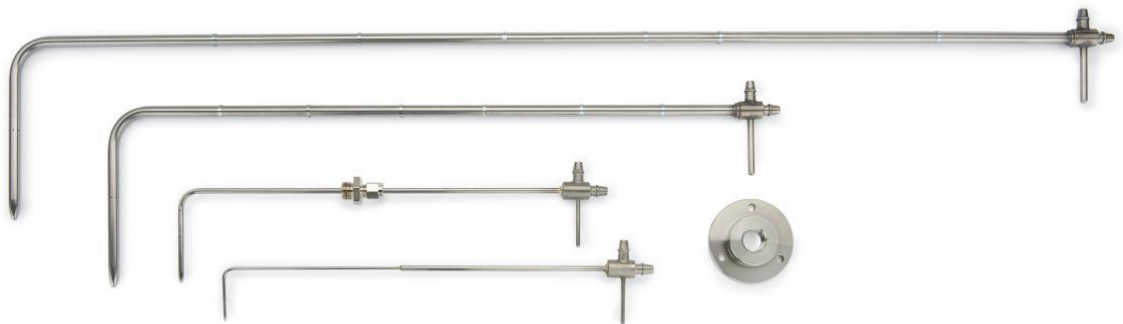

Operating instructions Pitot Static Tube



halstrup-walcher GmbH

Stegener Straße 10
D-79199 Kirchzarten, Germany

Phone: +49 (0) 76 61/39 63-0

Fax: +49 (0) 76 61/39 63-99

E-mail: info@halstrup-walcher.de

Internet: www.halstrup-walcher.com

Contents:

1	Pitot Static Tube	3
2	Description of the design	4
3	Characteristics.....	4
4	Telescopic Pitot static tube (on request)	5
5	Jointed Pitot static tube (on request).....	6
6	Long-term measurement	6
7	halstrup-walcher custom static tubes	6
8	Recommended selection of the measurement location.....	6
9	Recommended choice of measurement points for Pitot static tube measurements.....	7
10	Positions of measurement points for a grid measurement in a rectangular cross-section.....	8
11	Number of measurement points required.....	8
12	Air velocity calculation	9
13	Selection of Pitot static tube sizes.....	10

1 Pitot Static Tube

The Pitot static tube is an approved instrument for measuring air velocity in ducts. When used with a high precision **micromanometer**, the Pitot static tube is capable of producing far more accurate measurements than any other method which does not integrate over the cross-section.

The advantage of the Pitot static tube is that it is possible to obtain a quick measurement with reproducible results relatively easily. Compared to other techniques for measuring velocity in directed air or gas flows, it offers another key advantage: the medium does not flow through the measurement apparatus.

This eliminates the possibility of errors occurring due to changes in the system. It means that there is practically no restriction on the distance between the Pitot static tube and the **micromanometer**. The fact that no gas flows through the apparatus also prevents dust deposits accumulating in the Pitot static tubes. This makes the method simple to use even with contaminated media, e.g. with exhaust gases containing dust or combustion residues. The Pitot static tube is made from rugged stainless steel and is thus easy to clean with solvents and/or dry compressed air.

The halstrup-walcher Pitot static tube with \varnothing 8 mm has silver brazed joints. It can safely be exposed to temperatures of 450°C and, for short periods, up to approx. 550°C. The halstrup-walcher Pitot static tubes with $> \varnothing$ 8 mm have welded joints. They can safely be exposed to temperatures of 680°C and, for short periods, up to approx. 800°C. Sliding spring clip markers are already fitted to the Pitot static tube stems and can be used at temperatures up to approx. 275°C.

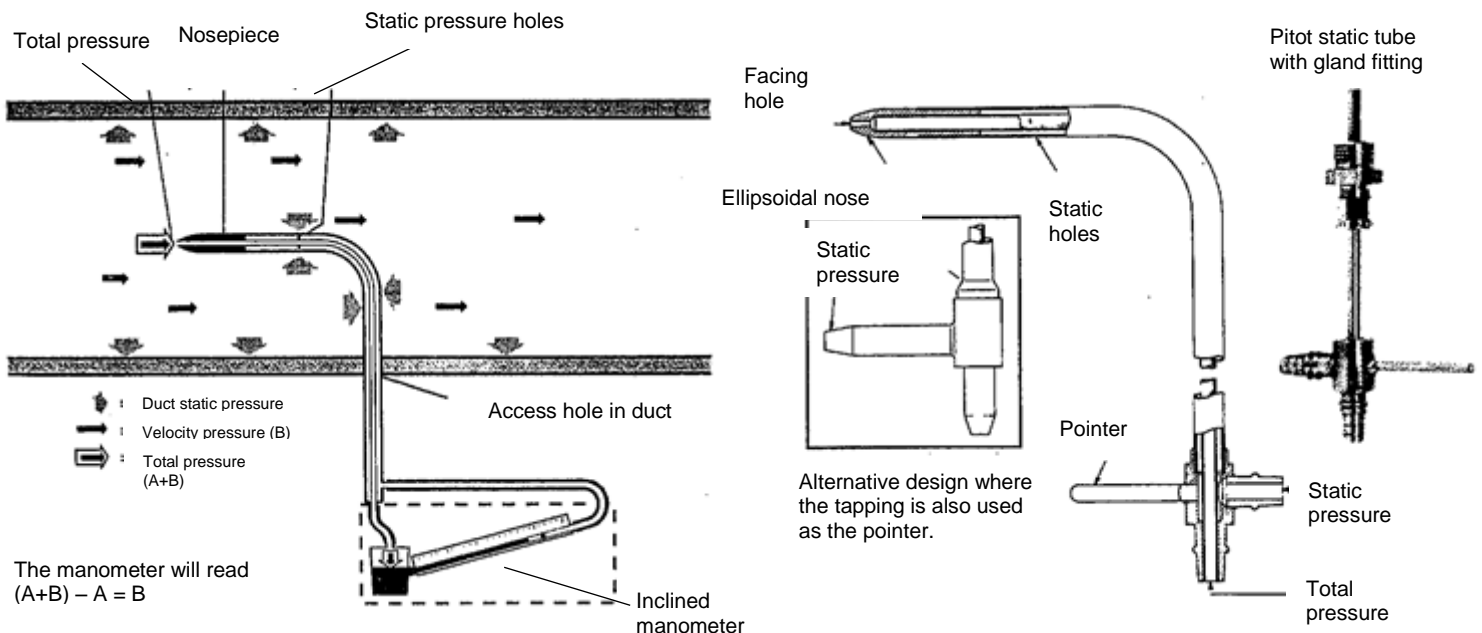


Fig. 1: Principle of operation of the Pitot static tube Fig. 2: Pitot static tube assembly

2 Description of the design

The Pitot static tube consists of two concentric metal tubes with their ends bent at an angle of 90°. This enables the tube to be secured facing into the direction of flow after it has been inserted into the measurement duct. The inner tube leads from the facing hole at the nose end to the tapping at the other end of the Pitot static tube. The outer tube leads from the circular openings around the nose of the tube to the second rectangular tapping which is welded onto the construction (see Fig. 2).

3 Characteristics

The form of the nosepiece, its size and the number and arrangement of the holes for recording pressures are key criteria in determining the characteristics of a Pitot static tube (see Fig. 1). The modified ellipsoidal shape of the nosepiece in halstrup-walcher Pitot static tubes is superior to that of the traditional Prandtl tube because it offers improved tolerance to errors caused by swirl and cross-flow. It has an outstanding track record in practical applications. The design combines two valuable practical advantages: a high level of precision in the useable range (coefficient is 0.997) and a relatively low level of sensitivity to swirl and cross-flow (Fig. 3 and 4).

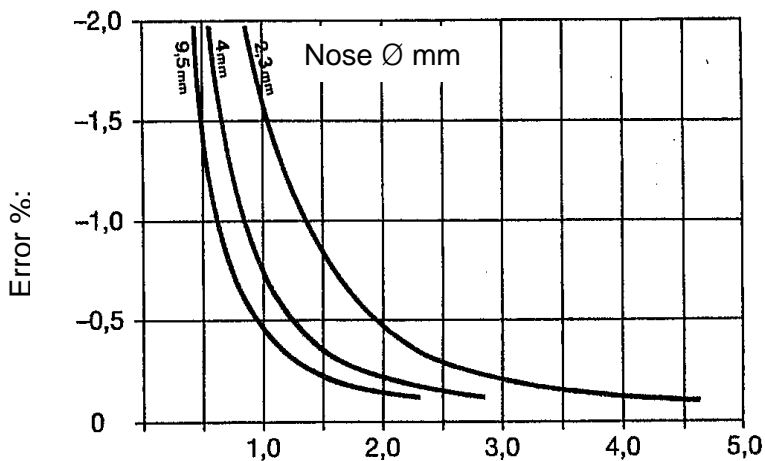


Fig. 3 Characteristics of halstrup-walcher Pitot static tubes of various diameters in very low air velocities

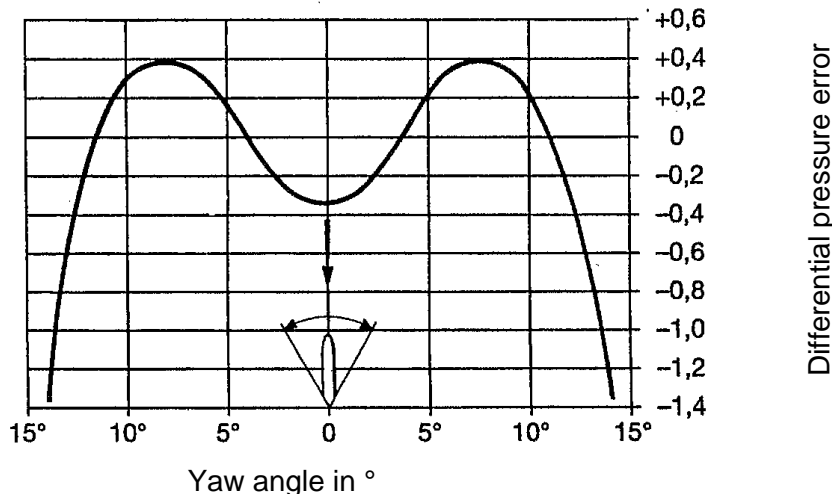


Fig. 4 Effect of yaw angle on pressure output of modified ellipsoidal nose Pitot tube

4 Telescopic Pitot static tube (on request)

The telescopic Pitot static tube is particularly practical and convenient to transport. It offers exactly the same level of accuracy as comparable Pitot static tubes. It is extendible from 250 to 980 mm, weighs only around 120 g and is temperature resistant up to approx. 100 °C.

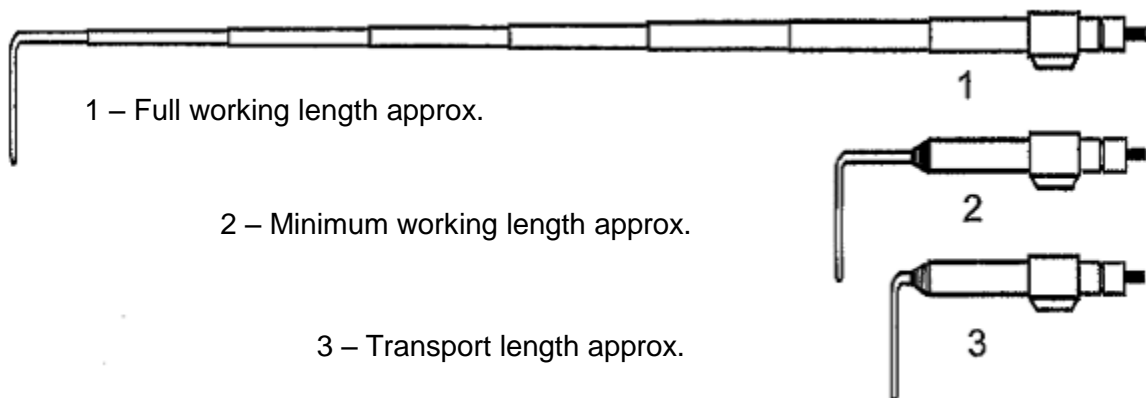


Fig. 5 Telescopic Pitot static tube assembly

5 Jointed Pitot static tube (on request)

Pitot static tubes with a length of more than 3 m have a joint in the middle of the tubular casing. This allows them to be divided into two sections for easier transportation. The two pressure tubes are fitted with internal securing screws and the connector for the tubular casings is designed so it can be guided smoothly through the measurement openings.

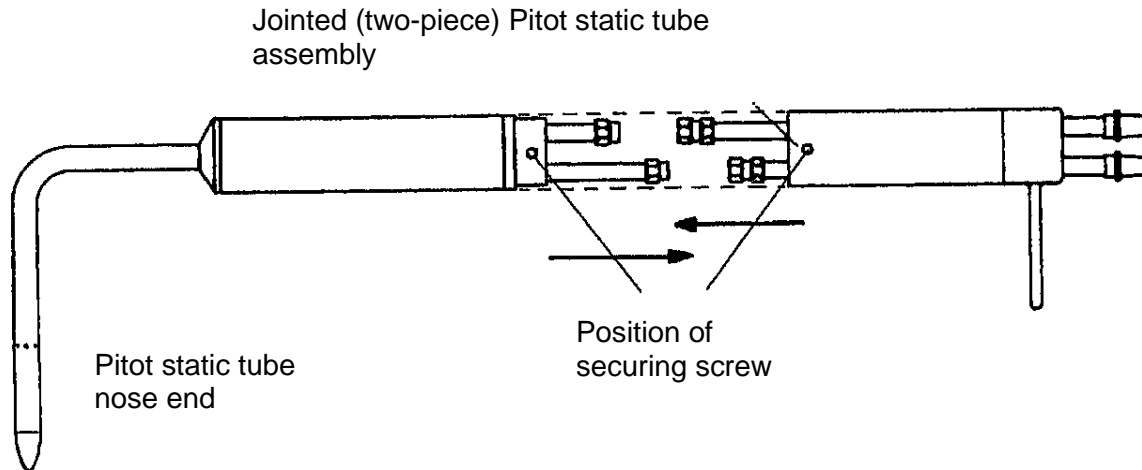


Fig. 6 Jointed Pitot static tube assembly

6 Long-term measurement

halstrup-walcher Pitot static tubes with a length of up to 1830 mm are supplied (also with gland fitting attached) for permanent installation in ducts. Sleeve couplings in brass or stainless steel are available for screwing or welding to the duct wall and connecting the corresponding gland fittings.

7 halstrup-walcher custom static tubes

Customised versions, e.g. with straight Pitot static tubes, S-shaped probes, different lengths or special pressure port constructions, are available on request. Please contact us directly if you have any special wishes.

8 Recommended selection of the measurement location.

Select a measurement location where the flow is as calm as possible. Bends, changes in cross-section, branches, valves and other installations incl. proximity to fans will have a negative effect on the flow conditions. The distribution of the flow will be uneven and thus produce results with a greater margin of error.

The measurement location should therefore be situated within a straight section of duct with a cross-section of a constant size and shape. The lengths of the unobstructed inlet and outlet sections upstream and downstream of the measurement section should both be at least 3x the cross-section of the duct – preferably 5x. For rectangular ducts use the diagonal of the duct cross-section. If this should be impossible, the inlet section should be longer than the outlet section (ratio approx. 2/3 to 1/3).

9 Recommended choice of measurement points for Pitot static tube measurements

As the air velocity can only be measured at a number of individual points in the cross-section, it is important to ensure that these measurement points are truly representative. The number and position of these measurement points in the cross-section should make it possible to measure the air flow very accurately at acceptable time and cost.

To perform a measurement, the cross-section is divided into sections of equal area and their centroids used as the measurement points (grid measurement). For rectangular ducts, the shapes of these sections should be similar to those of the duct as a whole (Fig. 9).

For circular cross-sections, the measurement plane is divided into circular rings of equal area. The measurement points should be at the traverse points of the centroidal axes with two measurement axes (Fig. 7).

With very even flows, one measurement axis may suffice. In special cases it may even be necessary to measure on several axes or install flow straighteners.

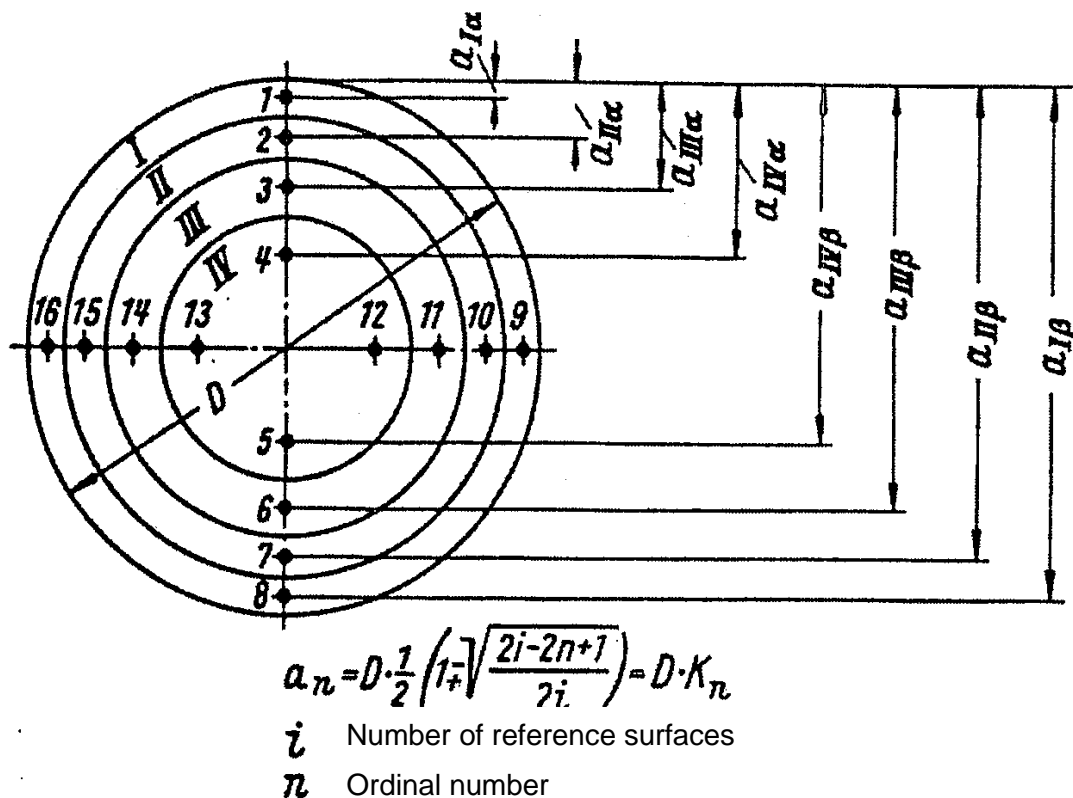


Fig. 7 Positions of measurement points in a circular cross-section

Values for K_n

$\pi \setminus L$	1	2	3	4	5	6	7	8	9	10
I α	0,14645	0,06699	0,04356	0,03229	0,02566	0,02129	0,01879	0,01588	0,01409	0,01266
I β	0,85355	0,93301	0,95644	0,96771	0,97434	0,97871	0,98181	0,98412	0,98591	0,98734
II α	X	0,25000	0,14645	0,10472	0,08167	0,06699	0,05679	0,04931	0,04357	0,03902
II β	X	0,75000	0,85355	0,89528	0,91833	0,93301	0,94320	0,95069	0,95643	0,96098
III α	X	X	0,29588	0,19382	0,14645	0,11812	0,09911	0,08542	0,07508	0,06699
III β	X	X	0,70412	0,80618	0,85355	0,88188	0,90089	0,91458	0,92492	0,93301
IV α	X	X	X	0,32322	0,22614	0,17725	0,14645	0,12500	0,10973	0,09689
IV β	X	X	X	0,67678	0,77386	0,82275	0,85355	0,87500	0,89087	0,90371
V α	X	X	X	X	0,34189	0,25000	0,20119	0,16928	0,14645	0,12919
V β	X	X	X	X	0,65811	0,75000	0,79881	0,83072	0,85355	0,87081
VI α	X	X	X	X	X	0,35566	0,26855	0,22049	0,18819	0,16459
VI β	X	X	X	X	X	0,64434	0,73146	0,77951	0,81180	0,83541
VII α	X	X	X	X	X	X	0,36637	0,28349	0,23648	0,20419
VII β	X	X	X	X	X	X	0,63363	0,71651	0,76352	0,79581
VIII α	X	X	X	X	X	X	X	0,37500	0,29588	0,25000
VIII β	X	X	X	X	X	X	X	0,62500	0,70412	0,75000
IX α	X	X	X	X	X	X	X	X	0,38215	0,30635
IX β	X	X	X	X	X	X	X	X	0,61785	0,69365
X α	X	X	X	X	X	X	X	X	X	0,38879
X β	X	X	X	X	X	X	X	X	X	0,61181

Fig. 8

10 Positions of measurement points for a grid measurement in a rectangular cross-section

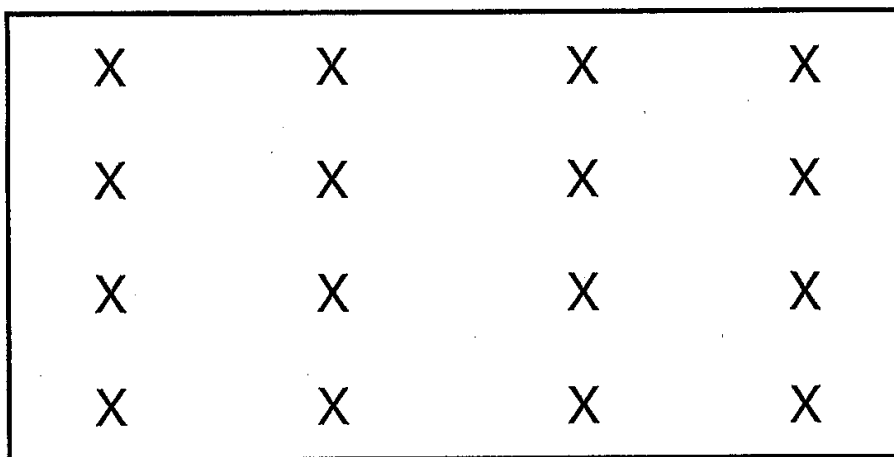


Fig. 9

11 Number of measurement points required

Generally, max. 20 measurement points are adequate in larger measurement cross-sections. The number of measurement points required depends on the distribution of the flow and the area of the measurement cross-section. The more unevenly the flow is distributed, the more measurement points will be required (see Table 1).

Table 1

Measurement cross-section m ²	No. measurement points
0.03 to 1 m ²	4
> 1 m ²	4 per m ² cross-section

12 Air velocity calculation

The air velocity for the measurement can be calculated using the following simplified formula from the stagnation pressure value of the dynamic pressure.

$$v \text{ (m/s)} = 1,29 \times \sqrt{p_{dyn} \text{ (Pa)}}$$

The simplified formula applies for standard air of 1.2 kg/m³ (in accordance with various standards: 16 °C at 1000 hPa or 20 °C at 1013 hPa, both at 55 % rel. humidity). As the stagnation pressure is significantly influenced by the density of the medium (in kg/m³), the correcting formula is stated below. In practice, no correction is required if the static pressure in the system is less than 1000 Pa and the other parameters do not deviate by more than approx. 2 to 3 %. Any corrections with more divergent values must be calculated using the following formula:

$$v = \sqrt{\frac{2}{\rho_f} \times p_{dyn}} \quad \rho_f = 1,2931 \times \frac{p_{atm} + p_{stat}}{b_0} \times \frac{T_0}{T_0 + T}$$

Abbreviations in the formulae:

- v*: air velocity (m/s) in the operating state of the medium
- ρ_f*: density of the medium
- ρ_n*: 1.2931 constant for standard air
- b₀*: standard barometric pressure (1013 hPa)
- T_{0a}*: standard temperature (293 K)
- p_{dyn}*: dynamic stagnation pressure (Pa) measured
- p_{atm}*: barometric pressure (hPa), measured
- p_{stat}*: static pressure in the system (Pa), measured
- T*: temperature of the medium (°C), measured

When calculating average velocity in a duct, the most accurate values are obtained by calculating the velocity at each measurement point and taking the average value. As long as the maximum individual pressure is not more than twice the minimum individual pressure, the deviation from the correct results in practice is < 2% if the dynamic pressure is calculated first and then converted into m/s. The reason for this deviation is the quadratic relationship between stagnation pressure and velocity.

13 Selection of Pitot static tube sizes

Table 2: Dimensions / gland fittings for Pitot static tubes

Total length (mm)	Tube Ø (mm)	Nosepiece Ø (mm)	Nosepiece length (mm)	Gland fitting	
				Available threads (inch)	
305	4	2.3	37.2	yes	1/4 ² "
305	4	4	64	yes	1/4 ² "
483	8	8	130	yes	3/8"
795	8	8	130	yes	3/8"
1000	8	8	130	yes	1/2"
1220	9.5	9.5	156	yes	1/2"
1523	9.5	9.5	156	yes	-
1830	12.77	9.5	156	yes	-
2130	19.05	9.5	156	Custom assembly, on request	
2440	19.05	9.5	156		
2740	19.05	9.5	156		
Two-piece					
3040	31.7	9.5	156	Custom assembly, on request	
3350	31.7	9.5	156		
3660	31.7	9.5	156		
4270	31.7	9.5	156		