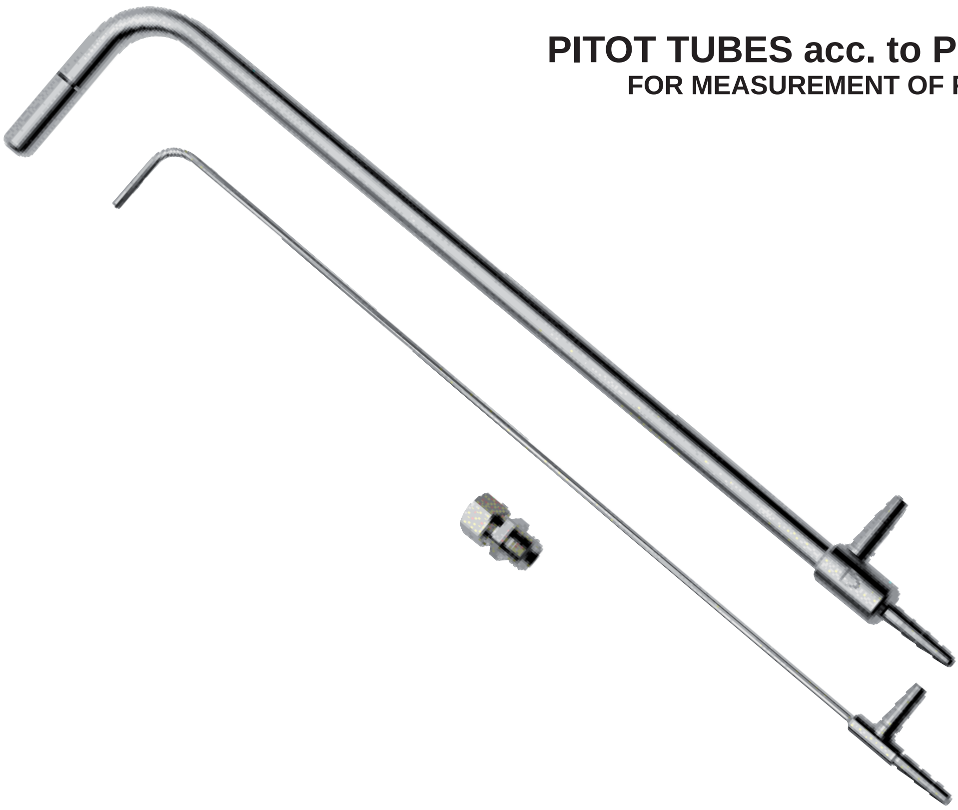


PITOT TUBES acc. to PRANDTL
FOR MEASUREMENT OF FLOW

APPLICATION

When connected to differential pressure gauges, pitot tubes may be used for the determination of pressure, velocity and quantity of flowing gases. These instruments do not have moving parts which wear or become damaged through handling. For these reasons Pitot tubes are suitable for application under rough service conditions. Recalibrations, which are occasionally required when using anemometers, are not necessary.

LAMBRECHT pitot tubes are made of brass. They are suitable for service temperatures up to max. 400 °C. The limit of sensitivity of measuring arrangements with Pitot tubes depends upon the sensitivity of the connected low pressure gauges and in case of velocity and quantity measurements also upon the specific weight ρ of the flowing gas.

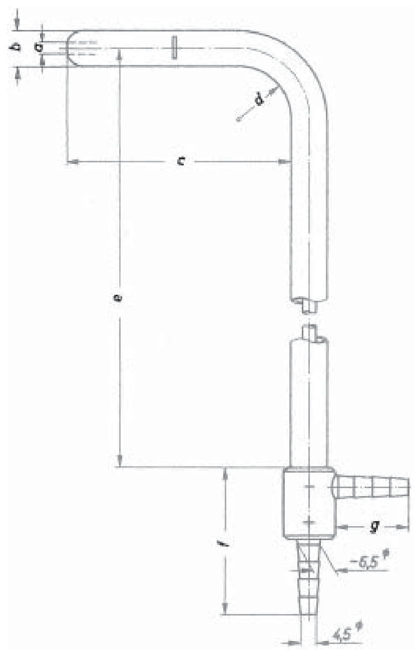


Table 1

Varieties: **Id-No.**	**a** **Ø**	**b** **Ø**	**c** **mm**	**d** **mm**	**e** **mm**	**f** **mm**	**g** **mm**	**weight** **g**
00.06280.025 000 (628)	1	3	28	7.5	250	32	18	20
00.06300.025 000 (630)	3	10	65	15	250	42	22	130
00.06300.050 000 (630a)	3	10	65	15	500	42	22	220
00.06300.075 000 (630b)	3	10	65	15	750	42	22	290

PHYSICAL FUNDAMENTALS

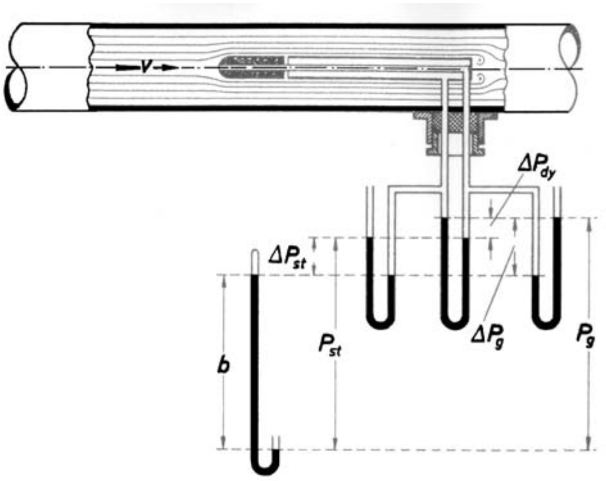
The formulae (1-5) specified in the following section can be used without difficulties for gas velocities up to 50 m/s (error -0.38%) and also for velocities up to 100 m/s (error approx. -1 %).

In case of higher velocities compressibility becomes important and this cain be taken into consideration when using equation (1a) or the more detailed equation specified in DIN 1945. Equation (1a) is valid up to 0. 95 Mach with an accuracy of 1 %. Even compression shocks, which might occur from approx. 0.8 Mach, do not influence the validity of this equation.

Pitot tubes have a coefficient of 1 and cause very little loss in pressure compared to nozzles and orifices in pipe lines. They work independent of the position. Deviations between flow direction and axis of the Pitot tube head up to 150 do not influence the measurements significantly.

Attention should, however, be paid to certain directives when installing the Pitot tubes. Corresponding details are specified in the section "Choice of the measuring place, installation".

In case of flowing gases the following pressure terms are applicable:



The STATIC PRESSURE *Pst*: is the internal pressure of a flowing gas or that pressure which a gas flowing parallel to the wall of the conduit is exerting on the same. Through a suitable boring in the wall of the pipe or the duct, or through the ring-shaped slit of a Pitot tube, it can be measured as absolute pressure Pst or as pressure difference ΔPst compared to the free atmosphere.

The Total pressure Pg: is the pressure which is measured at the head of a Pitot tube, when it is pointing into the flow. This pressure may also be measured as absolute pressure Pg or as pressure difference ΔPg compared to the free atmosphere.

The dynamic pressure ΔPdy : also known as impact or velocity pressure, is the pressure rise caused by the impact of a gas against an obstacle in the flow and is measured at the centre or stagnation point of the obstacle. It is equivalent to the pressure difference which is necessary for accelerating the gas from rest to the corresponding velocity. Its dependence on the velocity can be seen from the formula:

If v < 100 m/s:

$$\Delta Pdy = \frac{v^2}{2} \cdot \rho \quad \left[N/m^2 \right] \qquad (1)$$

If v > 100 m/s:

$$\Delta Pdy = \frac{v^2}{2} \cdot \rho \left(1 + 1/4 \, Ma^2 \right) \quad \left[N/m^2 \right] \qquad (1a)$$

Where:

ΔPdy ... dynamic pressure, impact or velocity pressure in N/m^2

v ... flow velocity in m/s
ρ ... density of the gas in kg/m^3
Ma ... v/c = Mach value
c ... velocity of sound = 343 m/s

Especially in case of low velocities the dynamic pressure ΔPdy will be measured by the height of a liquid column being in equilibrium with the dynamic pressure. It is, therefore, hereafter called "h" and defined, with sufficient accuracy for most practice by:

$$h = \frac{1}{9.81} \cdot \frac{v^2}{2} \cdot \rho \quad \left[mm \; of \; water \; or \; kp/m^2 \right] \qquad (2)$$

Moreover, the dynamic pressure is equal to the difference between total and static pressure, i. e.
h = Pg - Pst
or for the pressure difference compared to the free atmosphere
h = ΔPg − ΔPst.

Therefore it can be measured directly by transmitting the two pressures arising at the pitot tubes, Prandtl type, to the branches of a differential pressure gauge (e. & of an U-tube manometer). The flow velocity is thus:

$$v = \sqrt{\frac{2 \cdot 9.81 \cdot h}{\rho}} \quad [m/s] \qquad (3)$$

The quantity of flow can be determined from the measured dynamic pressure ***h*** *[mm of water column]* by means of the formula:

$$Q = F \cdot v = F \sqrt{\frac{2 \cdot 9.81 \cdot h}{\rho}} \quad \left[m^3/s \right] \qquad (4)$$

$$M = F \cdot v \cdot \rho = F \sqrt{2 \cdot 9.81 \cdot h \cdot \rho} \quad [kg/s] \qquad (5)$$

Where:
Q … quantity of flow in m^3/s (volume of flow)
M … quantity of flow in kg/s (mass of flow)
F … cross section of flow at the measuring point in m^2
v … flow velocity in m/s
h … dynamic pressure in mm of water column or kp/m^2
ρ … density of the gas in kg/m^3
9.81… conversion factor, unit: kg m/s^2 kp

$$1 \, N = 1 \, kg \, m/s^2$$

$$1 \, N/m^2 = \frac{1}{9.80665} kp/m^2 \approx 0.102 \, mm \; of \; water \; column$$

$$1 \, kp/m^2 = 9.80665 \, N/m^2 \approx 1 \, mm \; of \; water \; column$$

CHOICE OF THE MEASURING PLACE, .INSTALLATION

Pitot tubes can be used for mobile as well as for stationary measurements. Measurements can be carried out in closed ducts and - in case of suitable flow conditions - in the free jet. Perfect measuring results can be obtained only if the air flow at the measuring station is free from eddies and turbulences (see also DIN 1945 "VDI - Verdichter - Regeln" [VDI compressor rules] and DIN 1946 [leaflet I] -VDI -Lüftungs-Regeln- [VDI ventilation rules]).

Generally such an air flow exists in closed ducts if an undisturbed steadying length of 6 x D (D = inside diameter of the conduit respectively equivalent diameter in case of rectangular ducts) before and 4 x D behind the measuring place is available without sudden alternations of the cross section and without elbows or shut-off devices.

A steadying length of duct of 40 x D is required for measurements behind elbows. By arranging suitable baffles, the inlet path can be reduced to approx. 6 x D. In case of turbulent air flow, a straightener has to be installed at a distance of approx. 1 x D before the pitot tube. This straightener can easily be assembled from a number of thin-walled tubes which should have a diameter of approx. 1/10 D and a length of approx. 3/10 D. They should be installed axially into the pipe line and should completely fill the cross section of air flow.

Measurements before fresh air inlets and behind incoming air openings are often connected with certain difficulties since the velocity outside the duct decreases very quickly with the distance from the passage. The stream cross section increases by changing simultaneously the air flow direction. As far as the local conditions allow it, we recommend to attach a duct piece with the same cross section at such openings and to measure the velocity respectively the quantity within this connecting piece. The length of the duct piece, should be determined in consideration of the above-mentioned steadying sections.

It is not advisable to reduce the cross section for the sake of shortening the connection piece, otherwise losses of pressure will be caused which falsify the measurement.

Correct measuring results can be obtained within the free jet without elongation of the duct in case of large air passages and low velocity. At air passages which are protected by grilles or at otherwise partially covered air passages having a relatively small open cross section compared with the total cross section, the measurements have to be carried out at the single openings whereby the cross section of the pitot head compared with the cross section of the flow must be small.

In ease of stationary mounting, the pitot tubes should be installed in such a manner that they indicate mean values (with regard to the determination of the mean velocity, please, refer to the section "Measurement"). Our threaded couplings serve for the fastening. The structural parts of the dismantled threaded couplings will be pushed in correct sequence over the head with the borings for the bleeding of pressure and over the bend of the hook tube. After having screwed the threaded coupling M 12 or M 20 or 30 x 1.5 (turned towards the Pitot head) into the wall of the duct, the component parts should be screwed again.

The Pitot tube will be led through the two threaded couplings respectively through inserted discs, whereas the silicone-caoutchouc- packing in connection with the threaded coupling turned towards the connection for rubber tubing serves for the fixation in the desired position. Within the - loosened - packing, the Pitot tubes can be turned and shifted right-angled towards the flow direction.

Where the depth of immersion is large (E > 500 mm) and the velocities are high, the threaded couplings for mounting with their relatively short lengths will give no sufficient stability for the Pitot tube. In such cases, the tube will requite additional support.

The threaded couplings for mounting can be fastened also to thin-walled tubes by using an appropriate intermediate part.

Intermediate parts and supports should be adapted to the existing service conditions.

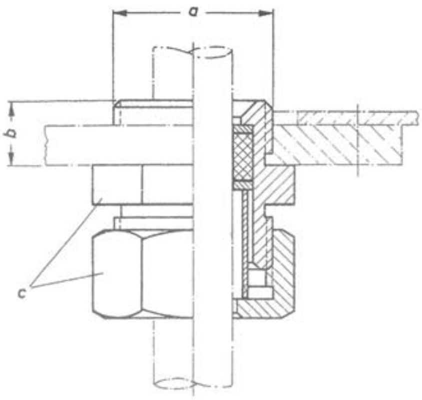


Table 2:

Accessories for pitot tubes for fixing*:

Id-No.	Code	for	a mm	b mm	c mm	Weight g
00.06286.000 000	**(628 G)**	(628)	M12x1.5	6.5	SW 14	20
00.06306.000 000	**(630 G)**	(630)	M20x1.5	8	SW 22	50
00.06316.000 000	**(631 G)**	(631)	M30x1.5	12	SW 36	170

The orifice of the Pitot tube is directed towards the air flow. Deviations between axle of Pitot tube and flow direction up to 15° do not influence the measurements.

With regard to all Pitot tubes, Prandtl type, the connection for the total pressure is marked with **"+"**, whereas the connection for the static pressure is marked with **"-"**. In addition, the connection for rubber tubing for the total pressure is **red** marked, the connection for rubber tubing for the static pressure is **blue** marked.

If only the static pressure compared with the free atmosphere should be measured in a closed duct, the connection for rubber tubing of the Pitot tube marked with **"-"** should be connected with the **"+"** socket piece of the differential pressure gauge provided that the static pressure is larger than the atmospheric pressure. Should the static pressure be smaller than the atmospheric pressure (undertow), the **"-"** mark of the Pitot tube has to be connected with the **"-"** sign of the differential pressure gauge.

The connecting lines have to be installed carefully. Leaky spots may considerably falsify the measuring results. Condense water which might arise in the measuring lines must be led off.

When measuring the pressure of gases it is in general sufficient to install the measuring lines between pitot tube and indicator with a steady sloping, thus enabling the condensate to flow back into the operation line. The pitot tube should be installed upside down (connections for rubber tubing upwards). If the connecting lines towards the differential pressure gauge have a drop, it Is recommended to provide for condense separators at the lowest points.

MEASUREMENT

In general, the velocity of the air flow is not equal at all points of a duct, cross section or air passage.

Therefore, the cross section is divided into a sufficient number of fields having the same area, and one measurement of the local velocity is made at each centre of the area (system measurement). The mean value of all measurements is the average velocity which is decisive for the determination of the air flow quantity. The flow quantity can also be ascertained - this is particularly applicable in case of partially covered passages- by multiplying the single measured velocity values with the appertaining cross sections. The sum of all single measurements is thus the rate of air flow.

Inside tubes with circular cross section it is recommended to take the measurements for two diameters perpendicular to each other in order to determine the mean velocity. The results are graphically represented in dependence upon the diameter and the velocity profiles are plotted accordingly. Now the diameter should be subdivided into 5 or 10 circular rings of the same area. The velocities corresponding to the centre circles of these circular rings as well as to the centre circle of the mean circular area can be read from the graph. Their arithmetic mean represents the mean velocity. The product of mean velocity and inside duct cross section is the rate of air flow. The graphical representation is not required if the measurements are made within the centre circles (lines of gravity method).

The following ***table 3*** shows the gravity point radii when dividing a circular cross section with the radius r = 1 into n = 5 (10 measuring points across the diameter) or n = 10 rings (20 measuring points across the diameter). The radii of the centre circles, which have to be considered when carrying out the measurement, are obtained by multiplying the gravity point radii with the actually existing radius of the duct.

Gravity point radii

n	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}
5	0.95	0.84	0.71	0.55	0.32					
10	0.97	0.92	0.87	0.81	0.75	0.67	0.59	0.50	0.39	0.22

n = number of circular rings having the same area

table 3

In case of stationary mounting, after having determined the velocity profile, the Pitot tube should be fastened at such a site where there exists a mean velocity. It is not necessary to arrange the head of the Pitot tube centrically inside the flow duct.

The measuring results should be evaluated in compliance with the formulae indicated in the section "Physical fundamentals". When measuring the velocity of air, the determination of the respective air density from atmospheric pressure, humidity and temperature is facilitated by the ***table 4.***

The ***table 5*** contains the most usual velocities in dependence upon dynamic pressure and air density so that calculations can largely be avoided.

If the dials of the differential pressure gauges supplied for the Pitot tubes are already divided into velocity units, the gas density marked on the dial must be always the same. Differential pressure gauges divided into quantity units indicate correct values provided that the cross section at the site, which has been taken as basis when designing the dial, will be maintained.

Density ρ of air in kg/m³
depending on relative humidity,
barometric pressure and temperature

p [torr]	700			750			800		
U [%]	20	60	100	20	60	100	20	60	100
t [°C]	ρ_{air} [kg/m³]								
-10	1.24	1.24	1.24	1.33	1.33	1.33	1.41	1.41	1.41
0	1.19	1.19	1.19	1.28	1.28	1.28	1.36	1.36	1.36
10	1.15	1.15	1.14	1.23	1.23	1.23	1.31	1.31	1.31
20	1.11	1.11	1.10	1.19	1.18	1.18	1.27	1.26	1.26
30	1.07	1.06	1.06	1.15	1.14	1.13	1.22	1.22	1.21
40	1.03	1.02	1.01	1.11	1.10	1.08	1.18	1.17	1.16
50	1.00	0.98	0.96	1.07	1.05	1.03	1.14	1.12	1.10
60	0.96	0.93	0.90	1.03	1.00	0.97	1.10	1.07	1.04
70	0.93	0.88	0.83	0.99	0.95	0.90	1.06	1.01	0.97
80	0.89	0.82	0.75	0.95	0.88	0.81	1.02	0.95	0.88
90	0.85	0.75	0.64	0.91	0.81	0.71	0.97	0.87	0.77
100	0.80	0.66	0.52	0.86	0.72	0.58	0.93	0.78	0.64

table 4

$$\rho_{air} = \frac{0.465 \cdot p - 0.175 \cdot e}{T} \quad \left[kg/m^3 \right]$$

p = atmospheric pressure in Torr

e = U · E/100 = partial pressure of the water vapour in Torr

U = rel. humidity in %

E = maximum vapour pressure in Torr at the existing temperature t in °C

T = 273 + t = absolute temperature in °K

Table 5:

Flow velocity as function of dynamic pressure and specific weight of the gas ρ

$$v = \sqrt{\frac{19.62}{\rho} \cdot h} \quad [m/s]$$

$$v = \sqrt{\frac{2}{\rho} \cdot \Delta Pdy} \quad [m/s]$$

v = flow velocity in m/s

ρ = specific weight of the gas in kg/m³

h = dynamic pressure in mm of water column

ΔPdy = dynamic pressure in N/m²

h [mm of water col.]	ρ [kg/m³] 0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	**ΔPdy** [N/m²]
	v [m/s]								
0.03	0.92	0.86	0.81	0.77	0.73	0.70	0.67	0.65	
	0.93	**0.87**	**0.82**	**0.78**	**0.74**	**0.71**	**0.68**	**0.65**	**0.3**
0.04	1.06	0.99	0.93	0.89	0.84	0.81	0.78	0.75	
	1.07	**1.00**	**0.94**	**0.89**	**0.85**	**0.82**	**0.78**	**0.76**	**0.4**
0.05	1.18	1.11	1.04	0.99	0.94	0.90	0.87	0.84	
	1.20	**1.12**	**1.05**	**1.00**	**0.95**	**0.91**	**0.88**	**0.85**	**0.5**
0.1	1.67	1.57	1.48	1.40	1.34	1.28	1.23	1.18	
	1.69	**1.58**	**1.49**	**1.42**	**1.35**	**1.29**	**1.24**	**1.20**	**1.0**
0.2	2.37	2.21	2.09	1.98	1.89	1.81	1.74	1.67	
	2.39	**2.24**	**2.11**	**2.00**	**1.91**	**1.82**	**1.75**	**1.69**	**2.0**
0.3	2.90	2.71	2.56	2.43	2.31	2.21	2.13	2.05	
	2.93	**2.74**	**2.58**	**2.45**	**2.34**	**2.24**	**2.15**	**2.07**	**3.0**
0.4	3.35	3.13	2.95	2.80	2.67	2.56	2.46	2.37	
	3.38	**3.17**	**2.98**	**2.83**	**2.70**	**2.58**	**2.48**	**2.39**	**4.0**
0.5	3.74	3.50	3.30	3.13	2.99	2.86	2.75	2.65	
	3.78	**3.54**	**3.33**	**3.16**	**3.02**	**2.89**	**2.77**	**2.67**	**5.0**
0.6	4.10	3.84	3.62	3.43	3.27	3.13	3.01	2.90	
	4.14	**3.87**	**3.65**	**3.46**	**3.30**	**3.16**	**3.03**	**2.93**	**6.0**
0.7	4.43	4.14	3.91	3.71	3.53	3.38	3.25	3.13	
	4.47	**4.18**	**3.94**	**3.74**	**3.57**	**3.42**	**3.28**	**3.16**	**7.0**
0.8	4.74	4.43	4.18	3.96	3.78	3.62	3.47	3.35	
	4.78	**4.47**	**4.22**	**4.00**	**3.81**	**3.65**	**3.51**	**3.38**	**8.0**
0.9	5.0	4.70	4.43	4.20	4.01	3.84	3.69	3.56	
	5.1	**4.74**	**4.47**	**4.24**	**4.05**	**3.87**	**3.72**	**3.59**	**9.0**
1.0	5.3	4.95	4.67	4.43	4.22	4.04	3.88	3.74	
	5.4	**5.0**	**4.71**	**4.47**	**4.26**	**4.08**	**3.92**	**3.78**	**10.0**
1.2	5.8	5.4	5.1	4.84	4.62	4.42	4.25	4.09	
	5.9	**5.5**	**5.2**	**4.90**	**4.67**	**4.47**	**4.30**	**414**	**12.0**
1.4	6.3	5.9	5.5	5.2	4.95	4.78	4.60	4.43	
	6.3	**5.9**	**5.6**	**5.3**	**5.1**	**4.83**	**4.64**	**4.47**	**14.0**
1.6	6.7	6.3	5.9	5.6	5.3	5.1	4.91	4.74	
	6.8	**6.3**	**6.0**	**5.7**	**5.4**	**5.2**	**4.96**	**4.78**	**16.0**
1.8	7.1	6.6	6.3	5.9	5.7	5.4	5.2	5.0	
	7.2	**6.7**	**6.3**	**6.0**	**5.7**	**5.5**	**5.3**	**5.1**	**18.0**
2.0	7.5	7.0	6.6	6.3	6.0	5.7	5.5	5.3	
	7.6	**7.1**	**6.7**	**6.3**	**6.0**	**5.8**	**5.6**	**5.4**	**20.0**
2.2	7.9	7.3	6.9	6.6	6.3	6.0	5.8	5.6	
	7.9	**7.4**	**7.0**	**6.6**	**6.3**	**6.1**	**5.8**	**5.6**	**22.0**
2.4	8.2	7.7	7.2	6.9	6.5	6.3	6.0	5.8	
	8.3	**7.8**	**7.3**	**6.9**	**6.6**	**6.3**	**6.1**	**5.9**	**24.0**
2.6	8.5	8.0	7.5	7.1	6.8	6.5	6.3	6.0	
	8.6	**8.1**	**7.6**	**7.2**	**6.9**	**6.6**	**6.3**	**61**	**26.0**
2.8	8.9	8.3	7.8	7.4	7.1	6.8	6.5	6.3	
	8.9	**8.4**	**7.9**	**7.5**	**7.1**	**6.8**	**6.6**	**6.3**	**28.0**
3.0	9.2	8.6	8.1	7.7	7.3	7.0	6.7	6.5	
	9.3	**8.7**	**8.2**	**7.8**	**7.4**	**7.1**	**6.8**	**6.6**	**30.0**
3.5	9.9	9.3	8.7	8.3	7.9	7.6	7.3	7.0	
	10.0	**9.4**	**8.8**	**8.4**	**8.0**	**7.6**	**7.3**	**7.1**	**35.0**
4.0	10.6	9.9	9.3	8.9	8.4	8.1	7.8	7.5	
	10.7	**10.0**	**9.4**	**8.9**	**8.5**	**8.2**	**7.8**	**7.6**	**40.0**
4.5	11.2	10.5	9.9	9.4	9.0	8.6	8.3	7.9	
	11.3	**10.6**	**10.0**	**9.5**	**9.1**	**8.7**	**8.3**	**8.0**	**45.0**
5.0	11.8	11.1	10.4	9.9	9.4	9.0	8.7	8.4	
	12.0	**11.2**	**10.5**	**10.0**	**9.5**	**9.1**	**8.8**	**8.5**	**50.0**
5.5	12.4	11.6	11.0	10.4	9.9	9.5	9.1	8.8	
	12.5	**11.7**	**11.1**	**10.5**	**10.0**	**9.6**	**9.2**	**8.9**	**55.0**
6.0	13.0	12.1	11.5	10.9	10.3	9.9	9.5	9.2	
	13.1	**12.3**	**11.6**	**11.0**	**10.4**	**10.0**	**9.6**	**9.3**	**60.0**
6.5	13.5	12.6	11.9	11.3	10.8	10.3	9.9	9.5	
	13.6	**12.8**	**12.0**	**11.4**	**10.9**	**10.4**	**10.0**	**9.6**	**65.0**
7.0	14.0	13.1	12.4	11.7	11.2	10.7	10.3	9.9	
	14.1	**13.2**	**12.5**	**11.8**	**11.3**	**10.8**	**10.4**	**10.0**	**70.0**
7.5	14.5	13.6	12.8	12.1	11.6	11.1	10.6	10.3	
	14.6	**13.7**	**12.9**	**12.3**	**11.7**	**11.2**	**10.7**	**10.4**	**75.0**
8.0	15.0	14.0	13.2	12.5	11.9	11.4	11.0	10.6	
	15.1	**14.1**	**13.3**	**12.7**	**12.1**	**11.6**	**11.1**	**10.7**	**80.0**
8.5	15.4	14.4	13.6	12.9	12.3	11.8	11.3	10.9	
	15.6	**14.6**	**13.7**	**13.0**	**12.4**	**11.9**	**11.4**	**11.0**	**85.0**
9.0	15.9	14.9	14.0	13.3	12.7	12.1	11.7	11.2	
	16.0	**15.0**	**14.1**	**13.4**	**12.8**	**12.3**	**11.8**	**11.3**	**90.0**

h [mm of water col.]	ρ [kg/m³] 0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	**ΔPdy** [N/m²]
	v [m/s]								
9.5	16.3	15.3	14.4	13.7	13.0	12.5	12.0	11.5	
	16.5	**15.4**	**14.5**	**13.8**	**13.1**	**12.6**	**12.1**	**11.7**	**95.0**
10	16.7	15.7	14.8	14.0	13.4	12.8	12.3	11.8	
	16.9	**15.8**	**14.9**	**14.1**	**13.5**	**12.9**	**12.4**	**12.0**	**100**
11	17.6	16.4	15.5	14.7	14.0	13.4	12.9	12.4	
	17.7	**16.6**	**15.6**	**14.8**	**14.1**	**13.5**	**13.0**	**12.5**	**110**
12	18.3	17.2	16.2	15.3	14.6	14.0	13.5	13.0	
	18.5	**17.3**	**16.3**	**15.5**	**14.8**	**14.1**	**13.6**	**13.1**	**120**
13	19.1	17.9	16.8	16.0	15.2	14.6	14.0	13.5	
	19.3	**18.0**	**17.0**	**16.1**	**15.4**	**14.7**	**14.1**	**13.6**	**130**
14	19.8	18.5	17.5	16.6	15.8	15.1	14.5	14.0	
	20.0	**18.7**	**17.6**	**16.7**	**16.0**	**15.3**	**14.7**	**14.1**	**140**
15	20.5	19.2	18.1	17.2	16.4	15.7	15.0	14.5	
	20.7	**19.4**	**18.3**	**17.3**	**16.5**	**15.8**	**15.2**	**14.6**	**150**
16	21.2	19.8	18.7	17.7	16.9	16.2	15.5	15.0	
	21.4	**20.0**	**18.9**	**17.9**	**17.1**	**16.3**	**15.7**	**15.1**	**160**
17	21.8	20.4	19.3	18.3	17.4	16.7	16.0	15.4	
	22.0	**20.6**	**19.4**	**18.4**	**17.6**	**16.8**	**16.2**	**15.6**	**170**
18	22.5	21.0	19.8	18.8	17.9	17.2	16.5	15.9	
	22.7	**21.2**	**20.0**	**19.0**	**18.1**	**17.3**	**16.6**	**16.0**	**180**
19	23.1	21.6	20.4	19.3	18.4	17.6	16.9	16.3	
	23.3	**21.8**	**20.6**	**19.5**	**18.6**	**17.8**	**17.1**	**16.5**	**190**
20	23.7	22.1	20.9	19.8	18.9	18.1	17.4	16.7	
	23.9	**22.4**	**21.1**	**20.0**	**19.1**	**18.3**	**17.5**	**16.9**	**200**
22	24.8	23.2	21.9	20.8	19.8	19.0	18.2	17.6	
	25.1	**23.5**	**22.1**	**21.0**	**20.0**	**19.1**	**18.4**	**17.7**	**220**
24	25.9	24.3	22.9	21.7	20.7	19.8	19.0	18.3	
	26.2	**24.5**	**23.1**	**21.9**	**20.9**	**20.0**	**19.2**	**18.5**	**240**
26	27.0	25.3	23.8	22.6	21.5	20.6	19.8	19.1	
	27.3	**25.5**	**24.0**	**22.8**	**21.7**	**20.8**	**20.0**	**19.3**	**260**
28	28.0	26.2	24.7	23.4	22.4	21.4	20.6	19.8	
	28.3	**26.5**	**24.9**	**23.7**	**22.6**	**21.6**	**20.8**	**20.0**	**280**
30	29.0	27.1	25.6	24.3	23.1	22.1	21.3	20.5	
	29.3	**27.4**	**25.8**	**24.5**	**23.4**	**22.4**	**21.5**	**20.7**	**300**
32	29.9	28.0	26.4	25.1	23.9	22.9	22.0	21.2	
	30.2	**28.3**	**26.7**	**25.3**	**24.1**	**23.1**	**22.2**	**21.4**	**320**
34	30.9	28.9	27.2	25.8	24.6	23.6	22.7	21.8	
	31.2	**29.2**	**27.5**	**26.1**	**24.9**	**23.8**	**22.9**	**22.0**	**340**
36	31.8	29.7	28.0	26.6	25.3	24.3	23.3	22.5	
	32.1	**30.0**	**28.3**	**26.8**	**25.6**	**24.5**	**23.5**	**22.7**	**360**
38	32.6	30.5	28.8	27.3	26.0	24.9	24.0	23.1	
	33.0	**30.8**	**29.1**	**27.6**	**26.3**	**25.2**	**24.2**	**23.3**	**380**
40	33.5	31.3	29.5	28.0	26.7	25.6	24.6	23.7	
	33.8	**31.6**	**29.8**	**28.3**	**27.0**	**25.8**	**24.8**	**23.9**	**400**
45	35.5	33.2	31.3	29.7	28.3	27.1	26.1	25.1	
	35.9	**33.5**	**31.6**	**30.0**	**28.6**	**27.4**	**26.3**	**25.4**	**450**
50	37.4	35.0	33.0	31.3	29.9	28.6	27.5	26.5	
	37.8	**35.4**	**33.3**	**31.6**	**30.2**	**28.9**	**27.7**	**26.7**	**500**
55	39.3	36.7	34.6	32.9	31.3	30.0	28.8	27.8	
	39.6	**37.1**	**34.9**	**33.2**	**31.6**	**30.3**	**29.1**	**28.0**	**550**
60	41.0	38.4	36.2	34.3	32.7	31.3	30.1	29.0	
	41.4	**38.7**	**36.5**	**34.6**	**33.0**	**31.6**	**30.4**	**29.3**	**600**
65	42.7	39.9	37.6	35.7	34.1	32.6	31.3	30.2	
	43.1	**40.3**	**38.0**	**36.1**	**34.4**	**32.9**	**31.6**	**30.5**	**650**
70	44.3	41.4	39.1	37.1	35.3	33.8	32.5	31.3	
	44.7	**41.8**	**39.4**	**37.4**	**35.7**	**34.2**	**32.8**	**31.6**	**700**
75	45.9	42.9	40.4	38.4	36.6	35.0	33.6	32.4	
	46.3	**43.3**	**40.8**	**38.7**	**36.9**	**35.4**	**34.0**	**32.7**	**750**
80	47.4	44.3	41.8	39.6	37.8	36.2	34.7	33.5	
	47.8	**44.7**	**42.2**	**40.0**	**38.1**	**36.5**	**35.1**	**33.8**	**800**
85	48.8	45.6	43.0	40.8	38.9	37.3	35.8	34.5	
	49.3	**46.1**	**43.5**	**41.2**	**39.3**	**37.6**	**36.2**	**34.9**	**850**
90	50.2	47.0	44.3	42.0	40.1	38.4	36.9	35.6	
	50.7	**47.4**	**44.7**	**42.4**	**40.5**	**38.7**	**37.2**	**35.9**	**900**
95	51.6	48.3	45.5	43.2	41.2	39.4	37.9	36.5	
	52.1	**48.7**	**46.0**	**43.6**	**41.6**	**39.8**	**38.2**	**36.8**	**950**
100	52.9	49.5	46.7	44.3	42.2	40.4	38.8	37.4	
	53.5	**50.0**	**47.1**	**44.7**	**42.6**	**40.8**	**39.2**	**37.8**	**1000**

Subject to change without notice.

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