DIRECT MOUNTING WITH MANIFOLD

Code: 000
Specify Accessory: 3VDM (3 Valve)
5VDM (5 Valve)



DIRECT MOUNT INTEGRAL MANIFOLD

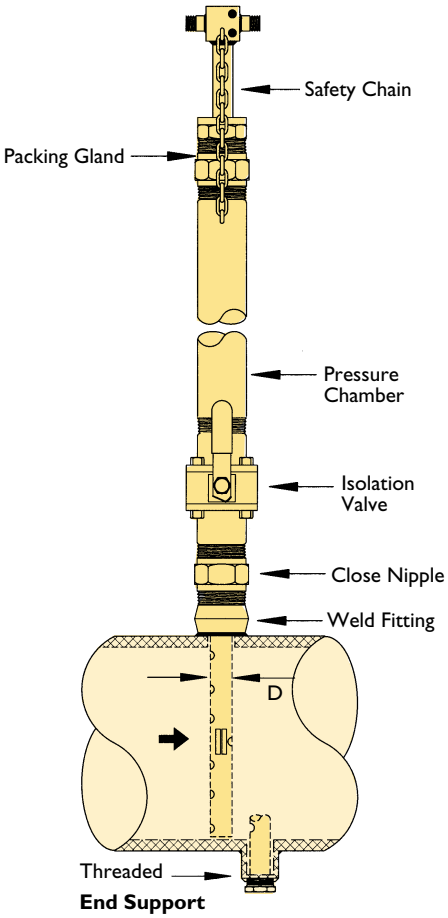
Code: 000
Specify
Accessory: DM3V



WITHDRAWABLE TYPES (HOT TAP)

MODEL SELECTION

THREADED FITTING
LOW PRESSURE



End Support
Model L702

BASIC MODEL	D (mm)	FITS PIPE SIZES (mm)
L601	13	50 - 100
L701†	25	100 - 1800
L702*	25	300 - 3000

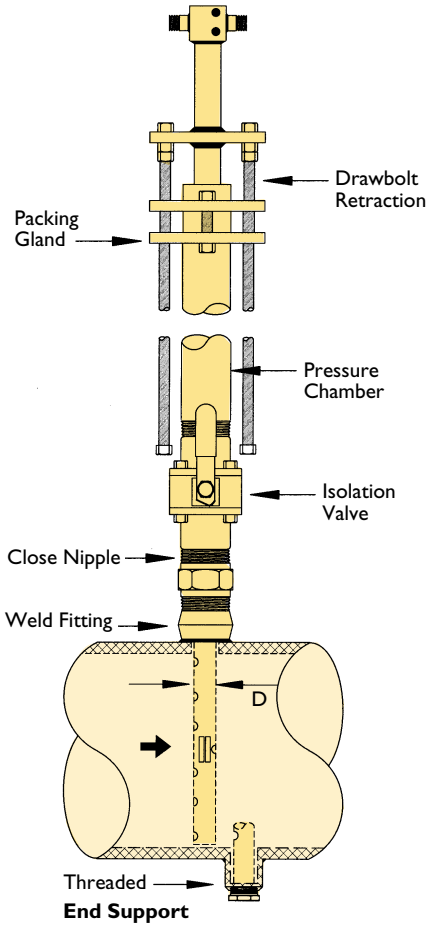
Supplied with weld fittings, isolation valve and pressure chamber with safety chain as standard. Gland packing material is standardly supplied as non-asbestos graphite ribbon. Teflon is available.
Please specify at time of order.
For isolation valve details - see page 7.

MAXIMUM PRESSURE / TEMPERATURE

With standard ball valve 10 bar and 200˚c
With standard gate valve 10 bar and 450˚c
(Temperature is at valve)

† *For liquid flow applications where there is a possibility of process pulsations or intermittent excessive flow velocity, the end-support model should always be selected for pipe sizes over 250mm internal diameter.*
*with end support

THREADED FITTING
HIGH PRESSURE



End Support
Model H702

BASIC MODEL	D (mm)	FITS PIPE SIZES (mm)
H601	13	050 - 100
H701†	25	100 - 1800
H702*	25	300 - 3000

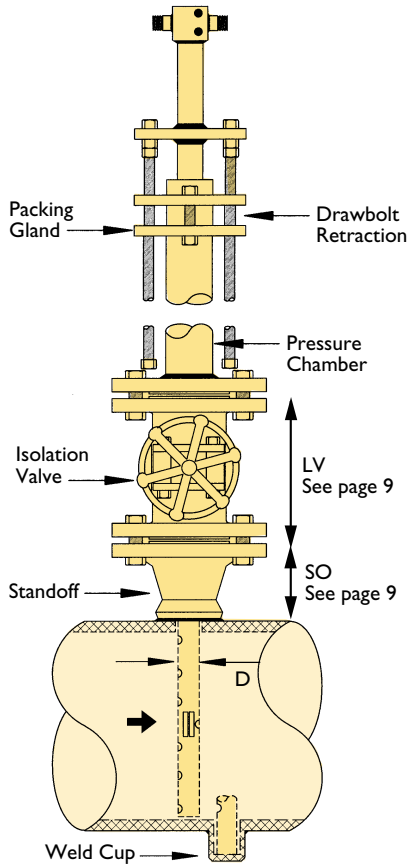
Supplied with weld fittings, isolation valve, pressure chamber and draw bolt retraction (illustrated) as standard. Gland packing material is standardly supplied as non-asbestos graphite ribbon. Teflon is available. Please specify at time of order.
Geared retraction - optional (see page 8).
For isolation valve details - see page 7.

MAXIMUM PRESSURE /TEMPERATURE

With standard ball valve 40 bar and 200˚c
With standard gate valve 40 bar and 450˚c
(Temperature is at valve)

† *For liquid flow applications where there is a possibility of process pulsations or intermittent excessive flow velocity, the end-support model should always be selected for pipe sizes over 250mm internal diameter.*
*with end support

FLANGED FITTING



End Support
Model H712 and H812

BASIC MODEL	D (mm)	FITS PIPE SIZES (mm)	STANDARD FLANGE SIZE
H611	13	50 - 100	1"(DN25)
H711†	25	100 - 1800	1½"(DN40)
H712*	25	300 - 3000	1½"(DN40)
H811†	60	300 - 2000	3"(DN80)
H812*	60	600 - 3000	3"(DN80)

other sizes available

Supplied with isolation valve and pressure chamber, and draw bolt retraction assembly and without flanged pipe fitting or stud bolts and gasket (Available as accessories - page 8). Gland packing material is standardly supplied as non-asbestos graphite ribbon. Teflon is available. Please specify at time of order.
Geared retraction - Optional (see page 8).
For isolation valve details - see page 7.

MAXIMUM PRESSURE / TEMPERATURE

With standard ball valve 100 bar and 200˚c
With standard gate valve 100 bar and 450˚c
(Temperature is at valve)

† *For liquid flow applications where there is a possibility of process pulsations or intermittent excessive flow velocity, the end-support model should always be selected for pipe sizes over 600mm internal diameter.*
*with end support

Models L702, H702, H712 and H812 should not be installed into a pressurised pipe because of the requirement to fit an end support. Refer to detailed installation instructions.

FOR VERTICAL PIPE INSTALLATIONS, SPECIFY OPTION 'VS' - SEE PAGE 12

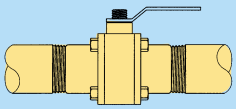
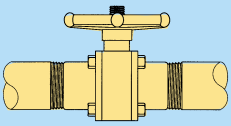
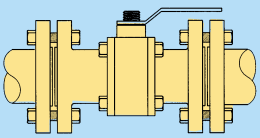
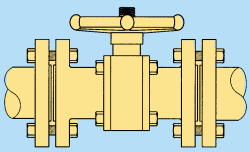
WITHDRAWABLE TYPES (HOT TAP)

MODEL CODING

XXX - XXX - XX - XXX - XX - XXX - XXX - XXX

- BASIC MODEL *(See opposite page)*
- NOMINAL PIPE SIZE
- TORBAR PROBE MATERIAL *(refer to options - page 5)*
- PROCESS ISOLATION VALVE *(see below)*
- ACCESSORIES *(see page 8)*
- FLANGE SIZE & RATING *(models H711, H712, H811, H812)*
- DP OUTPUT CONNECTION *(refer to options - page 5)*
- PIPE FITTING MATERIAL *(refer to options - page 5)*

PROCESS ISOLATION VALVES

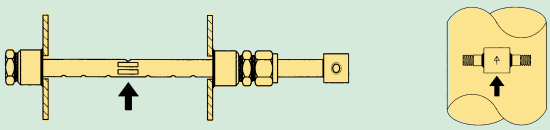
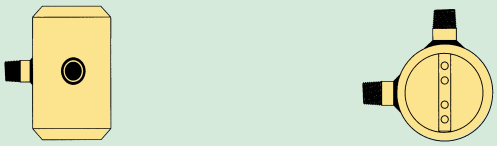
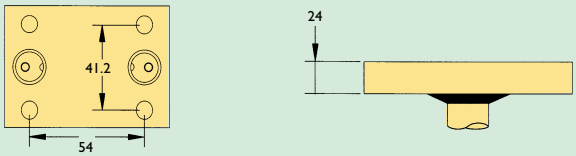
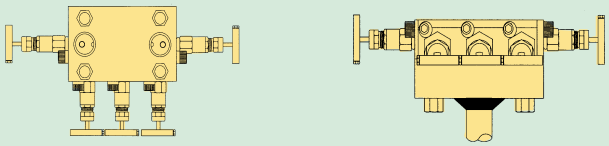
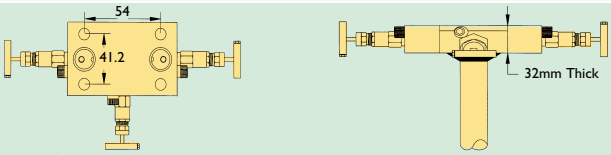
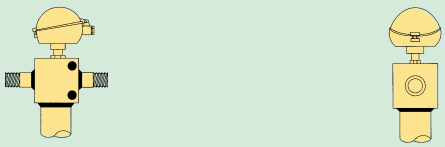
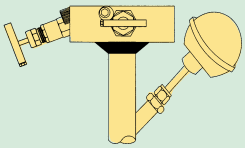
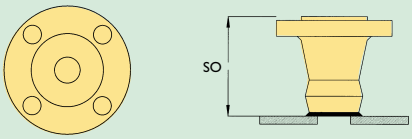
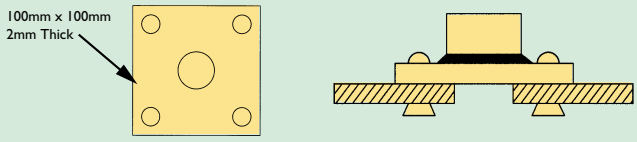
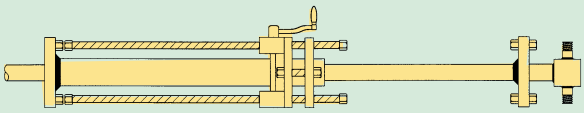
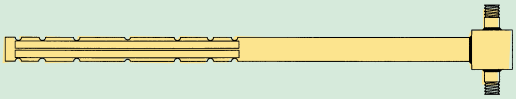
VALVE TYPE	TORBAR MODEL	VALVE SIZE	CODE (* IS MATERIAL SEE BELOW)	MAXIMUM TEMPERATURE AT VALVE
Threaded Ball 	L601	¾" BSPT	5B*	200°C
	L701 L702 H701 H702	1¼" BSPT	7B*	200°C
Threaded Gate 	L701 L702 H701 H702	1¼" BSPT	7G*	450°C
Flanged Ball 	H611	1"	4B*	200°C
	H711	1½"	8B*	200°C
	H712	2"	6B*	200°C
	H811 H812	3"	9B*	200°C
Flanged Gate 	H611	1"	4G*	450°C
	H711	1½"	8G*	450°C
	H712	2"	6G*	450°C
	H811 H812	3"	9G*	450°C

Code * defines valve material

316SS - (S) Carbon Steel - (C) Monel - (M) For other material specify (Example: 7GC is 1 1/4" BSPT Gate Valve in Carbon Steel).

When valve is supplied by purchaser, whole code is: XXX.

ACCESSORIES

DESCRIPTION	MODELS	ILLUSTRATION	CODE
Vertical Pipe Installation	301, 311, 401, 402, 411, 412, 511, 512, L601, L701, L702, H701, H702, H711, H712, H811, H812		VS
	121, 122, 123		
Head for Direct Mounting of Valve Manifold or Transmitter	301, 311, 401, 402, 411, 412, 511, 512, L601, L701, L702, H701, H702, H711, H712, H811, H812		DM
Direct Mounting Head fitted with 3 or 5 Valve Manifold	301, 311, 401, 402, 411, 412, 511, 512, L601, L701, L702, H701, H702, H711, H712, H811, H812		3VDM (3 VALVE) 5VDM (5 VALVE)
Head with integral Valve Manifold (3 or 5) for fitting of transmitter by others. Transmitter fitted by TFL refer to TRIBAR, see page 16	301, 311, 401, 402, 411, 412, 511, 512, L601, L701, L702, H701, H702, H711, H712, H811, H812		DM3V DM5V
PT100 Temperature Element fitted through TORBAR head. For Hazardous Area Installations specify certification required	401, 402, 411, 412, 511, 512, L601, L701, L702, H701, H702, H711, H712, H811, H812		RTB Without Transmitter RTT With Transmitter
PT100 Temperature Element fitted through TORBAR neck. For Hazardous Area Installations specify certification required	401, 402, 411, 412, 511, 512, L601, L701, L702, H701, H702, H711, H712, H811, H812	 When specified with DM3V Head and integral DP Transmitter, refer to TRIBAR on page 16	NRTB Without Transmitter NRTT With Transmitter
Flanged Pipe Fittings (Stand-Off). Material is specified by "Pipe Fitting Material" in Model Number. Type, Size & Rating is specified with Model Number	311, 411, 412, 511, 512, H711, H712, H811, H812	 Note: Length "SO" is given on page 9	FS
Stud Bolts, Nuts & Gasket	311, 411, 412, 511, 512, H711, H712, H811, H812	**Standard Materials** Stud, Bolts & Nuts: A193-B7/A 194-2H Gasket: Asbestos Free Glass/Aramid Fibre/Nitrile	SBG
		For Other Gasket Material: Specify	SBGS
Thin duct wall Mounting Plate. Recommended for large ducts with wall thickness of less than 2mm	301, 401, 402, L601, L701, L702, H701, H702		DF
Gear Retraction Assembly (Material: 316L Stainless Steel)	H701, H702, H711, H712, H811, H812		GR
Bi-Directional Probe	401, 402, 411, 412, 511, 512, L601, L701, L702, H701, H702, H711, H712, H811		BW

TORBAR DIMENSIONAL INFORMATION

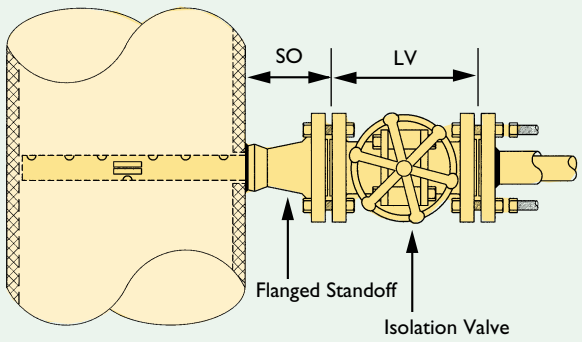
FLANGED STANDOFF DIMENSIONS (ACCESSORY FS) OVERALL LENGTH SO (mm)

ANSI CLASS	SIZE			
	1"	1½"	2"	3"
150	83	95	102	118
300	89	100	108	127
600	95	109	117	137
900	106	122	146	156
1500	106	122	146	171
2500	122	150	171	222

DIN CLASS	SIZE			
	DN25	DN40	DN50	DN80
PN10	67	78	86	98
PN16	67	78	86	98
PN25	67	78	86	98
PN40	67	78	86	106
PN50	89	101	108	127
PN110	89	103	111	131
PN150	100	116	140	150
PN260	100	116	140	165

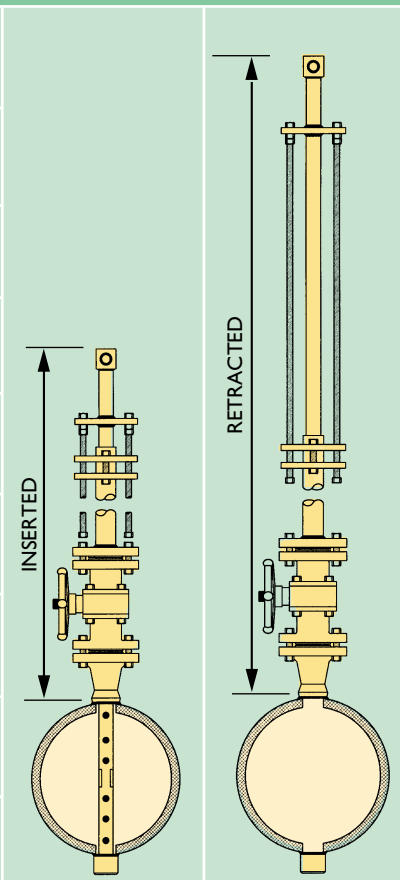
FLANGED ISOLATION VALVE OVERALL LENGTH LV (mm)

SIZE	ANSI CLASS			
	150	300	600	1500
1"	127	165	216	254
1½"	165	191	241	305
2"	178	216	308	368
3"	203	283	375	381



WITHDRAWABLE TYPES (HOT-TAPS) INSERTED AND RETRACTED LENGTHS (ALLOWS 5% FOR TOLERANCING) (mm)

L601	Inserted	ID + 236
	Retracted	INSERTED + ID + WALL + 211
L701	Inserted	ID + 346
	Retracted	INSERTED + ID + WALL + 208
L702	Inserted	ID + WALL + 371
	Retracted	INSERTED + ID + WALL + 233
H701	Inserted	ID + 493
	Retracted	INSERTED + ID + 355
H702	Inserted	ID + WALL + 518
	Retracted	INSERTED + ID + WALL + 380
H711	Inserted	ID + WALL + 2(SO + LV) + 340
	Retracted	INSERTED + ID + WALL + SO + LV
H712	Inserted	ID + 2(WALL + SO + LV) + 380
	Retracted	INSERTED + ID + WALL + SO + LV + 40
H811	Inserted	ID + WALL + 2(SO + LV) + 355
	Retracted	INSERTED + ID + WALL + SO + LV
H812	Inserted	ID + 2(WALL + SO + LV) +419
	Retracted	INSERTED + ID + 2x WALL + SO + LV + 60

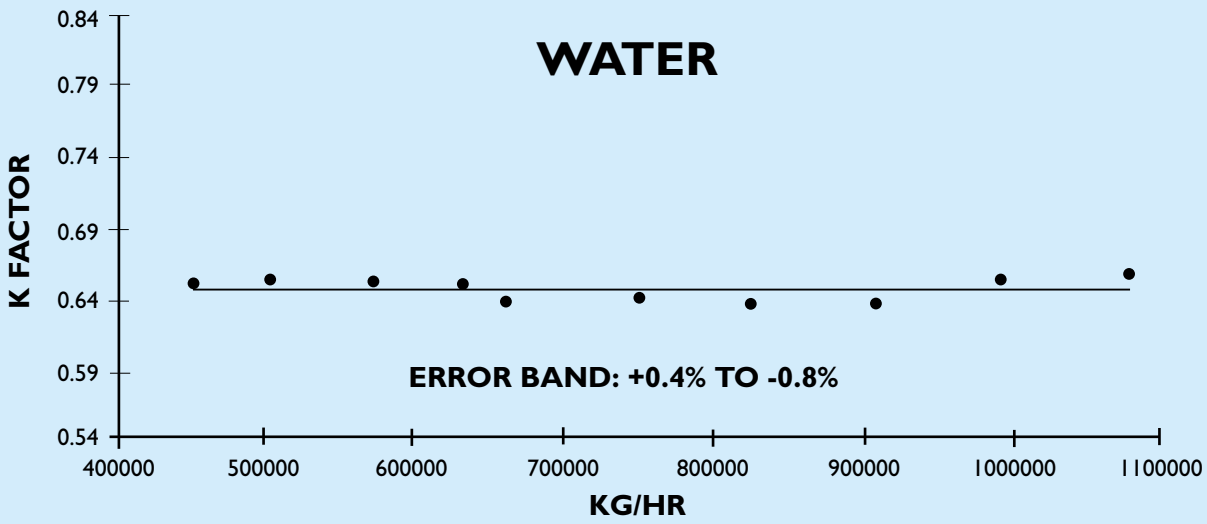


FOR GEARED RETRACTION UNITS (ACCESSORY GR) ADD 100mm TO ABOVE DIMENSIONS

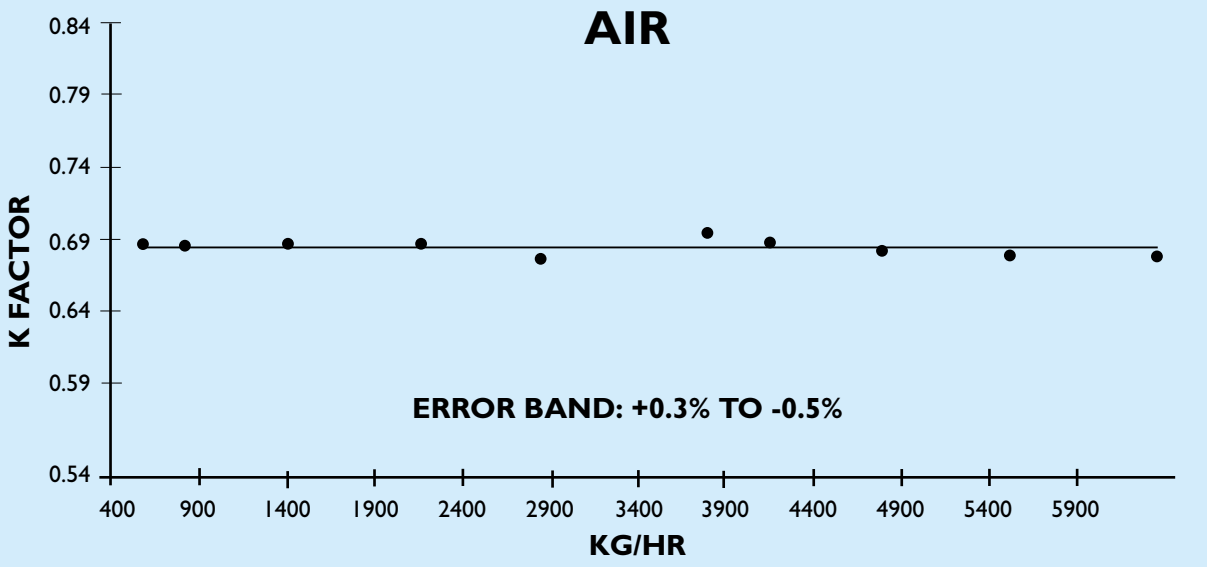
INDEPENDENT TEST REPORTS

A range of TORBAR models and sizes have been tested at Independent Flow Laboratories to determine the accuracy and repeatability of measurement. Those test were conducted in both Air and Water.

MODEL 401 SIZE: 16INCH SERIAL No. TEST 597



MODEL: 401 SIZE: 12INCH SERIAL No. 20153



Full details of the test results above and of those shown in the table below are available on request.

TEST FLUID	MODEL	SIZE	SERIAL NUMBER	ERROR BAND
WATER	123	2”	TEST 197	+0.2 TO -0.43%
WATER	301	4”	TEST 297	+1 TO -1%
AIR	401	6”	TEST 397	+0.1 TO -0.5%
AIR	402	18”	20186	+0.6 TO -0.5%
WATER	411	24”	TEST 697	+0.3 TO -0.4%

DIFFERENTIAL PRESSURE CALCULATIONS AND RESONANCE FREQUENCY CHECK

FLOW TO DP

LIQUIDS (Volumetric)

$$DP = \left[\frac{QA \times \sqrt{D}}{K \times A \times 4.6285}\right]^2 \text{ mbar}$$

GASES (Volumetric)

$$DP = \left[\frac{S \times (Tf + 273)}{Pf}\right]\left[\frac{QB}{K \times A \times 66.839}\right]^2 \text{ mbar}$$

LIQUIDS / GASES / STEAM (Mass)

$$DP = \left[\frac{QC}{K \times A \times \sqrt{D} \times 4.6285}\right]^2 \text{ mbar}$$

SYMBOLS & UNITS

QA = Flow (m^3/hr)
QB = Flow (Nm^3/hr) at 0°C, 1 atms (1.013 bar)
QC = Flow (kg/hr)
S = Specific Gravity (Air = 1)
D = Density at actual conditions (kg/m^3)
Base Density of water at 4°C = 999.972 kg/m^3
Density of water at 15.55°C = 999.074 kg/m^3
Base Density of Air at 0°C
1 ATMOS (1.013 bar) = 1.292 kg/m^3
A = Pipe internal X-Section Area (cm^2)
Tf = Actual Temperature (°C)
Pf = Actual Pressure (bar Absolute)
K = Torbar Co-efficient (see table)

Copies of the derivations of these formulae are available on request.

THE CALCULATION SOFTWARE (TORWIN) IS AVAILABLE FREE OF CHARGE BY POST OR E-MAIL.

TORBAR CO-EFFICIENT K

PIPE SIZE (Internal diameter) (mms)	MODEL NUMBER 301 601 311	401 402 411 412 701 702 711 712	511 512 811 812
50	0.6483		
75	0.7027		
100	0.7497	0.6174	
150	0.7671	0.6505	
200		0.6647	
250		0.6794	0.6876
300		0.6941	0.7024
350		0.7160	0.7303
400		0.7380	0.7564
450		0.7402	0.7699
600		0.7468	0.7815
900		0.7473	0.7847
1200		0.7475	0.7849
1500		0.7476	0.7850
1800	and above	0.7476	0.7850

FOR SIZES NOT SHOWN ABOVE, DETERMINE K BY EXTRAPOLATION

For Models 121, 122, 123 (all sizes) K = 1

IT IS IMPORTANT THAT THE ANSWERS FROM THESE EQUATIONS ARE VERIFIED WITH THE FACTORY OR TORBAR ACCREDITED SUPPLIER BEFORE USE WITH YOUR SYSTEM

DP TO FLOW

LIQUIDS (Volumetric)

$$Flow(Q) = \sqrt{DP} \times \left[\frac{KxAx4.6285}{\sqrt{D}}\right] m^3/hr$$

GASES (Volumetric)

$$Flow(Q) = \sqrt{DP} \times \left[\frac{KxAx\sqrt{(Tf+273)}}{\sqrt{Sx4.0323x\sqrt{Pf}}}\right] Am^3/hr \text{ (Actual conditions)}$$

or

$$Flow(Q) = \sqrt{DP} \times \left[\frac{KxAx66.839x\sqrt{Pf}}{\sqrt{Sx\sqrt{(Tf+273)}}}\right] Nm^3/hr \text{ (Normal conditions)}$$

LIQUIDS / GASES / STEAM (Mass)

$$Flow(Q) = \sqrt{DP} \times (KxAx\sqrt{D}x4.6285) \text{ kg/hr}$$

SYMBOLS & UNITS

DP Differential Pressure (mbar)
S Specific Gravity (Air = 1)
D Density at Actual Conditions (kg/m^3)
Base Density of Water at 4°C 999.972 kg/m^3
Density of Water at 15.55°C 999.074 kg/m^3
Density of Air at 0°C 1.292 kg/m^3
A Pipe Internal x-section Area (cm^2)
Tf Actual Temperature (°C)
Pf Actual Pressure (Bar A) (Absolute)
K TORBAR Co-Efficient (see Table)

Normal Conditions 0°C, 1 Atmosphere (1.013 bar)

STATEMENT OF ACCURACY: The calculated differential pressure will lie within an uncertainty band of */- 1% with 95% confidence if the TORBAR is installed strictly in accordance with the published Installation Instructions. For applications which do not conform to those instructions, it is recommended that an on site calibration is performed in order to achieve the optimum accuracy.

RESONANCE FREQUENCY CHECK

This check is not necessary for LIQUID FLOWS. because the maximum allowable DP is reached before resonance occurs (see table opposite) or Models 121, 122, and 123
For Gas and Vapour flows a Resonance Frequency Check MUST be made. Equations have been derived for the various TORBAR models to determine LOW and HIGH critical velocities (VL and VH) which define the narrow resonance band of velocities which should be outside the continuous operating flow range of the TORBAR.
The table below lists those equations to calculate the VL and VH. If the calculation shows VL to VH to be within the continuous operating flow range, then an alternative, suitable model of TORBAR should be selected to give acceptable values of VL and VH.
Always check that the maximum flow DP is less than the 'Maximum Allowable DP' as shown in the opposite table.

TORBAR MODEL	CRITICAL VELOCITIES VL (M/SEC)	VH (M/SEC)	UNSUPPORTED LENGTH L (METRES) (see below)
301	$0.472 \div L^2$	$0.728 \div L^2$	ID + WALL + 0.05
311	$0.472 \div L^2$	$0.728 \div L^2$	ID + WALL + SO
L601	$0.472 \div L^2$	$0.728 \div L^2$	ID + WALL + 0.02
401	$1.843 \div L^2$	$2.840 \div L^2$	ID + WALL + 0.08
402	$8.08 \div L^2$	$12.44 \div L^2$	ID + 2 x WALL + 0.115
411	$1.843 \div L^2$	$2.840 \div L^2$	ID + WALL + SO
412	$8.08 \div L^2$	$12.44 \div L^2$	ID + 2 x WALL + SO + 0.05
L701	$1.843 \div L^2$	$2.840 \div L^2$	ID + WALL + 0.05
L702	$8.08 \div L^2$	$12.44 \div L^2$	ID + 2 x WALL + 0.10
H701	$1.843 \div L^2$	$2.840 \div L^2$	ID + WALL + 0.05
H702	$8.08 \div L^2$	$12.44 \div L^2$	ID + 2 x WALL + 0.10
H711	$1.843 \div L^2$	$2.840 \div L^2$	ID + WALL + SO + VV + 0.05
H712	$8.08 \div L^2$	$12.44 \div L^2$	ID + 2 x WALL + SO + VV + 0.10
511	$10.88 \div L^2$	$16.766 \div L^2$	ID + WALL + SO
512	$47.65 \div L^2$	$73.43 \div L^2$	ID + 2 x WALL + SO + 0.08
H811	$10.88 \div L^2$	$16.766 \div L^2$	ID + WALL + SO + VV + 0.05
H812	$47.65 \div L^2$	$73.43 \div L^2$	ID + 2 x WALL + SO + VV + 0.13

L = UNSUPPORTED LENGTH (METRES)
ID = PIPE INTERNAL DIAMETER (METRES)
WALL = PIPE WALL THICKNESS (METRES)
SO = OVERALL LENGTH OF FLANGED PIPE FITTING (METRES) (See page 9)
VV = OVERALL LENGTH OF ISOLATION VALVE (METRES) (See page 9)

THE ABOVE EQUATIONS ARE DERIVED FROM TORBAR RESONANCE FREQUENCY DATA AND CALCULATIONS. FULL DETAILS ARE AVAILABLE ON REQUEST.

MAXIMUM ALLOWABLE DP

Depending on the model and size of TORBAR there is a maximum figure of Differential Pressure above which the TORBAR should NOT be used due to the imposition of excessive mechanical stresses. Check the table below to ensure that the application is suitable. If the calculated DP exceeds the maximum shown below, then select an other appropriate model to suit the application. For Bi-Directional configurations (accessory code BW), use 50% of the figures in this table.

FOR LIQUID FLOW APPLICATIONS WHERE THERE IS A POSSIBILITY OF PROCESS PULSATIONS OR INTERMITTENT EXCESSIVE FLOW VELOCITY, THEN THE END-SUPPORT MODELS SHOULD ALWAYS BE SELECTED FOR PIPE SIZES OVER 250mm DIAMETER (400 AND 700 SERIES) AND 600mm (500 AND 800 SERIES).

PIPE SIZE (Internal Dia.)		TORBAR BASE MODEL NUMBER * 301 311 601 611	401 411 701 711	402 412 702 712	511 811	512 812
(ins)	(mms)	Maximum allowable DP in mbar				
2	50	6250				
3	75	2790				
4	100	1565	5100			
6	150	695	2285			
8	200		1285			
10	250		820	3250	3400	
12	300		570	2250	2350	
14	350		415	1680	1725	
16	400		320	1285	1335	
18	450		250	1015	1055	4225
24	600		140	570	590	2375
36	900		50	250	265	1055
48	1200		30	140	145	590
60	1500		20	90	90	380
72	1800		10	60	65	265

Above 1800 mm - consult factory

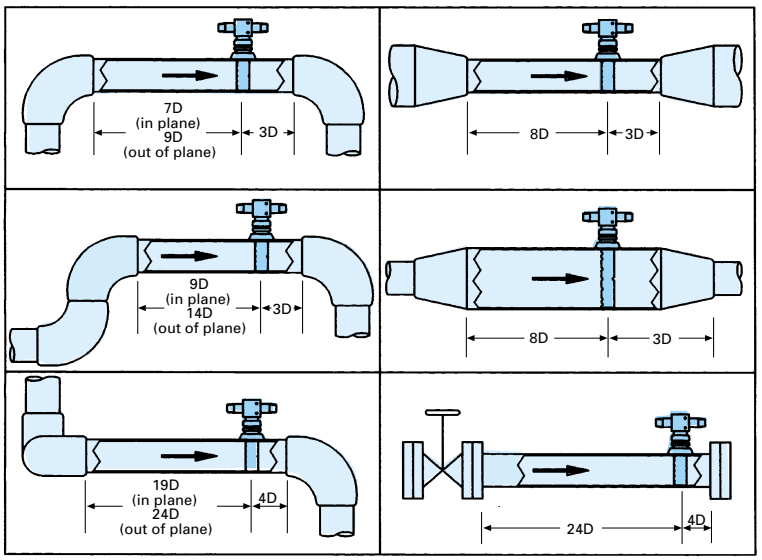
FOR SIZES NOT SHOWN ABOVE DETERMINE MAXIMUM ALLOWABLE DP BY EXTRAPOLATION

** For models 121, 122, 123 (all sizes) Maximum DP value is 2500 mbar.*

THE ABOVE FIGURES ARE THEORETICALLY DERIVED AND INCLUDE A X10 SAFETY FACTOR OVER AND ABOVE BASIC STANDARDS AND SPECIFICATION. FULL THEORETICAL DATA IS AVAILABLE ON REQUEST.

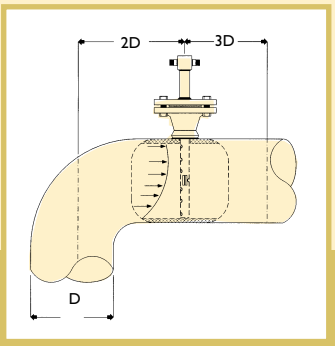
INSTALLATION & LOCATION

Recommended Upstream and Downstream Distances



Correct location of the **TORBAR** in the piping system is important in order to optimise performance. Flow that is disturbed by upstream configurations such as elbows, T's and valves may have an adverse effect on accuracy unless the **TORBAR** is located at recommended positions shown in the table opposite. The diagrams illustrate the distances in multiples of pipe bore 'D' between the **TORBAR** and the upstream and downstream disturbances. If the **TORBAR** is fitted within distances less than those shown, then absolute accuracy may be downgraded BUT repeatability of measurement will still be excellent due to inherent averaging characteristics.

Where it is not possible to provide the specified distances and maximum accuracy is required, the use of a flow straightening spool piece allows for shorter distances.



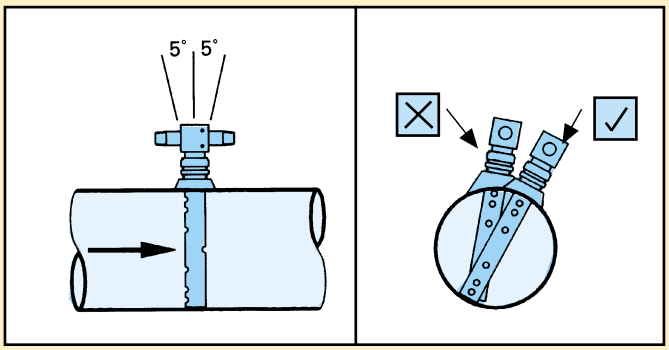
ELBOW INSTALLATION (Right)

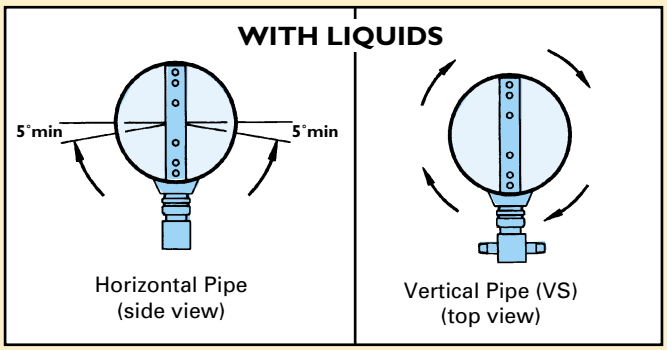
The **TORBAR** can be installed 2 diameters downstream of a 90° elbow at the exit of the elbow to give an accuracy of +/-3% to +/-5%.

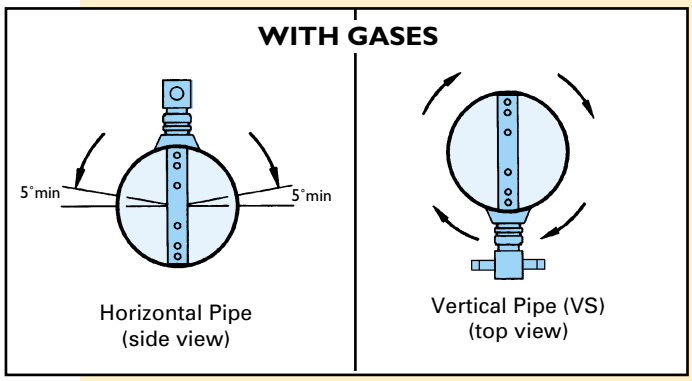
Orientation in Pipe

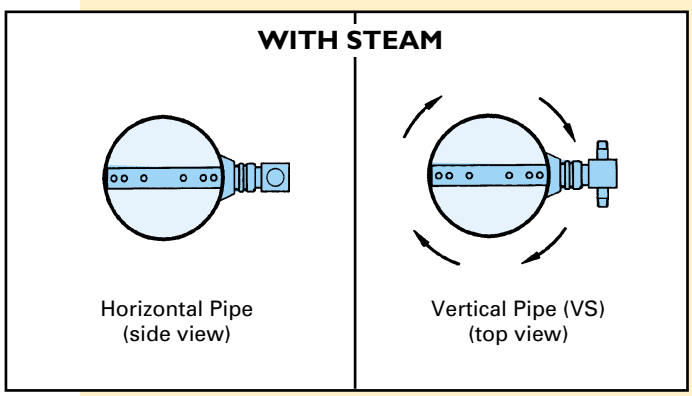
The **TORBAR** must be installed at right angles to the pipe run and across a pipe diameter within the tolerances shown in the diagrams opposite.

To avoid 'noisy' signal outputs, do not locate the **TORBAR** in a pulsating flow. A vibrating pipe can also distort the output signal and affect the structural limits of the **TORBAR.** This limitation particularly applies to the integrally mounted transmitter option DM3V and to the TRIBAR configuration









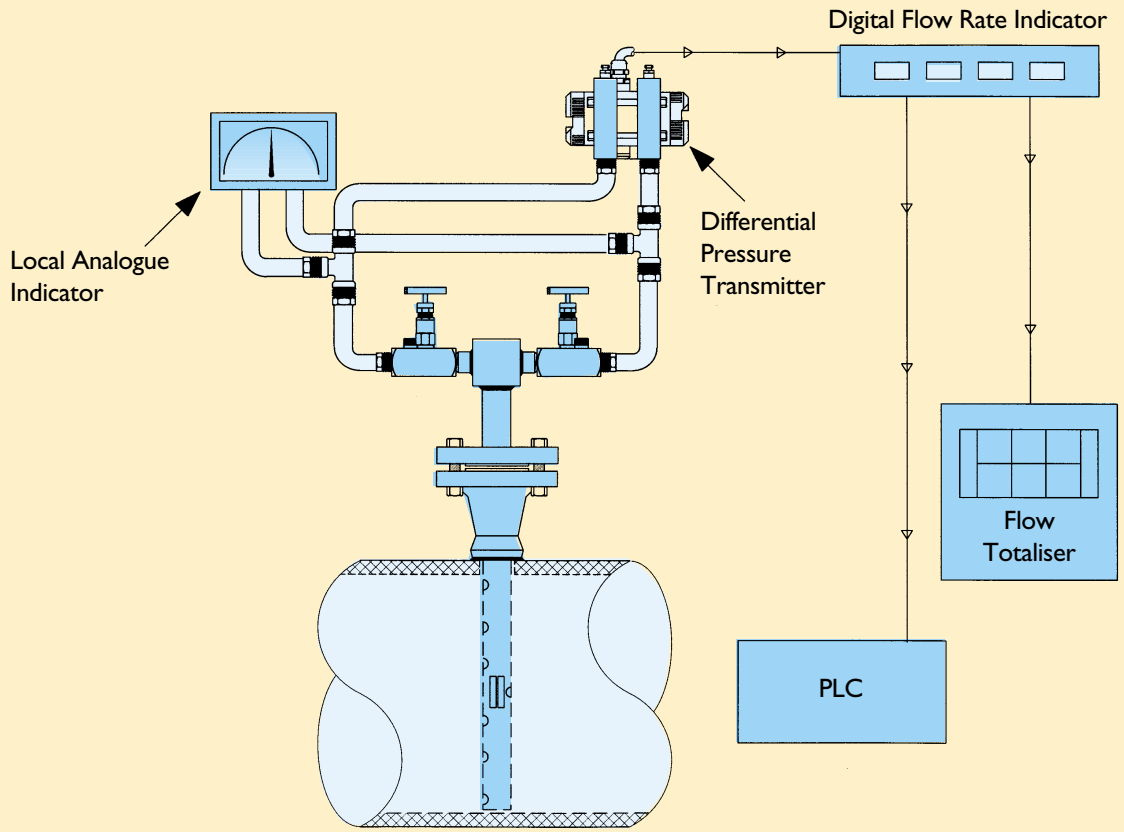
For vertical pipe applications, the 'head' of the **TORBAR** is repositioned to ensure that DP connections are at the same vertical level. This is option VS. **IT IS NECESSARY TO SPECIFY THIS OPTION WHEN ORDERING THE TORBAR.**

IT IS ESSENTIAL THAT IN ALL STEAM INSTALLATIONS THE ENTIRE TORBAR HEAD AND FITTING ASSEMBLY ARE WELL LAGGED TO PREVENT THE FORMATION OF CONDENSATE IN THE TORBAR HEAD. THE TORBAR WILL NOT FUNCTION CORRECTLY WITH CONDENSATE IN THE HEAD. FILLING T'S OR CONDENSATE POTS SHOULD BE FITTED AS APPROPRIATE.

Before installation or removal of a **TORBAR** it is imperative that careful reference is made to the appropriate installation instructions that are supplied with each **TORBAR** shipment. The installation instructions are also available separately on request.

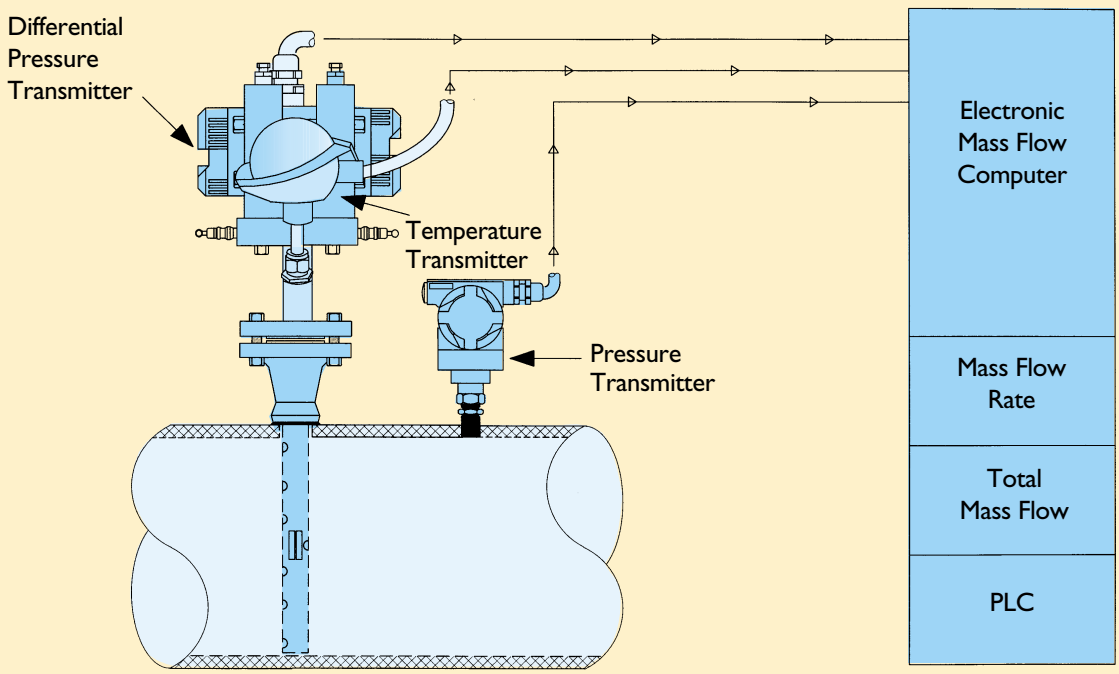
TYPICAL HOOK-UP DIAGRAMS

VOLUMETRIC flow measurement with TORBAR
Alternative output configurations



Abbreviated details of the **TORBAR** installation are shown on page 12, but the Installation and Operating Instructions manual should be referred to before making a final installation. Copies are available on request.

MASS FLOW measurement with TRIBAR
Using remote flow Computer



The above diagram shows how the **TRIBAR** can be used to complete a **MASS FLOW LOOP**. Alternatively, the **MASS TRIBAR** can be considered as a totally integrated package.

• Full details of the **TRIBAR** are on pages 16 & 17 • Full details of the **MASS TRIBAR** are on pages 18 &19

APPLICATIONS

Thousands of **TORBARS** have been successfully used on a large variety of flow applications throughout the world by many different industries, such as:

- OIL PRODUCTION (ONSHORE, OFFSHORE)
- OIL REFINING
- CHEMICAL
- PHARMACEUTICAL
- POWER GENERATION
- BUILDING SERVICES
- H V A C
- NUCLEAR
- FOOD
- WATER DISTRIBUTION
- WATER TREATMENT
- EFFLUENT TREATMENT
- GAS PROCESSING
- GAS TRANSMISSION

etc. etc.

Applications where **TORBARS** have been used successfully were for the flow measurement of:

- NATURAL GAS
- FLUE GAS
- NITROGEN GAS
- HYDROCARBON GAS
- METHANE GAS
- COMBUSTON GAS
- SOUR GAS
- EXHAUST GAS
- COKE OVEN GAS
- CARBON DIOXIDE GAS
- PETROL VAPOUR

- VENTILATION AIR
- COMPRESSED AIR
- HOT AIR
- SOLVENT LADEN AIR
- SATURATED AIR

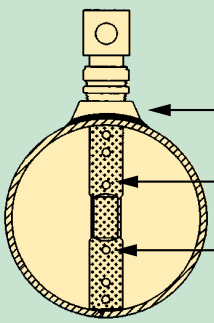
.....

- SATURATED STEAM
- SUPERHEATED STEAM

- SEA WATER
- COOLING WATER
- RIVER WATER
- WASTE WATER
- POTABLE WATER
- LIQUID OXYGEN
- CRUDE OIL
- NITRIC ACID
- RED WINE
- LIQUID PETROLEUM

and many other...

COST SAVINGS TORBAR v ORIFICE PLATE

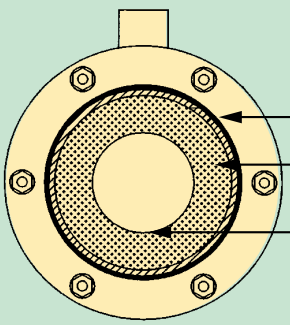


TORBAR

Low Installation Cost

Low Pressure Loss - LOW ENERGY CONSUMPTION

Long Term Accuracy - LOW MAINTENANCE COST



ORIFICE-PLATE

High Installation Cost

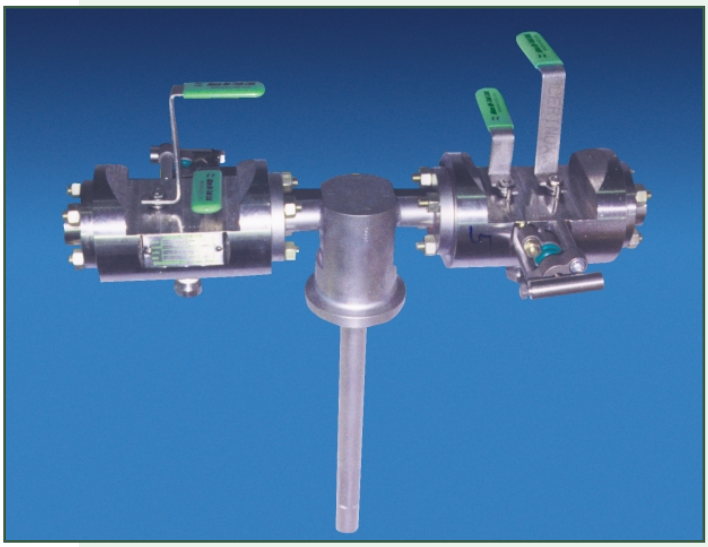
High Pressure Loss - HIGH ENERGY CONSUMPTION

Short Term Accuracy - HIGH MAINTENANCE COST

SPECIAL CONFIGURATIONS

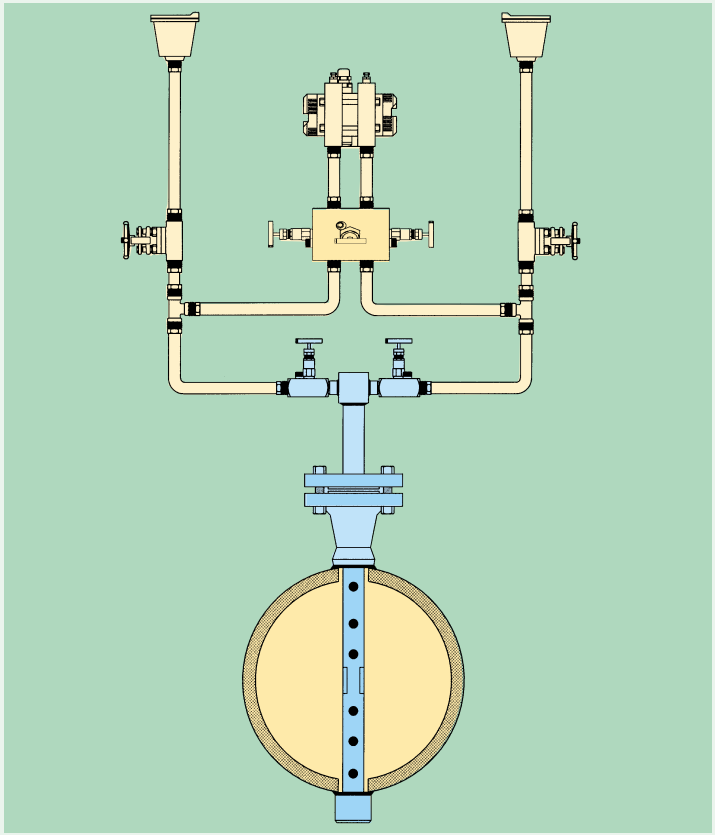
The **TORBAR** and **TRIBAR** flow meters are well suited for special configurations to satisfy customer applications and specifications. Qualified engineering staff and sophisticated computer facilities enable the rapid and accurate translation of the customer requirements into a reliable product.

On this page are shown a few examples of this engineering capability.



A TORBAR MACHINED FROM SOLID DUPLEX MATERIAL BAR WITH SPECIAL TECKLOK FLANGE RATED AT 455 BAR AND FITTED WITH DOUBLE BLOCK AND BLEED VALVES

CONTINUOUS AIR PURGE SYSTEM FOR USE WITH A TORBAR MEASURING CONTAMINATED GAS FLOWS



AUTOMATIC AIR VENTING PACKAGE FITTED TO TORBAR IN ORDER TO REMOVE THE AIR WHEN THE TORBAR IS INSTALLED VERTICALLY DOWNWARDS

A TRIBAR WITH INTEGRAL TEMPERATURE TRANSMITTER AND MOUNTED ON TO AN ELEMENT MANUFACTURED FROM SUPER DUPLEX.

TOTAL METER PACKAGE

TRIBAR

DESCRIPTION

The **TRIBAR** is the established and proven flowmeter from Torbar Flowmeters Ltd, the company that developed and perfected the **TORBAR** technology, and Siemens a world leader in Differential Pressure measurement.

The **TRIBAR** is an accurate insertion flowmeter comprising of an integral 3 valve manifold and Siemens Sitrans P Transmitter connected to a **TORBAR** averaging insertion element.

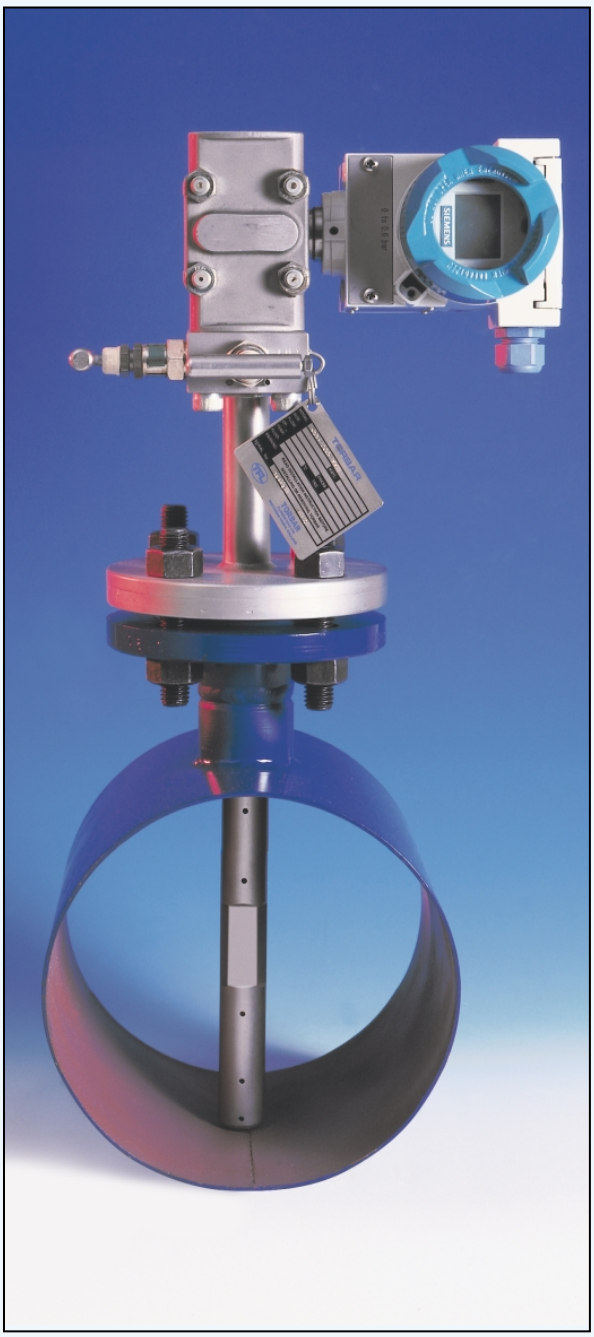
The **TRIBAR** is suitable for the flow measurement of most liquids and gases at process temperatures of less than 160°C. It is not recommended for steam flow due to the temperature specification of the transmitter. This restriction of use applies to all flowmeters of this type.

For steam flow and other applications which fall outside of the **TRIBAR** specifications, the transmitter and manifold should be mounted remotely from the **TORBAR** as shown on page 13. Please contact TFL or agent for details.

The **TRIBAR** concept provides several economic and operational advantages.

- SIMPLE ONE OR TWO HOLE INSTALLATION
- COMPACT INSTRUCTION
- LOW PRESSURE LOSS/LOW OPERATING COSTS
- COMPETITIVE PRICING
- ZERO TRANSMISSION LAGS

The **TRIBAR** is available WITHOUT the transmitter which can be fitted by the customer (or TFL agent). For this optional arrangement specify a standard **TORBAR** with DM3V (integral manifold) option (see page 8). Also specify the manufacturer and type of transmitter to be fitted.



MODEL CODING

T XXX - XXX - SS - XX - XX - XXX - XXX - XXX

TORBAR MODELS *PERMANENT*
Page 4

HOT TAP
Page 6

PIPE SIZE

TORBAR MATERIAL
(316L SS)

ISOLATION VALVE
Page 7
Hot Tap models only

PIPE FITTING MATERIAL
Page 5

FLANGE SIZE & RATING
Models 311, 411, 412
H711, H712

ACCESSORIES
Pages 8

TRANSMITTER TYPE

TEMPERATURE MEASUREMENT

The **TRIBAR** can be supplied with an RTD element with or without a Transmitter. Refer to page 8 code NRTB or NRTT.
Also see page 13 for typical application.

INSTALLATION & LOCATION

For basic information about the installation and location of the **TRIBAR** refer to page 12.

SPECIFICATIONS AND OPTIONS

TRIBAR

- FLOWMETER TYPE: Insertion
- REFERENCE ACCURACY: +/- 1.25%
- REPEATABILITY OF MEASUREMENT: 0.1%
- FLOW TURNDOWN: 10:1
- PIPE SIZES: 5 to 4000mm
- INTEGRAL MANIFOLD: 3 valve-stainless steel
- PROCESS MOUNTING: Compression or flanged
- INSTALLATION OPTION:

  By Hot-tapping under pressure
- WETTED PARTS: 316 stainless steel
- MAXIMUM PRESSURE:

  160 Bar (420 bar optional)
- MAXIMUM TEMPERATURE: 160°C at process

DP TRANSMITTER PROGRAMMABLE AND SMART

- SUPPLY: 11V - 45 VDC (AC optional)
- OUTPUT: 4 to 20 mA with Hart 5.1 superimposed (optional PROFIBUS PA)
- MINIMUM DP RANGE: 0-1 mbar to 0-20 mbar
- CERTIFICATION: Intrinsically Safe Eexiallc T4/T5/T6
- ELECTRONICS HOUSING:

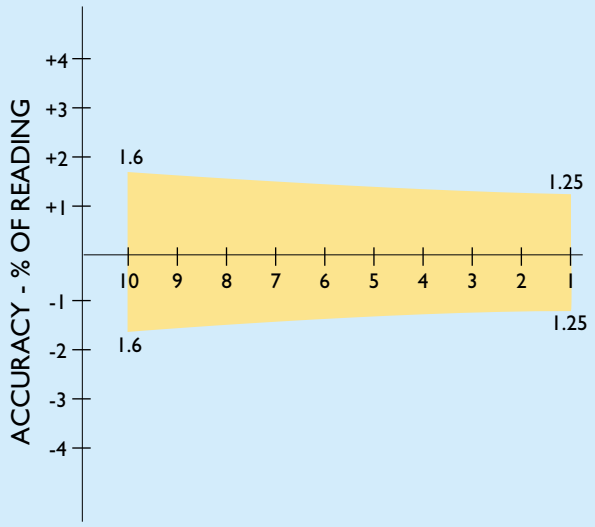
  Coated die-cast Aluminium (option stainless steel)
- INGRESS PROTECTION: IP65 (option IP68)
- CABLE ENTRY: M20 X 1.5 cable gland
- CALIBRATION CERTIFICATE: Available as option
- NACE CERTIFICATE: Available as option

EASIER ON-SITE COMMISSIONING WITH CURRENT GENERATOR OUTPUTS (3.6, 4, 12, 20mA)

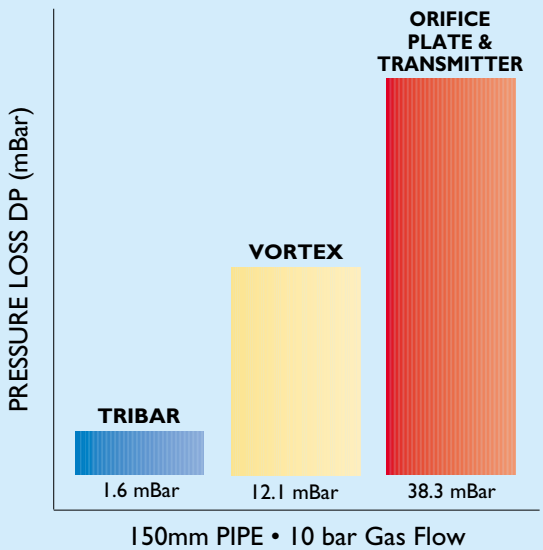
SIMPLE PUSH BUTTON CALIBRATION WHICH CAN BE USED IN HAZARDOUS AREAS

FULL WARRANTY COVER BY TFL SUPPORTED BY SIEMENS OFFICES WORLDWIDE

FLOW TURN DOWN



PRESSURE LOSS



COMPENSATED MASS FLOWMETER

MASS TRIBAR

DESCRIPTION

The **MASS TRIBAR** is an insertion flowmeter comprising an integral valve manifold a PT100 temperature element and a Smart Multivariable Transmitter attached to a **TORBAR** averaging flow element.

The **MASS TRIBAR** measures pressure, temperature and differential pressure directly from the **TORBAR** and computes the compensated mass flow within the MV transmitter by automatically compensating for fluctuations in temperature and pressure.

The **MASS TRIBAR** is ideally suited for the flow measurement of liquids and gases and the totally integrated concept provides several direct advantages.

- AVERAGED FLOW PROFILE MEASUREMENT
- SIMPLE ONE OR TWO HOLE INSTALLATION
- COMPACT INTEGRAL CONSTRUCTION
- RTD EASILY REMOVABLE FOR MAINTAINANCE
- ZERO TRANSMISSION LAGS
- LOW PRESSURE LOSS/LOW OPERATING COSTS
- SINGLE PRODUCT SOURCING

METER CODING

MT XXX - XXX - SS - XX - XX - XXX - XXX - XXX

TORBAR MODELS
Page 4, 6

PIPE SIZE

TORBAR MATERIAL
316L SS

ISOLATION VALVE
(Hot tap only)

PIPE FITTING MATERIAL
Page 5

FLANGE SIZE & RATING
Models: 411, 412
H711, H712

ACCESSORIES
Pages 8

TRANSMITTER TYPE

APPLICATION LIMITATION

For steam flow and other applications which fall outside of the **MASS TRIBAR** specifications, the multivariable transmitter and manifold should be mounted remotely. Please contact TFL or Agent for details of that arrangement.

INSTALLATION & LOCATION

For the basic information about the installation and location of the **MASS TRIBAR** refer to page 12.

Refer to the MV Transmitter data sheet for the transmitter calibration and set-up information and procedures.

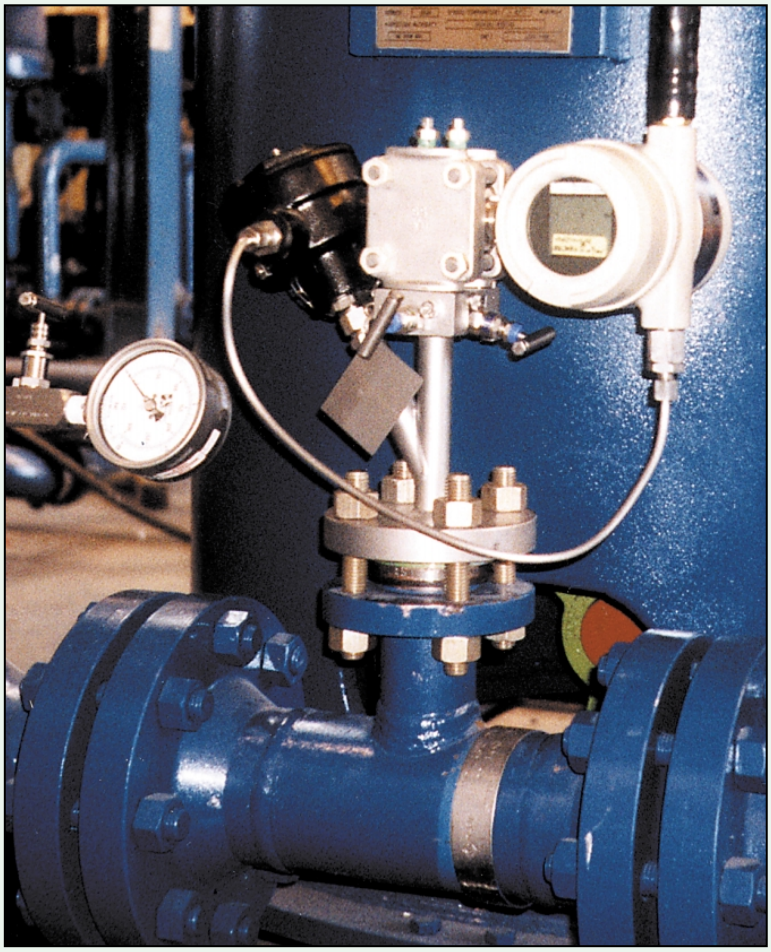
PRESSURE - TEMPERATURE - FLOW
THE MASS TRIBAR CAN DO IT ALL

MASS TRIBAR

COST SAVINGS

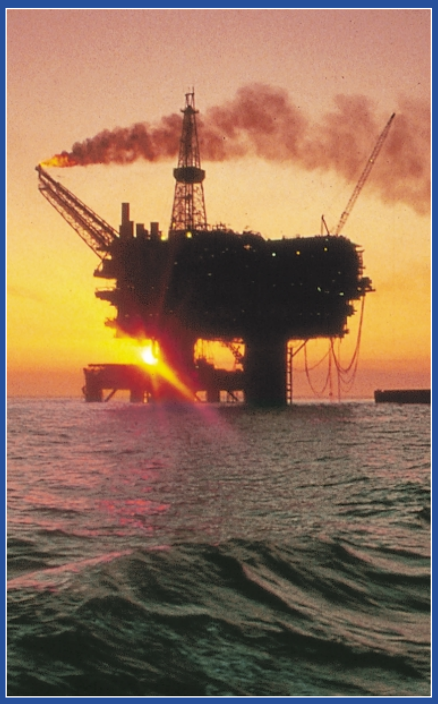
With the **MASS TRIBAR** configuration, you can expect substantially lower wiring costs, as well as much less capital spending on piping, manifolds, mounting, safety barriers and the like. With four measurements from one instrument you will be driving down the installed cost of flow compensation by as much as 60%. Also the MASS TRIBAR may totally eliminate the need for a mass flow computer and can free your control system from performing complex flow calculations. The compensated flow calculation is done right in the instrument before it sends data to your control room freeing up your automation system for other process control tasks.

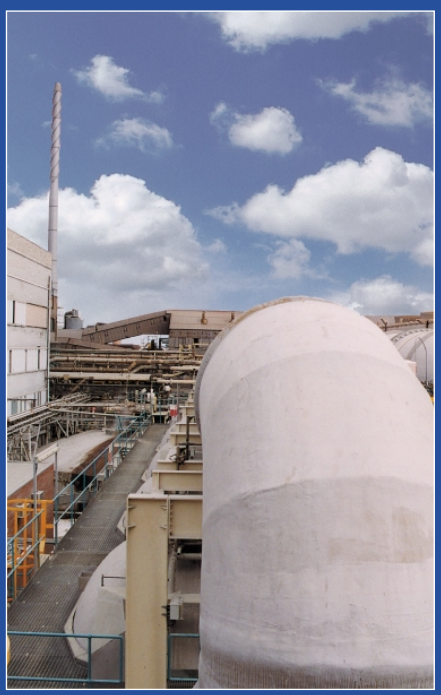
Because it has been difficult and expensive to directly measure flow, most applications infer flow. Inferential flow calculations assume pressure and temperature remain constant, which is often extremely misleading and gives rise to large inaccuracies. THIS TRANSLATES TO LOST PROFITS. Accurate, reliable measurements of flow are essential to ensure your company meets customer quality demands, minimises expenses and increases your bottom line profitability.



SPECIFICATION

- ACCURACY: +/-1% FLOW +0.1% OF CALIBRATED SPAN
- REPEATABILITY OF MEASUREMENT: 0.2%
- FLOW RANGE TURNDOWN: 10 TO 1
- TEMPERATURE ELEMENT: RTD - 4 WIRE
- MAXIMUM PRESSURE: 400 Bar
- MAXIMUM TEMPERATURE AT MANIFOLD/TRANSMITTER FACE: 120°C
- MINIIMUM TEMPERATURE AT MANIFOLD/TRANSMITTER FACE: -50°C
- AMBIENT TEMPERATURE RANGE: -40°C TO 85°C
- SYSTEM: 2 WIRE (DC11V - 45V) EXTERNAL POWER SUPPLY REQUIRED
- OUTPUT: 2 WIRE 4 TO 20 mA LINEAR TO MASS FLOW
- DIGITAL HART PROTOCOL AVAILABLE TO HOST WHICH CONFORMS TO THE HART PROTOCOL
- PRESSURE, TEMPERATURE AND DP VARIABLES ARE AVAILABLE THROUGH HART
- PROCESS INDICATOR: INTEGRAL. 2LINE. 6CHARACTER
- PROTECTION: IP67. EEXia11CT4/T5/T6
- WETTED PARTS: 316L STAINLESS STEEL
- PIPE SIZES: 100mm TO 8000mm
- DIFFERENTIAL PRESSURE RANGES: 0.5/10mbar TO 1/100bar
- STABILITY: +/-0.1% URL FOR 12 MONTHS
- FOR MORE DETAILED SPECIFICATIONS REFER TO THE TRANSMITTER SPECIFICATION SHEET





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