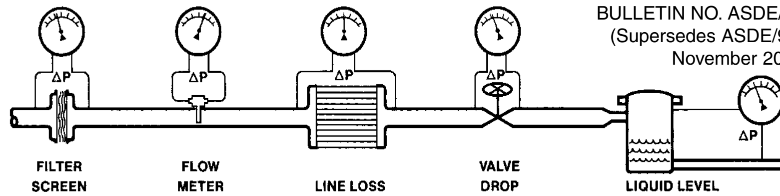
Mid-West®
Instrument



BULLETIN NO. ASDE/04
(Supersedes ASDE/99)
November 2004

delta tube®

APPLICATION & SYSTEM DESIGN DATA

TABLE OF CONTENTS

NOMENCLATURE

The following symbols and terminology are used for all equations and calculations used in conjunction with the DELTA-TUBE.

Symbol	Description	Units
ACFM	Actual Cubic Ft/min.	ft^3/min.
C_f	Flow Coefficient	dimensionless
CFM	Cubic Ft/min. (see ACFM)	ft^3/min.
D	Pipe Inside Diameter	inches
D_e	Equivalent Diameter	inches
GPM	Flow	gal/min.
h	Height of Duct	inches
P	Pressure	lb/in^2 (Gauge)
Q	Volume Flow	gal/min.
R_D	Reynolds Number	dimensionless
SCFM	Standard Cubic Ft/min.	ft^3/min.
s_f	Specific Gravity of the Fluid at Flow Conditions (See Fig. 3)	dimensionless
s_s	Specific Gravity of the Fluid at Standard Conditions (See Fig. 3)	dimensionless

Symbol	Description	Units
V	Fluid Velocity	ft/sec.
W	Weight Flow	lbs/hr.
w	Width of Duct	inches
w_f	Specific Weight at Flow Conditions (See Fig. 1)	lb/ft^3
w_s	Specific Weight at Standard Conditions for Gas $w_s = s_s \times w_s$ (AIR)	lb/ft^3
—	w_s (AIR) = .0764 lbs/ft^3 (See Fig. 1)	
ΔP	Differential Pressure	in. H_2O
p	Flowing Density	$\frac{lb\text{-}sec^2}{ft^2}$
μ	Absolute Viscosity	$\frac{lb\text{-}sec}{ft^2}$
μ_{cp}	Viscosity (Centipoise)	centipoise

CONVERSION TO STANDARD CONDITIONS

Standard Pressure = 1 ATMOSPHERE
= 14.696 lb/in^2
Absolute Pressure = (14.696 + Gauge Pressure) lbs/in^2

Standard Temperature = 60°F
= 520°R (Absolute)
°R = °F + 460

TO CONVERT ACFM TO SCFM

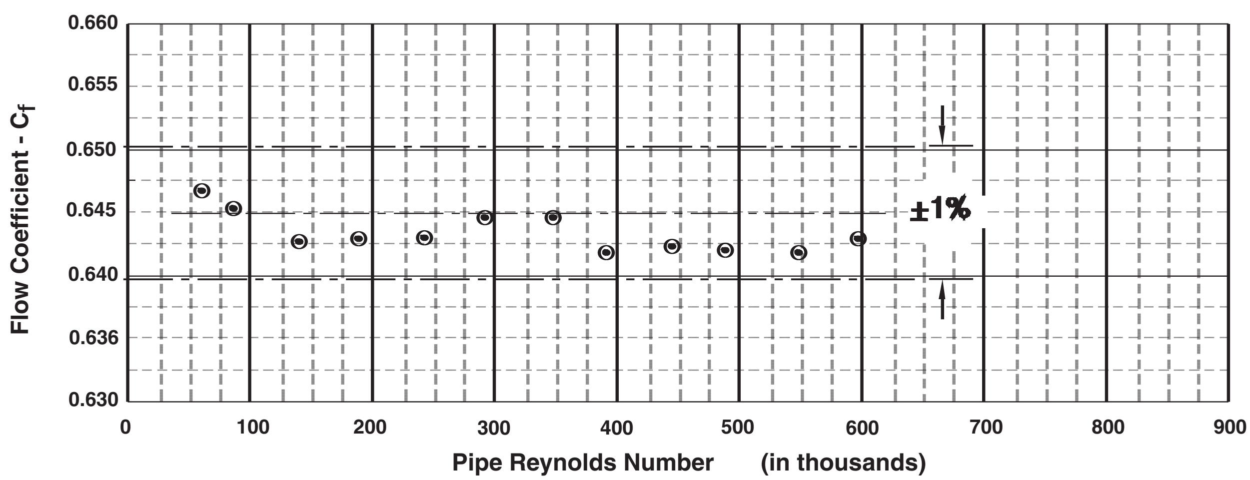
$$SCFM = ACFM \frac{\text{Line Pressure (Absolute)}}{\text{Std. Pressure (Absolute)}} \bullet \frac{\text{Std. Temperature (Absolute)}}{\text{Line Temperature (Absolute)}}$$

TO CONVERT SPECIFIC WEIGHT AT STANDARD TO SPECIFIC WEIGHT AT FLOW CONDITIONS

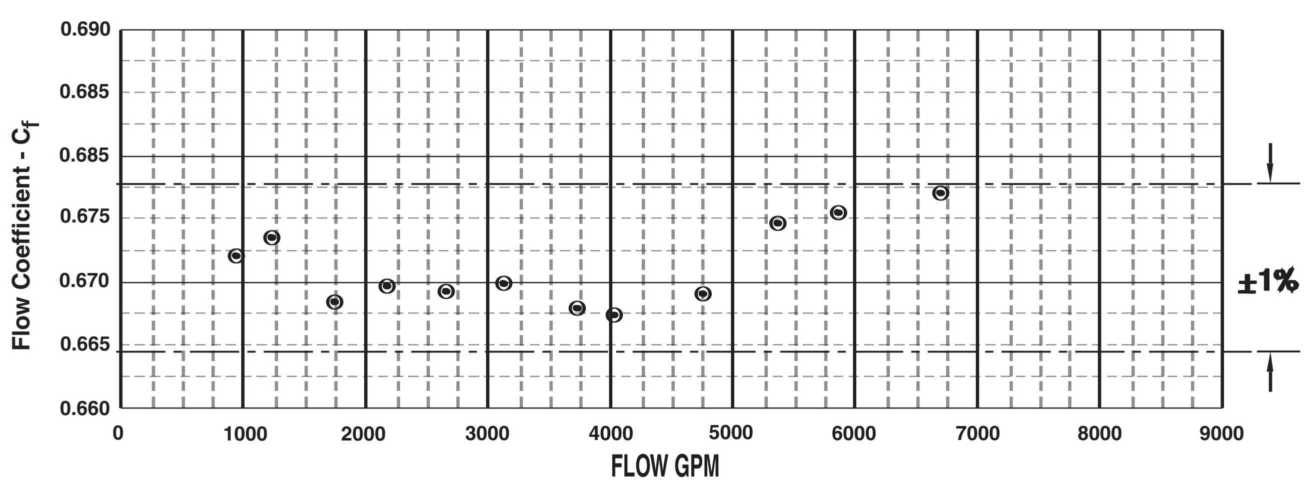
$$w_f = w_s \frac{\text{Line Pressure (Absolute)}}{\text{Std. Pressure (Absolute)}} \bullet \frac{\text{Std. Temperature (Absolute)}}{\text{Line Temperature (Absolute)}}$$

FIGURE 11 – TYPICAL FLOW COEFFICIENT TEST DATA

MODEL 301 FLOW ELEMENT IN A 3" SCHEDULE 40 PIPE*

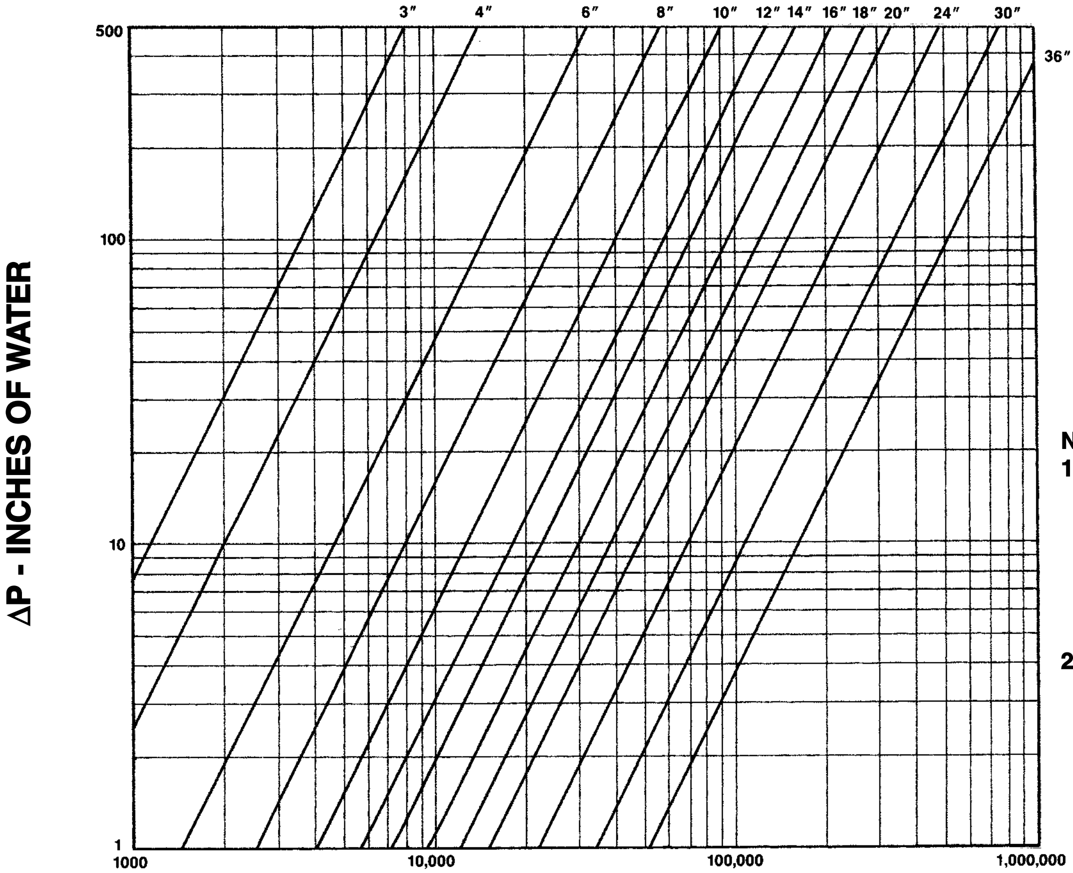


MODEL 302 FLOW ELEMENT IN A 12" STANDARD PIPE*



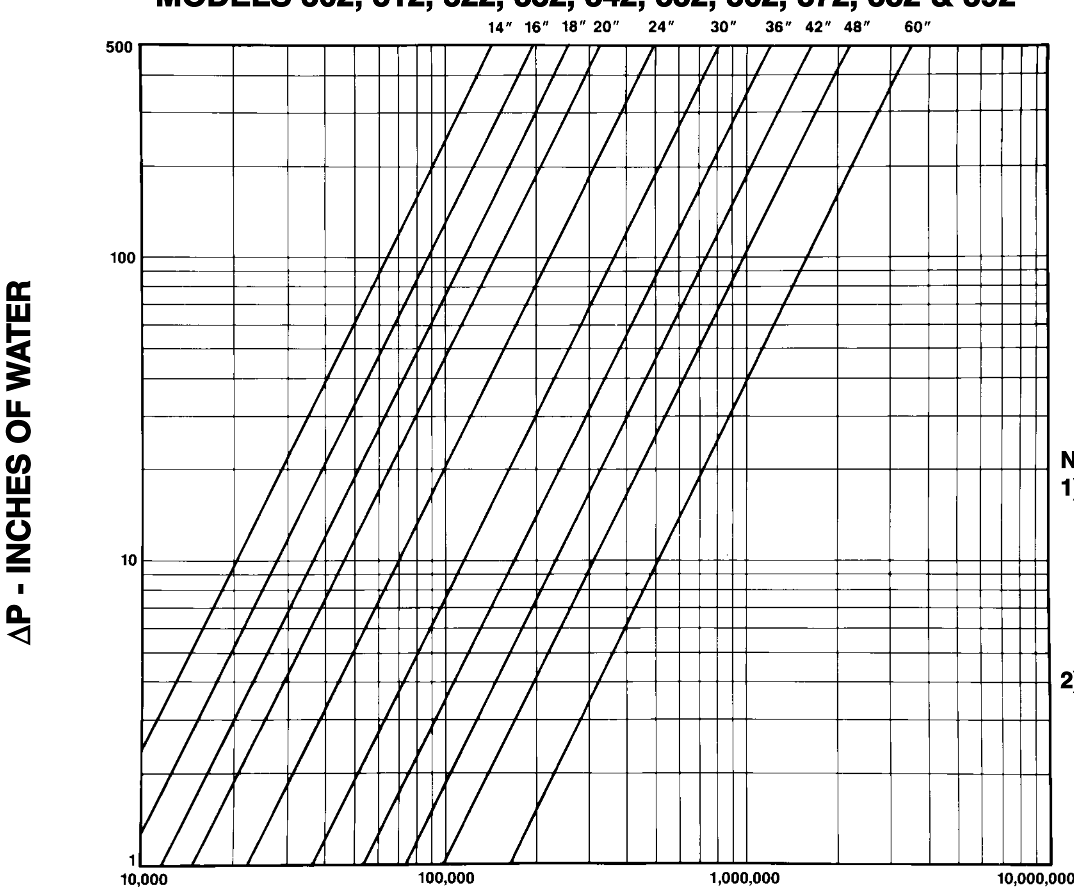
* Test performed by Alden Research Laboratory Inc.

FIGURE 10 – AIR HIGH PRESSURE 70°F., 114.7 PSIA



NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

STANDARD CUBIC FEET PER MINUTE (SCFM)
MODELS 302, 312, 322, 332, 342, 352, 362, 372, 382 & 392



NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

STANDARD CUBIC FEET PER MINUTE (SCFM)
MODELS 323, 343, 353, 363, 373, 383 & 393

I INTRODUCTION

The Delta-Tube, like the orifice plate, the flow nozzle, or the venturi meter, depends on the basic Bernoulli energy balance equation and the continuity equation, (Equations 1, 2 and 3).

$$\frac{P_1}{w_1} + \frac{V_1^2}{2g} = \frac{P_2}{w_2} + \frac{V_2^2}{2g} \qquad \text{(Eq. 1)}$$

$$Q_1 = Q_2 \qquad \text{(Eq. 2)}$$

$$Q = AV \qquad \text{(Eq. 3)}$$

All of the equations used for Delta-Tube flow calculations are transformations of these basic equations. The transformations are used to accommodate standard measurement practices and units of measure.

II PROCEDURE FOR SIZING A DELTA-TUBE SYSTEM

A) ***Define the system operating parameters:***
This is most simply done by completing form DAD-98 (Figure 14) for the appropriate media – liquid, gas or steam.

B) ***Determine the Reynolds Number (R_D) of the system.***
The standard flow coefficients are based on turbulent flow conditions $R_D > 5000$). The Reynolds number should be checked at the lowest measured flow where the stated accuracy is required.

$$R_D = \frac{.0001319 \times W}{D \times \mu} \qquad \text{(Eq. 4)}$$

$$\text{. . . or } R_D = \frac{6.318 \times W}{D \times \mu_{cp}} \qquad \text{(Eq. 5)}$$

$$\text{. . . or } R_D = \frac{.06588 \times Q \times s_s}{D \times \mu} \qquad \text{(Eq. 6)}$$

$$\text{. . . or } R_D = \frac{31.662 \times Q}{D \times \mu_s} \qquad \text{(Eq. 7)}$$

$$\text{. . . or } R_D = \frac{28.978 \times SCFM \times s_f}{D \times \mu_{cp}} \qquad \text{(Eq. 7a)}$$

Where: W = Flow in lb/hr.
Q = Flow in gal/min. @ flow conditions.
SCFM = Flow in ft^3/min.
D = Pipe Inside Diameter in inches.
μ = Absolute Viscosity in lb-sec/ft^2.
μ_{cp} = Viscosity in centipoise.
μ_s = Viscosity in stokes.
R_D = Reynolds number.
s_s = Specific gravity of liquid @ 60°F.
s_f = Specific gravity of the fluid at flow conditions.

If the calculations indicate that R_D is below 2000, the metering section should be resized to increase R_D at minimum measured flow rate so it is greater than 5000. If R_D is between 2000 & 5000, the accuracy will be acceptable for most applications. Where systems permit, the metering section should be sized so that $R_D > 5000$ for all measured flow conditions.

The metering section should conform to the configuration shown in Figure 2.

TABLE 1

FLOW COEFFICIENTS (C_f) vs MODEL NO. PROBE SIZE & PIPE INSIDE DIAMETER

MODEL			300	301(a)	302(b)	323	343(c)
F.E. Dia.			1/4"	1/2"	1"	2-1/4"	2-3/8"
Inside Dia.	Nominal Pipe Size	Pipe Sch.	Flow Coefficients (C_f)				
.546	1/2	80	.352	–	–	–	–
.622	1/2	40	.385	–	–	–	–
.742	3/4	80	.450	–	–	–	–
.824	3/4	40	.487	–	–	–	–
.957	1	80	.537	–	–	–	–
1.049	1	40	.559	–	–	–	–
1.500	1-1/2	80	.631	–	–	–	–
1.610	1-1/2	40	.647	–	–	–	–
1.939	2	80	.684	–	–	–	–
2.067	2	40	.694	–	–	–	–
2.323	2-1/2	80	.705	.637	–	–	–
2.469	2-1/2	40	.709	.638	–	–	–
2.624	3	160	.712	.639	–	–	–
2.900	3	80	.716	.641	.640	–	–
3.000	–	–	.717	.642	.640	–	–
3.068	3	40	.718	.642	.640	–	–
3.438	4	160	–	.645	.642	–	–
3.826	4	80	–	.647	.643	–	–
4.000	–	–	–	.648	.643	–	–
4.026	4	40	–	.648	.643	–	–
5.187	6	160	–	.653	.645	–	–
5.761	6	80	–	.655	.646	–	–
6.000	–	–	–	.656	.647	–	–
6.065	6	40	–	.656	.647	–	–
6.813	8	160	–	.659	.648	–	–
7.625	8	80	–	.661	.649	–	–
7.981	8	40	–	.662	.649	–	–
8.000	–	–	–	.662	.649	–	–
8.500	10	160	–	.663	.650	–	–
9.562	10	80	–	.666	.651	–	–
10.000	–	–	–	.667	.652	–	–
10.020	10	40	–	.667	.652	–	–
10.126	12	160	–	.667	.652	–	–
11.374	12	80	–	.667	.652	–	–
11.938	12	40	–	.670	.653	–	–
12.000	12	STD	–	.670	.653	–	–
12.500	14	80	–	.671	.654	.548	.538
13.124	14	40	–	.672	.654	.554	.545
13.250	14	STD	–	.672	.654	.557	.549
14.000	–	–	–	.674	.655	.565	.557
14.314	16	80	–	.674	.655	.569	.561
15.000	16	40	–	.675	.655	.575	.568
15.250	16	STD	–	.675	.656	.580	.572
16.000	–	–	–	.676	.656	.584	.576
16.124	18	80	–	.677	.656	.585	.577
16.876	18	40	–	.678	.656	.593	.586
17.250	18	STD	–	.678	.657	.593	.586
17.938	20	80	–	.679	.657	.597	.591
18.000	–	–	–	.679	.657	.598	.591
18.812	20	40	–	.680	.658	.603	.597
19.250	20	STD	–	.680	.658	.605	.599
20.000	–	–	–	.681	.658	.609	.603

Continued

a) ALSO APPLIES TO MODELS 307, 311, 341, 351, 361, 371, 381, 391
b) ALSO APPLIES TO MODELS 306, 308, 3123, 342, 352, 362, 372, 382, 392
c) ALSO APPLIES TO MODELS 353, 363, 373, 383, 393

TABLE 1 *Continued*

FLOW COEFFICIENTS (C_f) vs MODEL NO. FLOW ELEMENT SIZE & PIPE INSIDE DIAMETER							
MODEL			300	301(a)	302(b)	323	343(c)
F.E. Dia.			1/4"	1/2"	1"	2-1/4"	2-3/8"
Inside Dia.	Nominal Pipe Size	Pipe Sch.	Flow Coefficients (C_f)				
21.562	24	80	–	.683	.659	.616	.611
22.624	24	40	–	.684	.659	.621	.616
23.250	24	STD	–	.684	.660	.623	.618
24.000	24	–	–	.685	.660	.626	.621
29.000	30	XS	–	.689	.662	.641	.637
29.250	30	STD	–	.689	.662	.641	.637
30.000	–	–	–	.690	.662	.643	.639
35.000	36	XS	–	.693	.663	.652	.650
35.250	36	STD	–	.693	.664	.653	.650
36.000	–	–	–	.694	.664	.654	.651
41.000	42	XS	–	CONTACT FACTORY	CONTACT FACTORY	.661	.658
41.250	42	STD	–			.662	.659
42.000	–	–	–			.663	.660
47.000	48	XS	–			.668	.665
47.250	48	STD	–			.668	.665
48.000	–	–	–			.668	.666
59.250	60	STD	–			.677	.675
60.000	–	–	–			.677	.675

a) ALSO APPLIES TO MODELS 303, 307, 311, 321, 331, 341, 351, 361, 371, 381, 391
b) ALSO APPLIES TO MODELS 306, 308, 312, 322, 332, 342, 352, 362, 372, 382, 392
c) ALSO APPLIES TO MODELS 353, 363, 373, 383, 393

III DIFFERENTIAL PRESSURE (ΔP) CALCULATIONS

A. *Define the system operating parameters:*
This is most simply done by completing form DAD-98 (Figure 12) for the appropriate media – liquid, gas or steam.

B. ***You may use the standard flow charts (*****Figure 5-10) to determine the approximate ΔP produced. This technique should only be used to check system feasibility or to select the appropriate flow element size for the initial calculation.**

C. *Calculate ΔP* at maximum, normal & minimum flow where accurate measurement is required using the following equations.

Where Fluid Velocity is known:

$$\Delta P = \frac{w_f}{334}\left(\frac{V}{C_f}\right)^2 \qquad \text{(Eq. 8)}$$

Where: ΔP = Differential pressure in inches of water @ 60°F
W_f = Specific Weight (lbs/ft³) @ flow conditions
V = Velocity in ft/sec.
C_f = Flow Coefficient (See Table 1)

Where Volume Flow Rate for Liquids is Known:

$$\Delta P = \left[\frac{Q \times \sqrt{s_f}}{5.667 \times C_f \times D^2}\right]^2 \qquad \text{(Eq. 9)}$$

Where: ΔP = Differential pressure in inches of water @ 60°F
Q = Flow in gal/min.
C_f = Flow Coefficient (See Table 1)
D = Pipe Inside Diameter in inches
s_f = Specific Gravity of liquid @ flow condition

Where mass flow rate of the liquid, gas or steam is known:

$$\Delta P = \left[\frac{W}{359.12 \times C_f \times D^2 \times \sqrt{w_f}}\right]^2 \qquad \text{(Eq. 10)}$$

Where: ΔP = Differential Pressure in inches of water @ 60°F
W = Mass Flow Rate in lbs/hr.
C_f = Flow Coefficient (See Table 1)
D = Pipe Inside Diameter in inches
w_f = Specific Weight of fluid @ flow conditions

Where volume flow rate of the gas is known at standard conditions:

$$\Delta P = \left[\frac{SCFM \times w_s}{5.985 \times C_f \times D^2 \times \sqrt{w_f}}\right]^2 \qquad \text{(Eq. 11)}$$

Where: ΔP = Differential Pressure in inches of water @ 60°F
SCFM = Flow Rate in standard ft³/min
w_s = Specific Weight of gas @ standard conditions
C_f = Flow Coefficient (See Table 1)
D = Pipe Inside Diameter in inches
w_f = Specific Weight of fluid @ flow conditions

Note: If the differential pressure at minimum flow is less than 2" H_2O, downsize the metering section to increase the ΔP. See Figure 2 for appropriate metering section configuration.

IV DELTA-TUBE AND INSTRUMENT SELECTION

A) Compare the differential pressure at maximum flow with the values shown in Table 2. If the calculated values of ΔP exceed those shown, go to a larger diameter flow element or a double support configuration.

Note: If the process temperature is above 100°F (73°F for CPVC Model 300) check Table 3 for the appropriate temperature derating factor. Multiply the value in Table 2 by the derating factor in Table 3 to determine the maximum permissable ΔP at the system operating temperature.

B) If a larger flow element is required, recalculate the ΔP and repeat Step IV A) above.

C) Compare the system temperature and pressure to the values shown in Table 4. If the system temperature and/or pressure exceeds these values, contact the factory for other options.

D) When the Delta-Tube selection is finalized, select the proper ΔP range for the indicator or transmitter. As a general rule the instrument range should be selected so the normal flow reading is at 2/3 to 3/4 of the instrument range.

V FLOW CALCULATIONS

For normal plant or control applications, the following equations may be used to determine flow.

To calculate liquid volume flow rate:

$$Q = 5.677 \times C_f \times D^2 \times \frac{1}{\sqrt{s_f}} \times \sqrt{\Delta P} \qquad \text{(Eq. 12)}$$

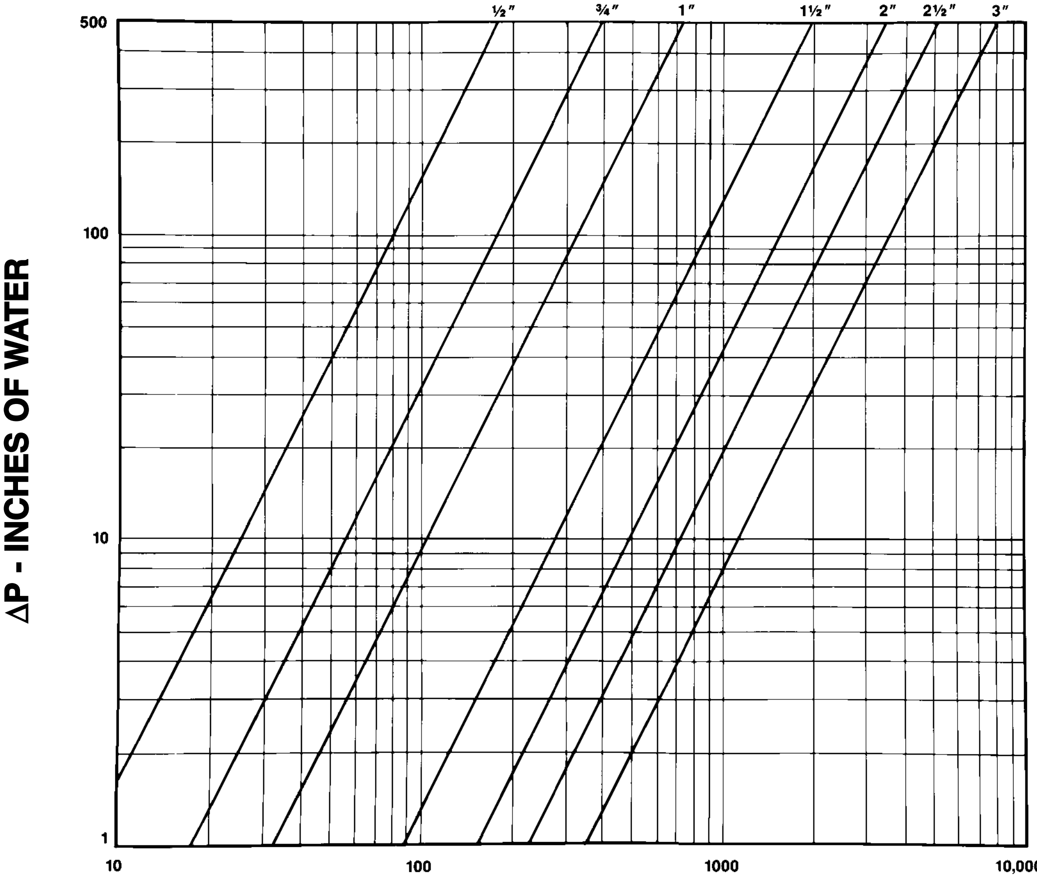
Where: Q = Flow in gal/min.
C_f = Flow Coefficient (see Table 1)
D = Pipe Inside Diameter in inches
s_f = Specific Gravity of the fluid @ flow conditions
ΔP = Differential Pressure in inches of water @ 60°F

To calculate mass flow rate for liquid, gas or steam:

$$W = 359.12 \times C_f \times D^2 \times \sqrt{w_f} \times \sqrt{\Delta P} \qquad \text{(Eq. 13)}$$

Where: W = Flow in lbs/hr.
C_f = Flow Coefficient (See Table 1)
D = Pipe Inside Diameter in inches
w_f = Specific Weight of fluid @ flow conditions
ΔP = Differential Pressure in inches of water @ 60°F

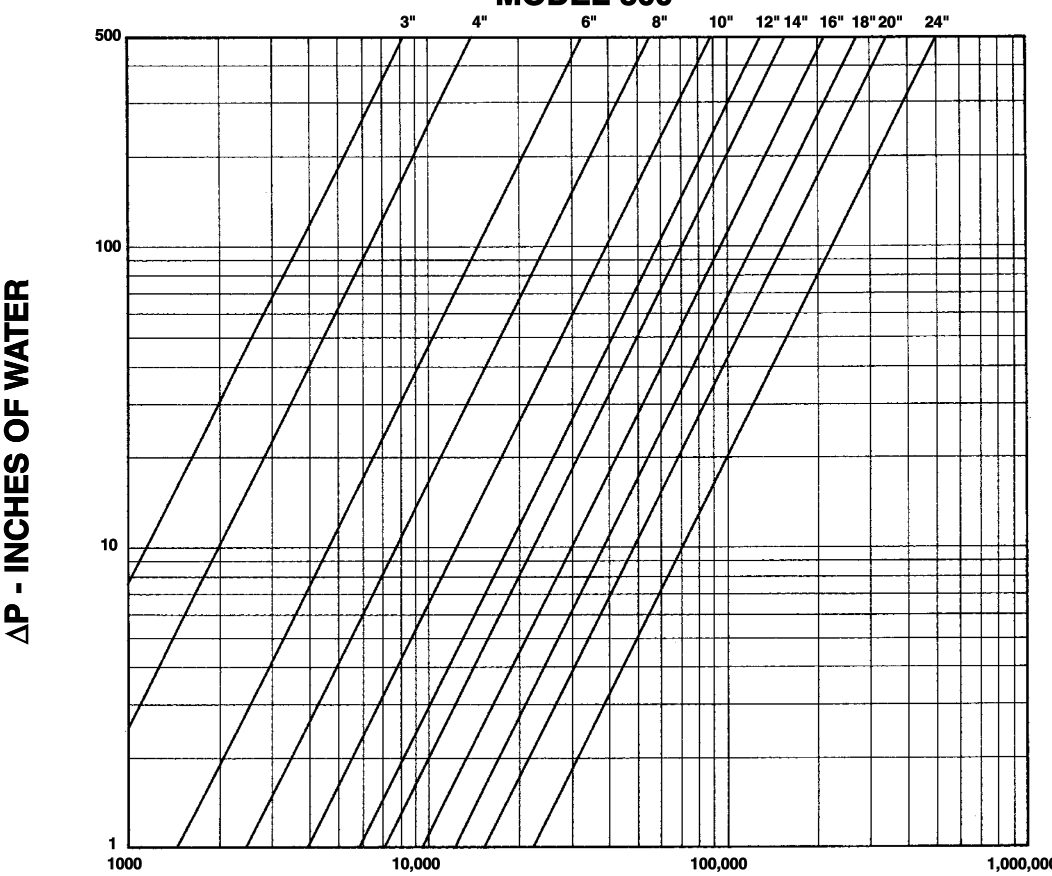
FIGURE 9 – AIR HIGH PRESSURE 70°F., 114.7 PSIA



STANDARD CUBIC FEET PER MINUTE (SCFM)

MODEL 300

NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

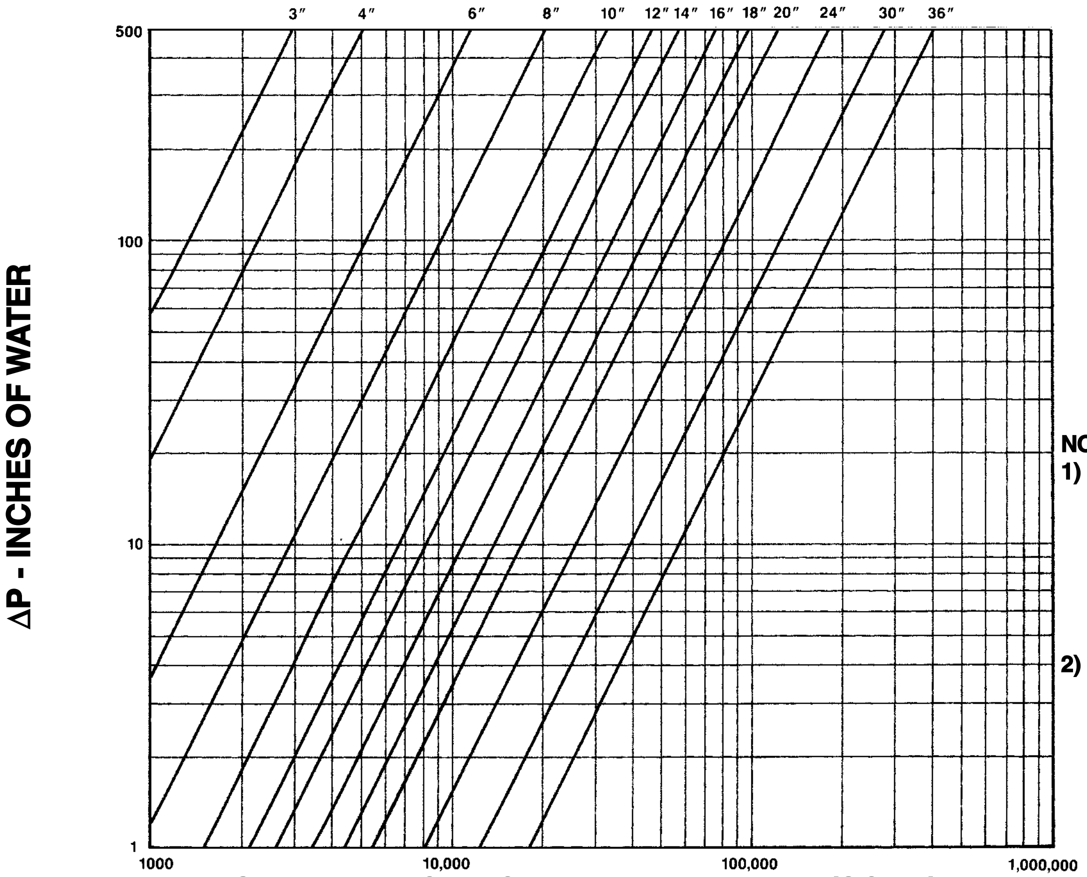


STANDARD CUBIC FEET PER MINUTE (SCFM)

301, 311, 321, 331, 341, 351, 361, 371, 381 & 391

NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

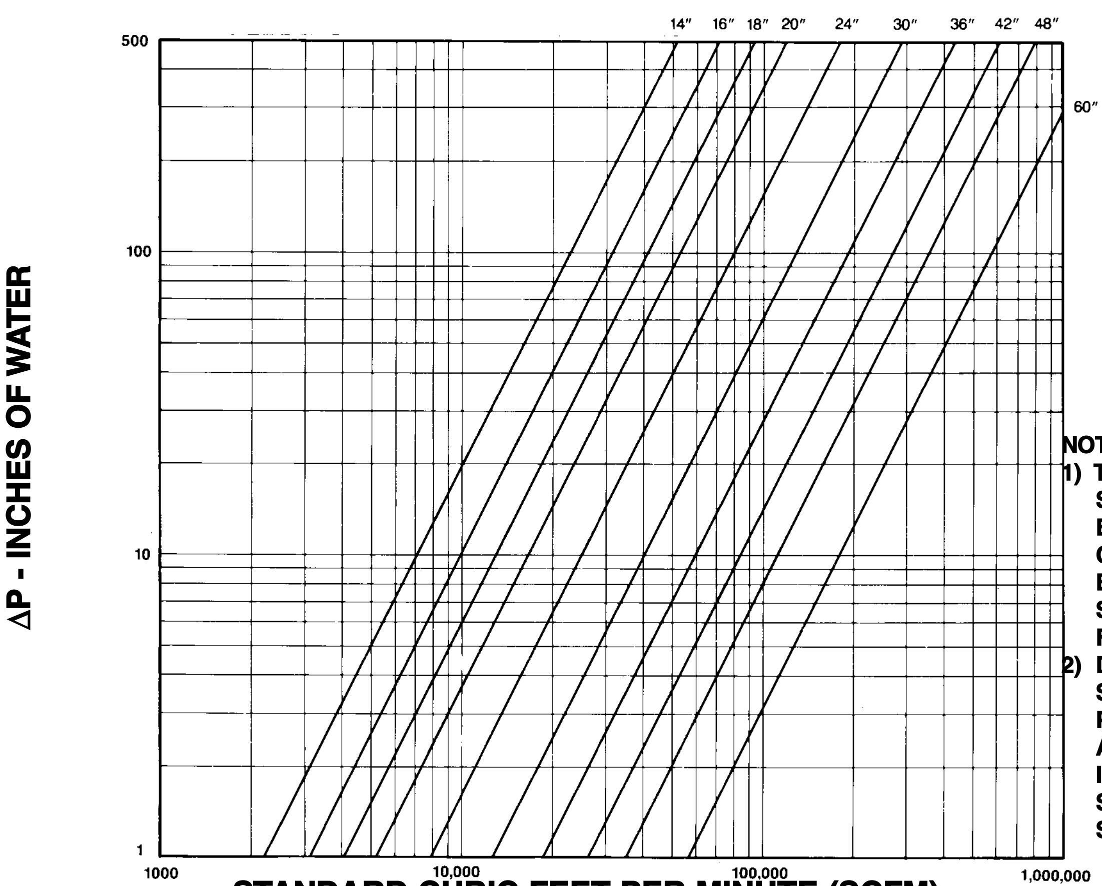
FIGURE 8 – AIR LOW PRESSURE 70°F., 14.7 PSIA



NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

STANDARD CUBIC FEET PER MINUTE (SCFM)

MODELS 302, 306, 308, 312, 322, 332, 342, 352, 362, 372, 382 & 392



NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

STANDARD CUBIC FEET PER MINUTE (SCFM)

MODELS 323, 343, 353, 363, 373, 383 & 393

To calculate gas volume flow rate at standard condtions:

$$SCFM = 5.985 \times C_f \times D^2 \times \sqrt{\frac{w_f}{w_s}} \times \sqrt{\Delta P} \quad \text{(Eq.14)}$$

C_f = Flow Coefficient (see Table 1)
D = Pipe Inside Diameter in inches
w_f = Specific Weight @ flow conditions
w_s = Specific Weight @ standard conditions
ΔP = Differential pressure in inches of water @ 60°F

VI ΔP AND FLOW IN RECTANGULAR DUCTS

In cases where square or rectangular ducts are employed, it is necessary to convert the square or rectangular section to an equivalent circular section.

This is done by calculating an equivalent round duct which has flow and pressure loss equal to that of the square or rectangular duct.

The equivalent circular duct is calculated as follows:

$$D_e = \frac{1.3\,(h \times w)^{.625}}{(h + w)^{.25}} \quad \text{(Eq. 20)}$$

Where: D_e = Equivalent diameter in inches
h = Height of the duct in inches
w = Width of the duct in inches

Used D_e to select the appropriate C_f and to perform calculations as shown in Sections II through V.

TABLE 2
PERMISSIBLE ΔP (IN H_2O) vs MODEL & PIPE SIZE

MATERIAL	CPVC	316 SS	316 SS	316 SS	316 SS	316 SS	ALUM.	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS
MODEL	300	300	301	301	302	302	306[a]	307[a]	308[a]	311[b]	312[c]	323	341[d]	341[d]	342[e]	342[e]	343[f]	343[f]
SUPPORT TYPE	D.S.	D.S.	S.S.	D.S.	S.S.	D.S.	D.S.	D.S.	D.S.	S.S.	S.S.	S.S.	S.S.	D.S.	S.S.	D.S.	S.S.	D.S.
FLOW ELEMENT SIZE	1/4"	1/4"	1/2"	1/2"	1"	1"	1"	1/2"	1"	1/2"	1"	2-1/4"	1/2"	1/2"	1"	1"	2-3/8"	2-3/8"
NOMINAL PIPE SIZE & SCHEDULE	MAXIMUM PERMISSIBLE ΔP (IN H_2O)																	
1/2-2 (40)	800	3000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2-1/2 (40)	565	3000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3 (40)	360	1960	680	–	1710	–	–	–	–	185	370	–	155	–	400	–	–	–
4 (40)	–	–	390	–	990	–	–	–	–	125	265	–	110	–	285	–	–	–
6 (40)	–	–	170	–	435	–	4200	1070	2650	70	155	–	60	–	165	–	–	–
8 (40)	–	–	95	–	250	–	–	–	–	45	105	–	40	–	110	–	–	–
10 (40)	–	–	55	–	160	640	–	–	–	30	75	–	25	–	80	295	–	–
12 (40)	–	–	40	–	110	450	1070	260	670	25	55	–	20	–	60	220	–	–
14 (STD)	–	–	–	140	90	365	–	–	–	20	50	330	18	70	50	185	540	–
16 (STD)	–	–	–	105	65	275	–	–	–	18	40	270	14	55	40	145	435	–
18 (STD)	–	–	–	85	–	215	475	115	325	14	30	220	10	45	30	115	355	–
20 (STD)	–	–	–	65	–	170	–	–	–	10	25	185	7	35	25	95	300	1070
24 (STD)	–	–	–	40	–	115	260	65	175	7	20	140	7	25	20	70	220	750
30 (STD)	–	–	–	–	–	75	–	–	–	–	13	95	–	–	14	45	145	490
36 (STD)	–	–	–	–	–	50	120	25	75	–	9	70	–	–	10	30	105	340
42 (STD)	–	–	–	–	–	–	–	–	–	–	7	50	–	–	7	25	80	255
48 (STD)	–	–	–	–	–	–	65	17	40	–	5	40	–	–	5	19	60	195
60 (STD)	–	–	–	–	–	–	–	–	–	–	–	25	–	–	3	12	40	125
72 (STD)	–	–	–	–	–	–	40	10	18	–	–	–	–	–	–	–	–	–

a) MODEL 306, 307, 308 DIMENSIONS ARE NOMINAL DUCT DIMENSIONS OF INSTALLED LENGTH.
b) MAXIMUM ΔP ALSO APPLIES TO MODELS 321 & 331.
c) MAXIMUM ΔP ALSO APPLIES TO MODELS 322 & 332.
d) MAXIMUM ΔP ALSO APPLIES TO MODELS 351, 361, 371, 381 & 391.
e) MAXIMUM ΔP ALSO APPLIES TO MODELS 352, 362, 372, 382 & 392.
f) MAXIMUM ΔP ALSO APPLIES TO MODELS 353, 363, 373, 383 & 393.

S.S. = SINGLE SUPPORT D.S. = DOUBLE SUPPORT

NOTE: THIS DATA IS FOR 100°F FOR ALL MATERIALS EXCEPT CPVC WHICH IS FOR 73°F. SEE TABLE 3 FOR ELEVATED TEMPERATURE DERATING FACTORS.

TABLE 3
DERATING FACTORS FOR CALCULATING
ALLOWABLE ΔP AT ELEVATED TEMPERATURES

TEMP. °F.	100	120	150	180	200	300	400	500	600	700	800
316 S.S.	1.00	1.00	1.00	1.00	.87	.76	.69	.64	.60	.57	.55
CPVC	.78	.62	.44	.25	NOT RECOMMENDED						
ALUM.	1.00	1.00	1.00	1.00	.95	.83	.47	NOT RECOMMENDED			

TO DETERMINE THE MAXIMUM ALLOWABLE ΔP AT ELEVATED TEMPERATURES, MULTIPLY THE MAXIMUM ΔP SHOWN IN TABLE 2 BY THE APPROPRIATE DERATING FACTORS SHOWN ABOVE.

FIGURE 2 - METERING SECTION CONFIGURATION

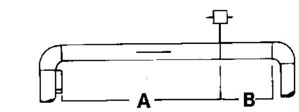
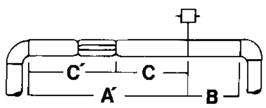
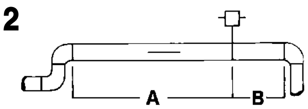
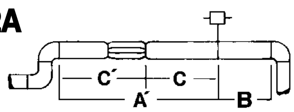
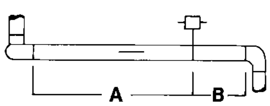
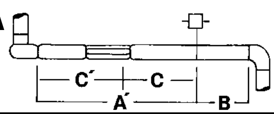
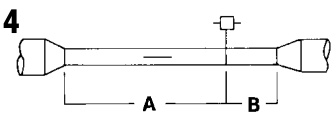
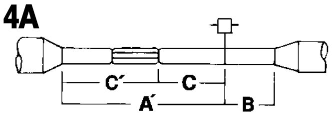
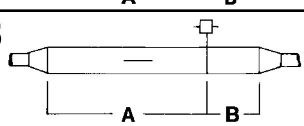
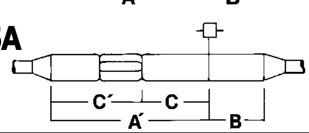
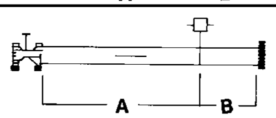
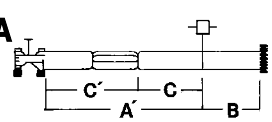
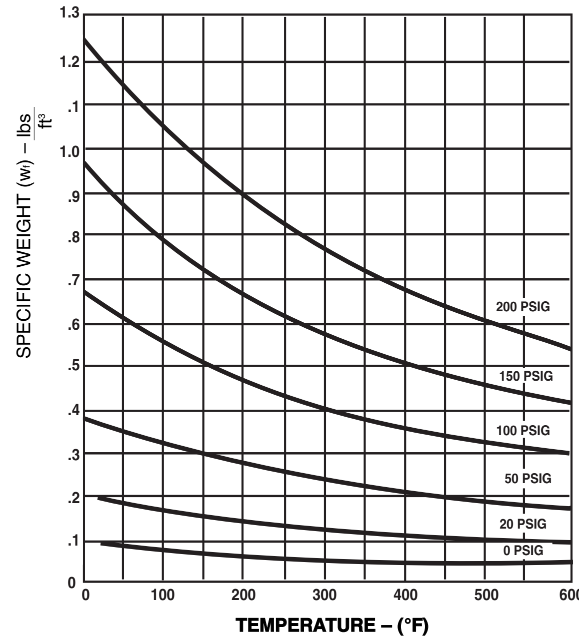
	Upstream Dimension in Pipe Diameters					
	Without vanes		With vanes			
	In Plane	Out of Plane				
	A	A	A'	C	C'	B
1 	7	9				3
1A 			6	2.7	3.3	
2 	9	14				3
2A 			8	3.6	4.4	
3 	19	24				4
3A 			9	4.1	4.9	
4 	8	8				3
4A 			8	3.6	4.4	
5 	8	8				3
5A 			8	3.6	4.4	
6 	24	24				4
6A 			9	4.1	4.9	

FIGURE 1 – SPECIFIC WEIGHT (w_f) FOR AIR VS. TEMPERATURE (°F) & PRESSURE (PSIG)

SPECIFIC WEIGHT OF AIR @ 60°F & 14.696 PSIA = .0764 $\frac{lbs}{ft^3}$



VIBRATION

When Delta Tubes are used in high velocity gas streams, vibrations are induced due to the "Von Karmen" effect. If the "Von Karmen" frequency coincides with the natural frequency of Delta Tube, structural damage may occur.

Virbration effects need not be considered if:

1. The media is a liquid.
2. The maximum generated differential pressure is equal or less than 20% of the maximum rated differential pressure of the Delta Tube.
3. The model 300 is used.

The Mid-West Delta-Tube differential pressure versus flow calculation computer program provides calculated resonant flow ranges. These resonance calculations are for the Delta Tube only with no consideration given to the piping system in which they are installed.

If your application will be operating in the resonant range and outside of the above three exceptions

The following alternatives should be considered:

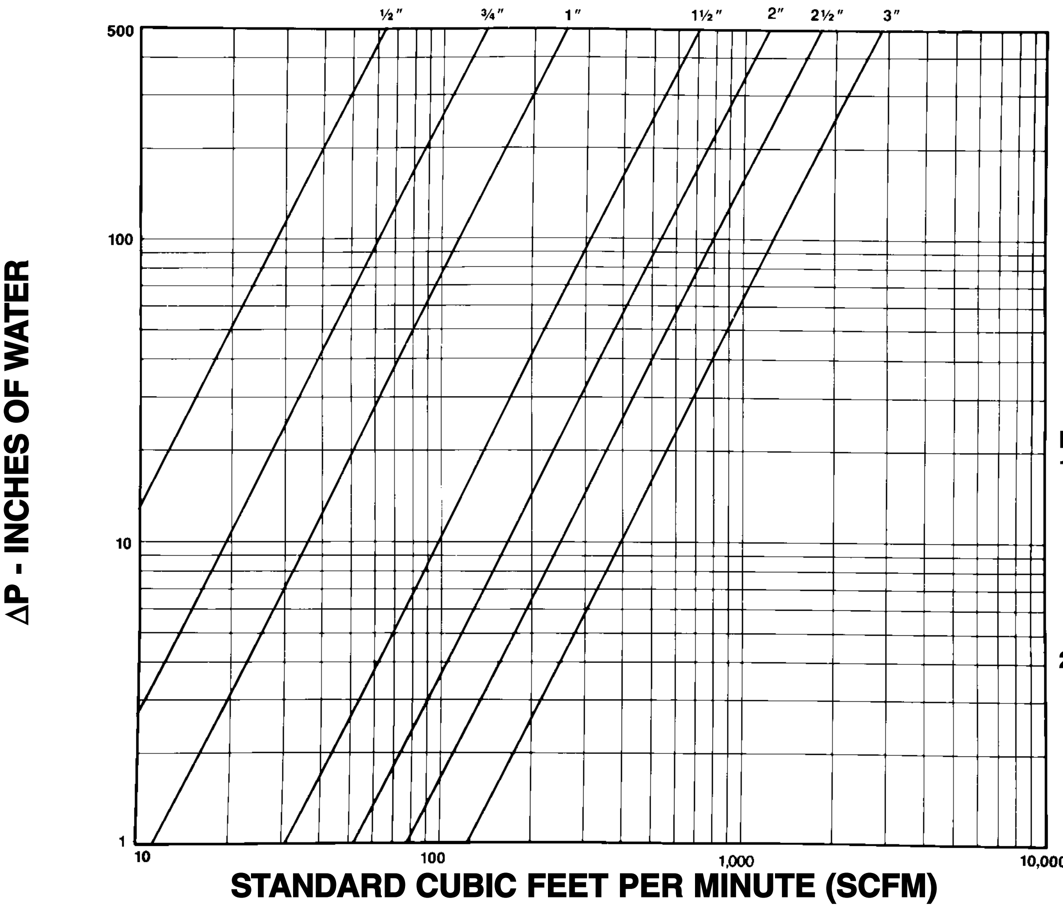
- Use double supported Delta Tube.
- Move to a larger diameter Delta Tube.
- Change meter run size to move resonance out of operating range.

In each case the vibration condition must be re-checked for proper operation.

B = Downstream Dimension in Pipe Diameters

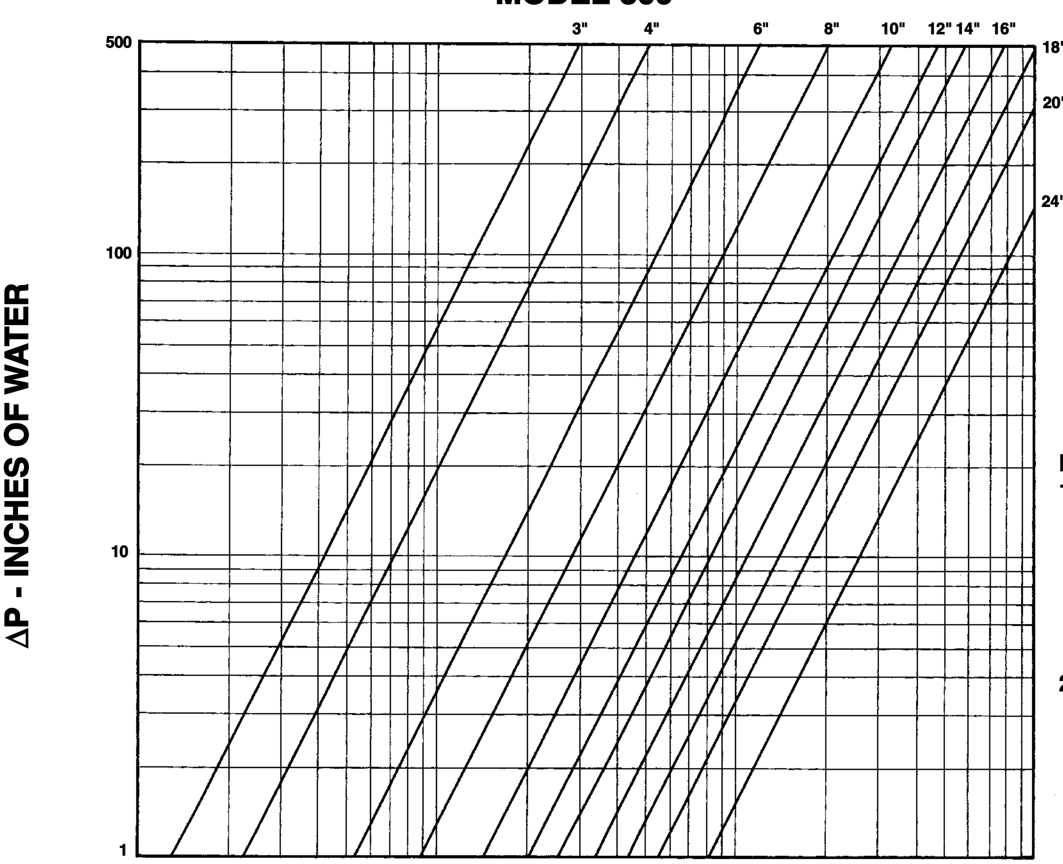
NOTE: The Delta Tube produces a repeatable signal in installations with less than the recommended upstream and downstream straight pipe lengths. These non-optimum locations still provide repeatable flow data and can be used for control or comparison applications where absolute accuracy is not the primary requirement.

FIGURE 7 – AIR-LOW PRESSURE 70°F., 14.7 PSIA



NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

MODEL 300

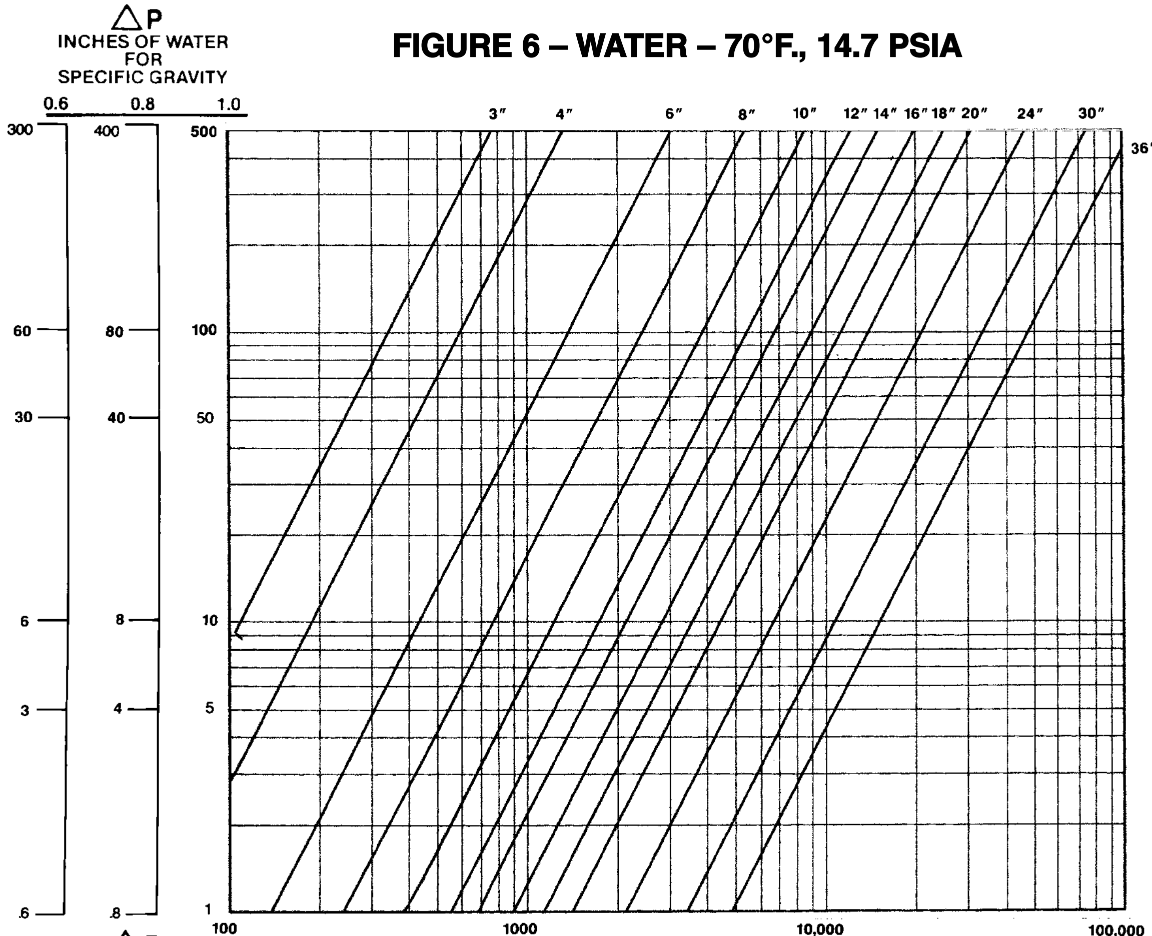


NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECKFOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

STANDARD CUBIC FEET PER MINUTE (SCFM)

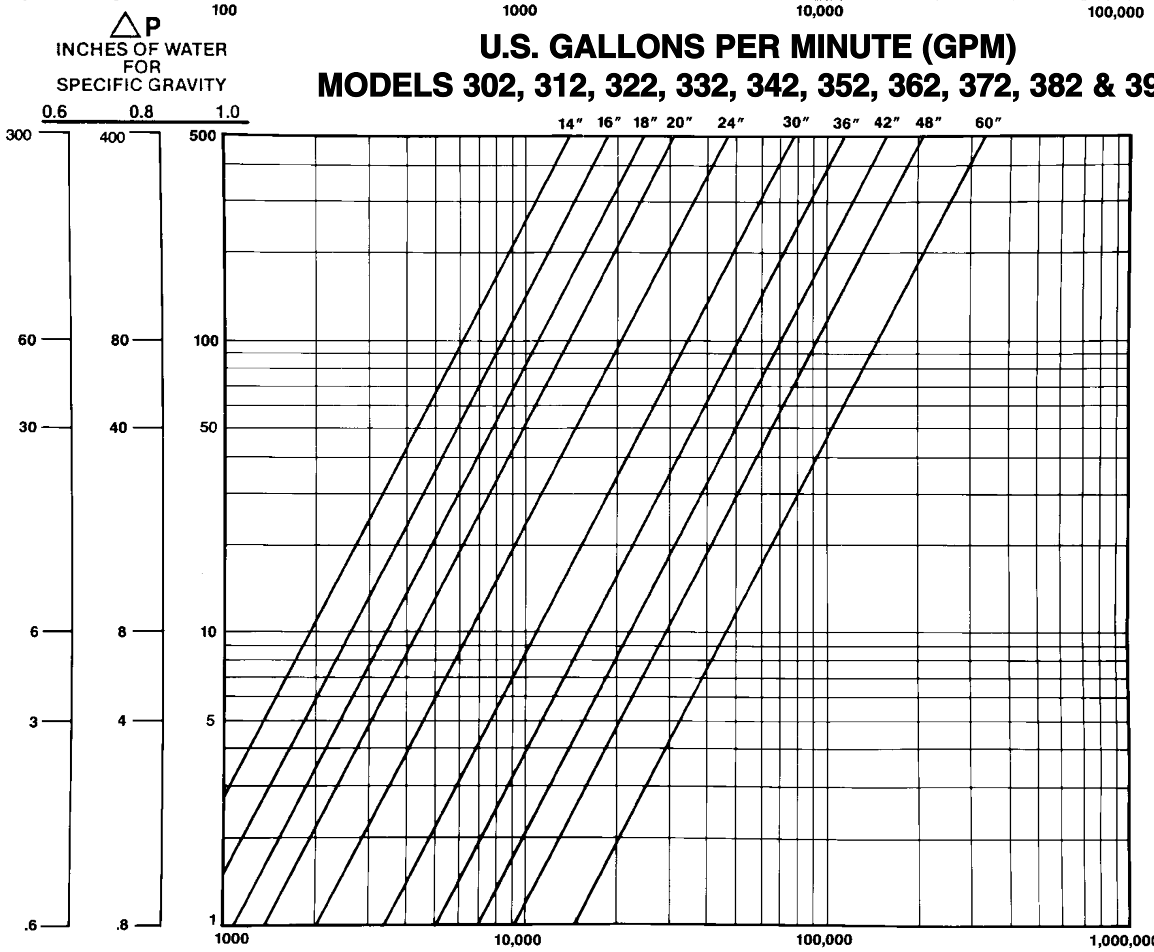
MODELS 301, 307, 311, 321, 331, 341, 351, 361, 371, 381 & 391

FIGURE 6 – WATER – 70°F., 14.7 PSIA



U.S. GALLONS PER MINUTE (GPM)
MODELS 302, 312, 322, 332, 342, 352, 362, 372, 382 & 392

NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.



U.S. GALLONS PER MINUTE (GPM)
MODELS 323, 343, 353, 363, 373, 383 & 393

NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

TABLE 4

MAXIMUM ALLOWABLE SYSTEM PRESSURE (PSIG) vs TEMPERATURE °F)[f]

(EXCEPT STEAM APPLICATIONS[a])

MODEL 300 CPVC

PIPE SIZE	1/2"	3/4"	1"	1-1/2"	2"	2-1/2"	3"
MATERIAL	CPVC (SCHEDULE 80)						
TEMP. (°F)	PRESSURE (PSIG)						
-20 to 73	300	240	220	170	140	150	130
80	280	225	205	160	130	140	120
100	235	190	170	130	110	115	100
120	195	155	140	110	90	95	85
140	150	120	110	85	70	75	65
160	110	90	80	60	50	55	45
180	75	60	55	40	35	35	30

MODELS 306, 307, 308, 311, 312

ALL PIPE SIZES

MODEL	306	307	308	311	312
MATERIAL	AL	SS	SS	CS/SS	CS/SS
F.E. SIZE	1"	1/2"	1"	1/2"	1"
TEMP. (°F)	PRESSURE (PSIG)				
0 to 400	15	15	15	100	100

MODEL 300 CARBON STEEL [b]

PIPE SIZE	1/2"	3/4"	1"	1-1/2"	2"	2-1/2"	3"	1/2"	3/4"	1"	1-1/2"	2"	2-1/2"	3"
ENDS	THREADED							WELDED						
TEMP. (°F)	PRESSURE (PSIG)													
-20 TO 600	1320	1130	1020	830	740	750	690	2950	2400	2240	1660	1390	1530	1320
700	1280	1100	990	800	720	730	670	2870	2330	2170	1610	1350	1480	1280

MODEL 300 STAINLESS STEEL [c]

PIPE SIZE	1/2"	3/4"	1"	1-1/2"	2"	2-1/2"	3"	1/2"	3/4"	1"	1-1/2"	2"	2-1/2"	3"
ENDS	THREADED							WELDED						
TEMP. (°F)	PRESSURE (PSIG)													
-20 to 200	2080	1770	1600	1310	1170	1180	1080	4640	3770	3520	2600	2190	2400	2080
300	2020	1730	1560	1270	1140	1150	1060	4520	3680	3430	2540	2130	2340	2020
400	2000	1710	1540	1260	1120	1130	1040	4460	3630	3380	2510	2100	2310	2000
500	1980	1700	1530	1250	1110	1120	1030	4430	3610	3360	2490	2090	2290	1980
600	1880	1610	1450	1180	1060	1070	980	4200	3420	3190	2360	1980	2170	1880
700	1800	1540	1390	1130	1010	1020	940	4030	3280	3050	2260	1900	2080	1800
800	1750	1500	1350	1100	980	990	910	3910	3180	2970	2200	1840	2020	1750

MODEL 301, 302 – ALL PIPE SIZES

MODEL	301	302	301	302
F.E. SIZE	1/2"	1"	1/2"	1"
MATERIAL	C.S.		316 S.S.	
TEMP. (°F)	PRESSURE (PSIG)			
-20 to 100	2980	1550	3210	1550
200	2980	1550	3210	1550
300	2980	1550	3210	1550
400	2980	1530	3170	1530
500	2980	1420	2950	1420
600	2980	1330	2760	1330
700	2860	1270	2640	1270
800	N.R.	N.R.	2540	1220

MODEL 321, 322, 323, 331, 332 – DELTA TAPS - ALL PIPE SIZES

MODEL	321	322	323	331	332	321	322	323	331	332
F.E00. SIZE	1/2"	1"	2-1/4"	1/2"	1"	1/2"	1"	2-1/4"	1/2"	1"
MATERIAL	CARBON STEEL					316 S.S.				
TEMP. (°F)	PRESSURE (PSIG)									
0 to 99	2000	1000	285	2020	1580	2000	1000	275	2000	1500
100	1225	1000	285	2020	1580	1225	1000	275	1225	1225
200	850	850	260	1750	1580	850	850	240	850	850
300	450	450	230	750	750	450	450	215	450	450
400	100	100	200	200	200	100	100	195	100	100

Note: Pressures & temperatures shown are for reinforced teflon seated ball valves. Consult the factory for valve options for higher pressures & temperatures.

ALL FLANGED MODELS - ALL PIPE SIZES

MODELS 300, 341, 351, 361, 371, 381, 391, 342, 352, 362, 372, 382, 392, 343, 353, 363, 373, 383, 393

FLANGE RATING	150#	300#	400#	600#	900#	1500#	2500#	150#	300#	400#	600#	900#	1500#	2500#
MATERIAL	CARBON STEEL[d]							STAINLESS STEEL[e]						
TEMP. (°F)	PRESSURE (PSIG)													
-20 to 100	285	740	990	1480	CONTACT FACTORY			275	720	960	1440	CONTACT FACTORY		
200	260	675	900	1350				240	620	825	1240			
300	230	655	875	1315				215	560	745	1120			
400	200	635	845	1270				195	515	686	1030			
500	170	600	800	1200				170	480	635	955			
600	140	550	730	1095				140	450	600	905			
700	110	535	710	1065				110	430	575	865			
800	NOT RECOMMENDED							80	415	555	830			

NOTE: a) The allowable pressures & temperatures shown **DO NOT APPLY TO STEAM SYSTEMS**. See bulletin SKSG for maximum allowable pressures & temperatures for steam systems.

b) Pressures & temperatures are based on ASTM A 53 grade A welded schedule 40 carbon steel pipe.

c) Pressures & temperatures are based on ASTM A 312 TP 316 welded schedule 40 stainless steel pipe.

d) Pressures & temperatures are based on ASTM A 105 C.S. flanges & compatible components.

e) Pressures & temperatures are based on ASTM A 182-F316 flanges & compatible components.

f) All data is based on ANSI standards B16, 11, B16, 34, B16, 5, B31.1.

FIGURE 3
SPECIFIC GRAVITY (S_f) vs. TEMPERATURE (°F) FOR TYPICAL LIQUIDS

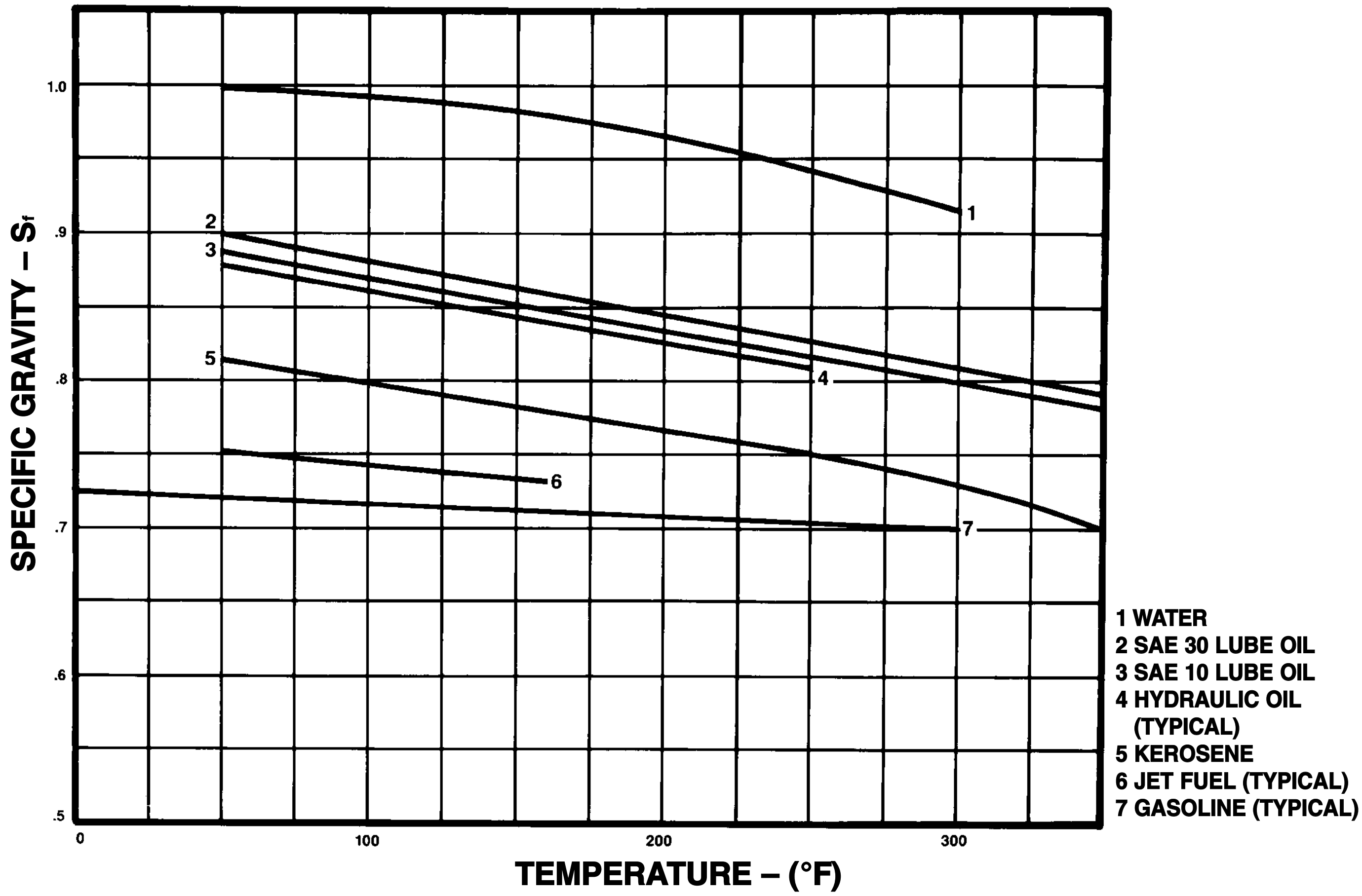
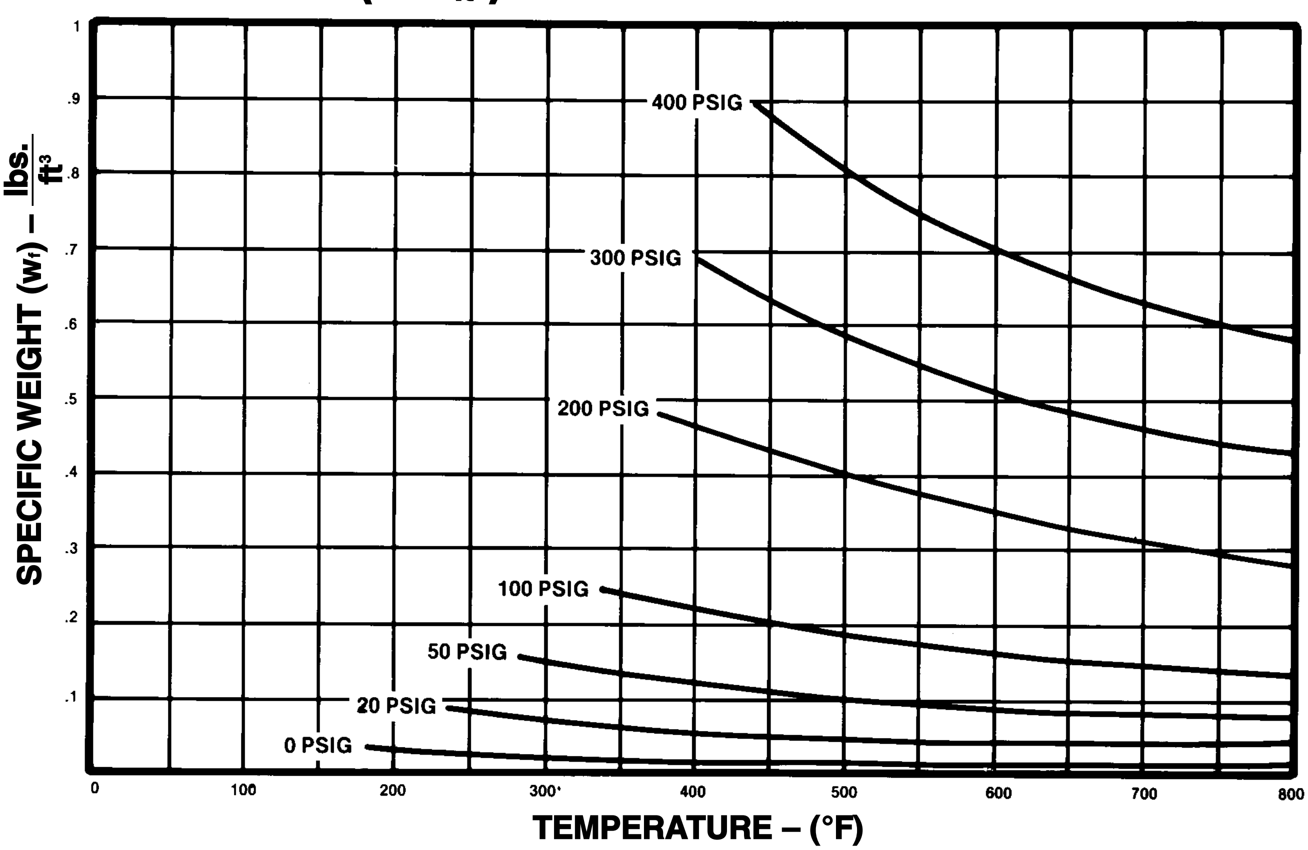
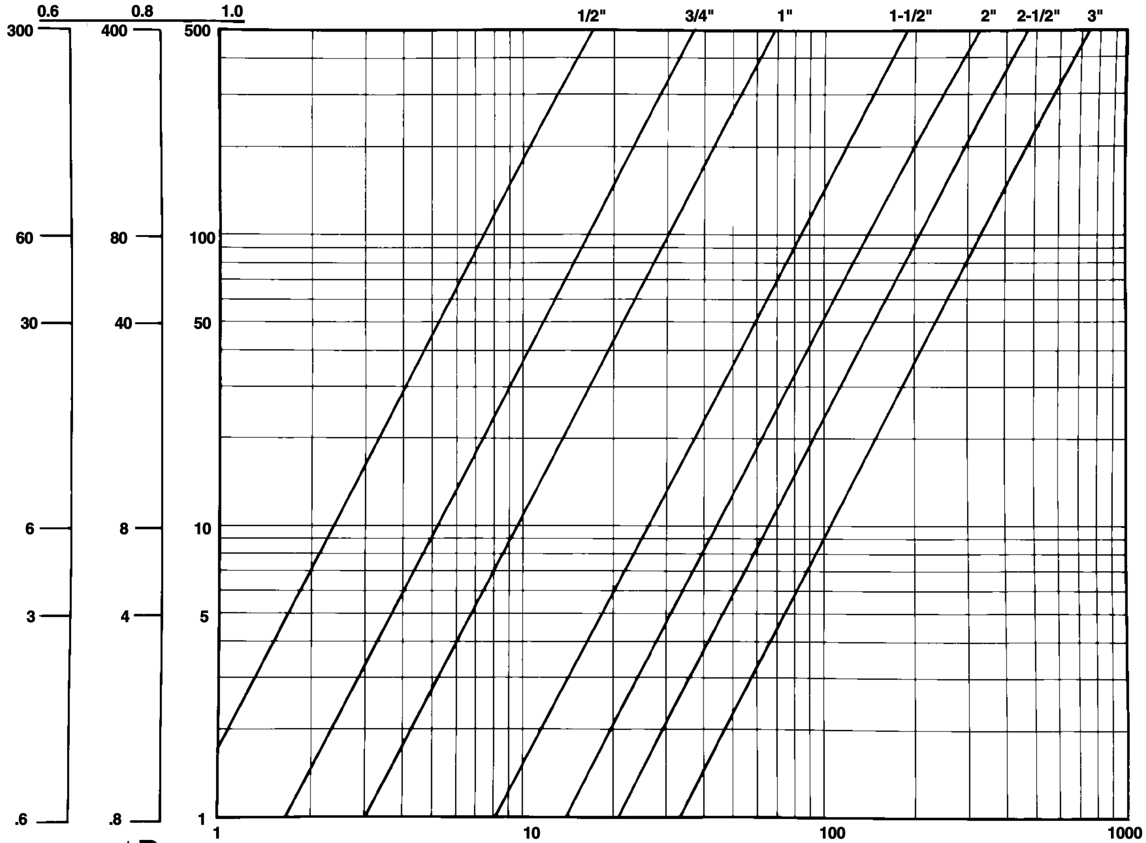


FIGURE 4
SPECIFIC WEIGHT $\left(w_f - \frac{lbs.}{ft^3}\right)$ vs. TEMPERATURE (°F) & PRESSURE (PSIG) FOR STEAM



ΔP
INCHES OF WATER
FOR
SPECIFIC GRAVITY

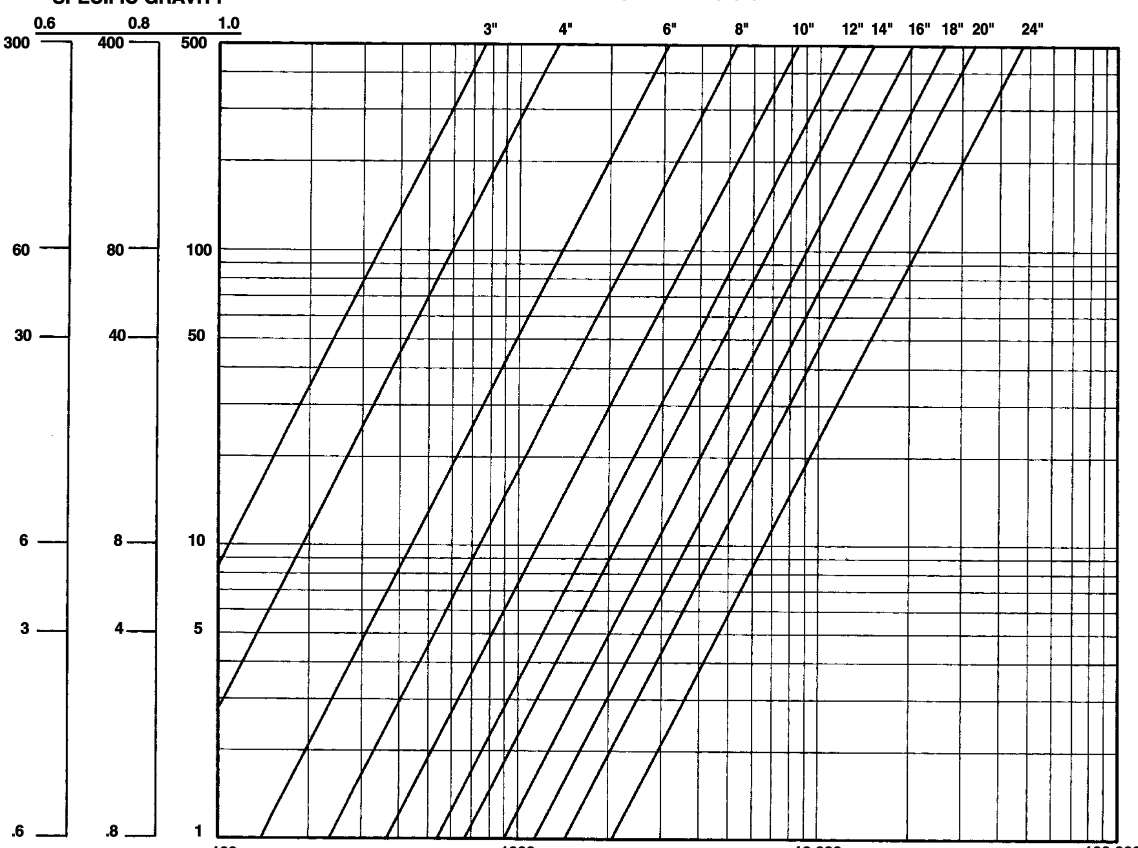
FIGURE 5 – WATER – 70°F., 14.7 PSIA



U.S. GALLONS PER MINUTE (GPM)
MODEL 300

NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

ΔP
INCHES OF WATER
FOR
SPECIFIC GRAVITY



U.S. GALLONS PER MINUTE (GPM)
MODELS 301, 307, 311, 321, 331, 341, 351, 361, 371, 381 & 391

NOTES:
1) THIS CHART SHOULD ONLY BE USED TO CHECK FOR BASIC SIZE OR SYSTEM FEASIBILITY.
2) DATA BASED ON SCHEDULE 40 PIPE THRU 12". ABOVE 12" DATA IS BASED ON STANDARD SCHEDULE.

FIGURE 12

FORM NO. DAD/98

DELTA TUBE APPLICATION DATA WORKSHEET

(ADDITIONAL FORMS AVAILABLE FROM LOCAL REPRESENTATIVE)

GENERAL INFORMATION

1	Tag or Identification No.		
2	Application		
3	Pipe I.D. & O.D. or Pipe Size & Schedule **(Specify Units)**		
4	Pipe Material	4a	Pipe Orientation: Vertical ☐ Horizontal ☐ Other ☐
5	Process Fluid		
6	System Design Temp. **(Specify Units)**	6a	System Design Press. **(Specify Units)**

IMPORTANT: Provide pressures & temperatures @ each flow rate for desired Δ P calculations

LIQUID

		UNITS	MAXIMUM	NORMAL	MINIMUM
7	Flow Rate **(Specify Units)**				
8	Pressure @ Flow Conditions Gauge ☐ Absolute ☐				
9	Temperature @ Flow Conditions **(Specify Units)**				
10	Specific Gravity or Specific Weight @ Flow Coniditions **(Specify Units)**				
11	Absolute Viscosity				

GAS

		UNITS	MAXIMUM	NORMAL	MINIMUM
7	Flow Rate **(Specify Units)**				
8	Pressure @ Flow Conditions Gauge ☐ Absolute ☐				
9	Temperature @ Flow Conditions **(Specify Units)**				
10	Specific Gravity or Specific Weight @ Flow Coniditions **(Specify Units)**				
11	Absolute Viscosity				

STEAM

		UNITS	MAXIMUM	NORMAL	MINIMUM
7	Flow Rate **(Specify Units)**				
8	Pressure @ Flow Conditions Gauge ☐ Absolute ☐				
9	Temperature @ Flow Conditions **(Specify Units)**				
10	Specific Weight @ Flow Coniditions **(Specify Units)**				
11	Absolute Viscosity				
12	Degrees Superheat				
13	Moisture or Liquid Content	%			
14	Saturated Yes ☐ No ☐				

REPRESENTED BY:

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Printed in U.S.A.