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NONCOMPRESSIBLE (LIQUID) ORIFICE, Calculations

REFERENCES: MARKS' MECHANICAL ENGINEERS HANDBOOK; PERRY'S CHEMICAL ENGINEERS HANDBOOK; FLUID FLOW by Sabersky & Acosta.

NOTE: Always begin a new case by retrieving the original file. Direct entry of data in cells that originally contain table lookups could cause functions to be lost, or incorrect calculations. I format cells requiring entry colored **RED**; calculated values are black.

···· Find Flow Imperial & Metric ····

1.) Enter identification at [C4].
2.) Enter orifice diameter at [C7].
3.) Enter orifice coefficient at [C9].
4.) Enter fluid at [G7], use [=], then go to the fluid name in the table located within the worksheet; at (A26..C73) eg. [=A73] is WATER. The specific gravity is then looked up, if the fluid is in the table. If not, enter at [G8].
5.) Enter inlet pressure at [C10].
6.) Enter outlet pressure at [G10].

The calculated flow "W" is indicated at D16.

···· Find Area Imperial & Metric ····

1.) Enter identification at [C4].
2.) Enter inlet pressure at [C7].
3.) Enter outlet pressure at [C8].
4.) Enter orifice coefficient at [C9].
5.) Enter flow in lb/hr at [C10].
6.) Enter fluid at [G7], use [=], then go to the fluid name in the table located within the worksheet; at (A39..C86) eg. [=A86] is WATER. The specific gravity is then looked up, if the fluid is in the table. If not, enter at [G8].
7.) The calculated area is indicated at [F16].
8.) Required orifice diameter is at [F20].
9.) Enter the existing orifice diameter at [C27]. If polygonal enter the length at [G27] and the width at [G28]. The resulting orifice parameters are shown at E32....E34.

···· Flow 2 Orifices Imperial & Metric ····

1.) Enter the orifice identification at [C4].
2.) Enter fluid at [D6], use [=], then go to the fluid name in the table located within the worksheet; at (A33..C88) eg. [=A80] is WATER. The specific gravity is then looked up, if the fluid is in the table. If not, enter at [D7].
3.) Enter inlet pressure `P1' at [F11].
4.) Enter outlet pressure `P3' at [H13].
5.) Enter Ko for first orifice at [F14].
6.) Enter first orifice diameter at [F15].
7.) Enter Ko for second orifice at [H14].
8.) Enter second orifice diameter at [H15].

NOTE:! **The calculation REQUIRES the pressures to ascend from P1 to P2 to P3; this may require a manual random number entry of P1 or P3 to iterate P2 to within the desired range. Depress the Calculate button to converge the equation.**

Flow `W' is calculated and shown at [F26].

···· Flow Segment Imperial & Metric ····

1.) Enter identification at [C4].
2.) Enter orifice or vessel diameter at [C7].
3.) Enter the opening depth at [C10].
4.) Enter orifice coefficient at [C11], if other than 0.6.
5.) Enter fluid at [G7], use [=], then go to the fluid name in the table located within the worksheet; at (A36..C84) eg. [=A83] is WATER. The specific gravity is then looked up, if the fluid is in the table. If not, enter at [G7].
6.) Enter P1 (usually the vessel MAP) at [G10].
7.) Enter P2 (outlet pressure, usually atmospheric) at [G11].
8.) Calculated flow `W' is indicated at E30.

···· Flow thru Perforated Screen Imperial & Metric ····

REFERENCES: **INDUSTRIAL PERFORATORS ASSOCIATION; TESTING BY BOYLE ENGINEERING LABORATORIES; MARKS' MECHANICAL ENGINEERS HANDBOOK.**

BACKGROUND: In many applications of perforated plate the estimated energy loss or pressure loss through perforated plates is one of the design considerations. This spreadsheet was developed based upon loss information from a battery of tests conducted on a laboratory liquid flow system at Boyle Engineering. This system maintained a non-swirling flow impacting perpendicularly on the sample. Various perforated thin gage plates were inserted into a uniform velocity liquid flow stream. Pressure loss for ambient liquid flow was then measured at a series of velocities for each flow. This data therefore presents the best flow condition value of loss. In applying this data consideration must be given to the actual anticipated characteristics of the flow impacting on the perforated plate. Distorted flow patterns with high velocity zones will increase the loss of the plate, as will directional flow not perpendicular to the plat surface.

1.) Enter the serivice condition at [C4].
2.) Enter fluid at [C5], use [=], then go to the fluid name in the table located within the worksheet; at (A36..C83) eg. [=A83] is WATER.
3.) Enter (W) the calculated mass flow thru the supply pipe at [E7].
4.) Enter the supply pipe id [E10], this assists in determining the velocity.
5.) The impact velocity is calculated and shown at [E12].
6.) Enter the per cent "open area" of the perforated plate at [E11].
9.) The specific gravity will be looked up and inserted in cells F12, if in the database. If not enter directly.
10.) The appropriate equation is selected from the % open area and shown at [D16].

The delta P is calculated and shown at [D18].

Print out using direct Excel commands. This application is provided by Chemical Engineers Resource Website, cheresources.com for additional selections.

Print out using direct EXCEL commands.

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Noncompressible (Liquid) Flow thru Orifice, Find Flow

ORIFICE: Hot Water to Redi-Bond System; Device L-60

.... **Orifice**			.... **Fluid**		
Internal Diameter :	2.000	in	Fluid:	WATER	
Orifice Area :	3.142	in^2	Specific Gravity:	1.00	
Orifice Coefficient:	0.50	K_o	Density:	62.40	lb/cu ft
Upstream Pressure:	75	P_1, psig	Downstream Pressure:	9.50	P_2, psig

$$W = 2410 \cdot Ko \cdot A \cdot [(P1 - P2) \cdot D]^{0.5}$$

W = 242019.22 lb/hr = 484.03845 gpm

Noncompressible (Liquid) Flow thru Orifice, Find Flow

ORIFICE: Hot Water to Redi-Bond System; Device L-60

.... Orifice			.... Fluid		
Internal Diameter :	50.800	mm	Fluid:	WATER	
Orifice Area :	0.0020268	m^2	Specific Gravity:	1.00	
Orifice Coefficient:	0.50	K_o	Density:	1000.00	kg/cu meter
Upstream Pressure:	517106.8	P_1, Pa	Downstream Pressure:	65500.19	P_2, Pa

$$W = 1.42 \cdot Ko \cdot A \cdot [(P1 - P2) \cdot D]^{0.5}$$

W = 30.58129 kg/sec

Noncompressible (Liquid) Flow thru Orifice, Find Area

ORIFICE: Bleached Broke Dump Chest; 03D-001

.... Orifice			.... Fluid		
Upstream Pressure:	0.35	P_1, psig	Fluid:	MULTITHERM PG-1	
Downstream Pressure:	0.000	P_2, psig	Specific Gravity:	0.875	
Orifice Coefficient:	0.80	K_o	Density:	54.60	lb/cu ft
Flow Rate:	2790250	W, lb/hr	Flow Rate:	6377.7	Q, gpm

···· Orifice, Required Area ····

$$A := \frac{W}{2410 \cdot K_o \cdot \sqrt{(P1 - P2) \cdot D}} = 331.059 \text{ sq. in.}$$

diameter, ø = 20.531 in

···· Orifice, Shape/Area Determination ····

.... Circular			.... Polygonal		
diameter, ø =	24	in.	length =	0	in.
orifice area =	452.389	sq. in.	width =	0	in.
			area =	0.000	sq. in.

orifice area =	452.39	sq. in.
area remaining =	121.33	sq. in.
area utilized =	73.2%	

Noncompressible (Liquid) Flow thru Orifice, Find Area

ORIFICE: Bleached Broke Dump Chest; 03D-001

············· **Orifice** ·············			·············· **Fluid** ··············		
Upstream Pressure:	2413.1651	P_1, Pa	Fluid:	MULTITHERM PG-1	
Downstream Pressure:	0	P_2, Pa	Specific Gravity:	0.875	
Orifice Coefficient:	0.80	K_o	Density:	875.00	kg/cu meter
Flow Rate:	351.5656	W, kg/sec	Flow Rate:	1446.441	Q, m^3/hr

···· Orifice, Required Area ····

$$A := \frac{W}{1.42 \cdot K_o \cdot \sqrt{(P1 - P2) \cdot D}} = 0.2129759 \text{ sq. meter}$$

diameter, ø = 0.521 meter

···· Orifice, Shape/Area Determination ····

············ **Circular** ············			··········· **Polygonal** ···········		
diameter, ø =	0	meter	length =	0.5	meter
orifice area =	0.000	sq. meter	width =	0.5	meter
			area =	0.250	sq. meter

orifice area =	0.25	sq. meter
area remaining =	0.04	sq. meter
area utilized =	85.2%	

Noncompressible (Liquid) Flow thru Two Orifices, Find Flow

SERVICE: BOOSTED WATER TO INTERCOOLER

fluid: WATER

specific gravity: 1.00

density: 62.40 lb/ft^3

	Orifice #1		Orifice #2
Upstream Pressure, ... P_1, psi	19		
Intermediate Pressure, ... P_2, psi		18.755	
Downstream Pressure, ... P_3, psi			14
Orifice Coefficient, ... K_o	0.8		0.8
Orifice i.d., ... in	1.049		0.5
Orifice Area, ... in^2	0.8642529		0.1963495
Flow Rate W, ... lb/hr	6520.573		6520.5733
Flow Rate Q, ... gpm	13.041146		13.041147

···· flow calculation ····

error, Δ lb/hr = 0.00%

$$W := 2410 \cdot K_o \cdot A \cdot \sqrt{(P_1 - P_2) \cdot D}$$

W = 6520.573 lb/hr

Noncompressible (Liquid) Flow thru Two Orifices, Find Flow

SERVICE: BOOSTED WATER TO INTERCOOLER

fluid: WATER

specific gravity: 1

density: 1000 kg/m^3

	Orifice #1		Orifice #2
Upstream Pressure, ... P_1, Pa	131000.39		
Intermediate Pressure, ... P_2, Pa		129308.34	
Downstream Pressure, ... P_3, Pa			96526.602
Orifice Coefficient, ... K_o	0.8		0.8
Orifice i.d., ... meter	0.0266446		0.0127
Orifice Area, ... $meter^2$	0.0005576		0.0001267
Flow Rate W, ... kg/sec	0.8239348		0.8239326
Flow Rate Q, ... m^3/hr	2.9661653		2.9661572

···· flow calculation ····

error, Δ lb/hr = 0.00%

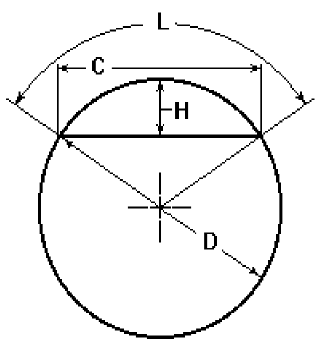
$$W := 1.42 \cdot K_o \cdot A \cdot \sqrt{(P_1 - P_2) \cdot D}$$

W = 0.8239348 kg/sec

Noncompressible (Liquid) Flow thru a Circular Segment, Find Flow

SERVICE: WATER STORAGE TANK

Orifice/Segment			Fluid		
Tank Diameter:	30.00	inches	Fluid:	WATER	
Tank Radius:	15.00	r, inches	Specific Gravity:	1.00	
Chord Length:	24.37	c, inches	Density:	62.40	lb/cu ft
Opening Depth:	6.25	H, rise, inches	Upstream Pressure:	0.92	P_1, psig
Orifice Coefficient =	0.60	K_o	Downstream Pressure:	0.00	P_2, psig



$$A := \frac{4 \cdot H^2}{3} \cdot \sqrt{\left(\frac{c^2}{4 \cdot H^2} + 0.392\right)}$$

A = 106.64 in^2

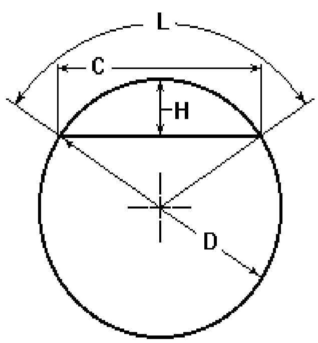
$$W := 2410 \cdot K_o \cdot A \cdot \sqrt{(P_1 - P_2) \cdot D}$$

W = 1168326 lb/hr, or 2,336.7 gpm

Noncompressible (Liquid) Flow thru a Circular Segment, Find Flow

SERVICE: WATER STORAGE TANK

.... **Orifice / Segment**			.... **Fluid**		
Tank Diameter:	0.762	meter	Fluid:	WATER	
Tank Radius:	0.381	r, meter	Specific Gravity:	1	
Chord Length:	0.6189214	c, meter	Density:	1000	kg/m^3
Opening Depth:	0.15875	H, rise, meter	Upstream Pressure:	6343.1767	P_1, Pa
Orifice Coefficient =	0.6	K_o	Downstream Pressure:	0	P_2, Pa



$$A := \frac{4 \cdot H^2}{3} \cdot \sqrt{\left(\frac{c^2}{4 \cdot H^2} + 0.392\right)}$$

A = 0.0687982 $meter^2$

$$W := 1.42 \cdot K_o \cdot A \cdot \sqrt{(P_1 - P_2) \cdot D}$$

W = 147.62838 kg/sec, or 531.4622 m^3/hr

Noncompressible Flow Thru A Perforated Screen - Find ΔP

SERVICE: Determination of Screen Pressure Drop
fluid: WATER

Flow Rate:	50000	W, lb/hr
=	100	gpm
Specific Gravity:	1.000	
Internal Diameter:	4	inches
Open Area:	21	%
impact velocity:	153	fpm

$$\Delta P = 5.910E-02 + -1.030E-02 \cdot \text{velocity} + 1.211E-04 \cdot \text{velocity}^2$$

ΔP = 1.339 in. Hg.

ΔP = 0.657 psig

Noncompressible Flow Thru A Perforated Screen - Find ΔP

SERVICE: Determination of Screen Pressure Drop
fluid: WATER

Flow Rate:	6.299894	W, kg/sec
=	22.679618	m^3/hr
Specific Gravity:	1.000	
Internal Diameter:	0.1016	meter
Open Area:	21	%
impact velocity:	46.623749	m/min

$$\Delta P = 5.910E\text{-}02 + -1.030E\text{-}02 \cdot velocity + 1.211E\text{-}04 \cdot velocity^2$$

ΔP = 33.976 mm Hg.

ΔP = 4.530 kPa

ORIFICE PLATES & FLANGES

SPEC NO:				SHT 1 of 8	
NO	BY	DATE	REVISION	DATE	REV
A	DMC	4/12/2002	Purchase	4/12/2002	A
				CONTRACT	
				BY	CHK	APPR
				DMC		

Orifice Plates / Orifice Flanges

1.	Plate Type :	Sanitary Orifice Plate			7.	Tap Type :	NA	
2.	Concentric :	✓	Other :		8.	Tap Size :	NA	
3.	Bore:	Maximum Rate : ✓	Nearest 1/8 in. Drill :		9.	Flange Type :	1-1/2" Sanitary Tri-Clamp	
4.	Material:	304SS :	316SS : ✓	Other :	10.	Material :	316 Stainless Steel	
5.	Ring Material & Type	Bonded Silicone (White) Plate Gasket			11.	Flanges :	Included :	By Others : ✓
6.	Mfr. & Model No.	Newman Model A80MP-XW			12.	Rating :		

GENERAL	13.	Tag Number	**FO-0526**	
	14.	Service	32% Sodium Hydroxide to V-1070	
		P&ID	X-26004.2LO	
	15.	Line Number	1-1/2"-CAUS-001-004	
FLUID DATA	16.	Fluid	32% Sodium Hydroxide	
	17.	Fluid State	Liquid	
	18.	Maximum Flow	4-GPM	
	19.	Normal Flow	2-GPM	
	20.	Pressure (max/norm)	29/11	
	21.	Temp (max/norm)	AMB	
	22.	Specific Gravity @ Base	1.34	
	23.	Operating Specific Gravity	1.34	
	24.	Supercomp. factor	NA	
	25.	Mol. Weight / Cp/Cv		
	26.	Operating Viscosity (cp)	30 CPS	
	27.	Quality % or °Superheat	NA	
	28.	Base Press. / Base Temp.	/ 68	
	29.	Differential Pressure	10.14-PSIG	
METER	30.	Type of Meter	NA	
	31.	Diff. Range - Dry	NA	
	32.	Seal sp. Gr. @ 60°F	NA	
	33.	Static Press. Range	NA	
	34.	Chart or Scale Range	NA	
	35.	Chart Multiplier	NA	
PLATE & FLANGE	36.	Beta = d/D	0.13686	
	37.	Orifice Bore Diameter	0.1875	
	38.	Line Size/Sched/I.D.	1-1/2" / Tube / 0.065 Wall Thk.	
	39.	Flange Rating	1-1/2" Sanitary Tri-Clamp	
	40.	Vent or Drain Hole	NA	
	41.	Plate Thickness	1/16"	
	42.	Manufacturer	Newman Sanitary Gasket Company	
	43.	Model No.	A80MP-XW	

Notes:

1.) Electropolish to 50 Ra
2.) Permanently Affix SS Tag. Use minimum 3/16" Lettering.
3.)
4.)

LIQUID	sp. gr.
ACETIC ACID 100%	1.050
ACETIC ACID 70%	1.010
ACETONE	0.789
AMMONIA 26%	0.905
AMMONIA 100%	0.682
BENZENE 26%	0.844
BLACK LIQUOR 50%	1.250
BLACK LIQUOR 63%	1.330
BLACK LIQUOR 68%	1.360
BRINE, CALCIUM CHLOF	1.230
BRINE, SODIUM CHLOR	1.190
CARBON DIOXIDE	1.102
CAUSTIC 20%	1.223
CAUSTIC 50%	1.530
CHLORINE LIQUID	1.467
DOWTHERM A	0.995
ETHANOL 100%	0.789
ETHANOL 40%	0.935
ETHANOL 95%	0.804
ETHYL CHLORIDE	0.923
ETHYLENE GLYCOL	1.110
FREON, R11	1.410
FREON, R12	1.170
FREON, R22	1.440
FUEL OIL #2	0.876
FUEL OIL #6	0.993
GASOLINE	0.751
GLYCEROL, 100%	1.260
HYDROCHLORIC 31.5%	1.159
ISOPROPYL ALCOHOL	0.785
KEROSENE	0.811
LUBE OIL MOBIL 634	0.884
METHANOL 100%	0.796
METHANOL 40%	0.937
METHANOL 90%	0.824
METHYL CHLORIDE	0.998
MULTITHERM PG-1	0.875
NITRIC ACID 60%	1.370
NITRIC ACID 95%	1.500
OIL, VEGETABLE HARDE	0.920
OIL, VEGETABLE UNHAF	0.880
SULPHUR DIOXIDE	1.434
SULPHURIC 110%, FUM	1.840
SULPHURIC ACID 60%	1.500
SULPHURIC ACID 98%	1.830
TOLUENE	0.862
TURPENTINE	0.864
WATER	1.000

Pipe Data Table			
nominal diameter	ID schd 10S	ID schd 40	ID schd 80
1/2	0.674	0.622	0.546
3/4	0.884	0.824	0.742
1	1.097	1.049	0.957
1 1/4	1.422	1.380	1.278
1 1/2	1.682	1.610	1.500
2	2.157	2.067	1.939
2 1/2	2.635	2.469	2.323
3	3.260	3.068	2.900
3 1/2	3.760	3.548	3.364
4	4.260	4.026	3.826
6	6.357	6.065	5.761
8	8.329	7.981	7.625
10	10.420	10.020	9.562
12	12.390	11.938	11.374
14	13.624	13.124	12.500
16	15.624	15.000	14.312
18	17.624	16.867	16.124
20	19.564	18.812	17.938
24	23.500	22.624	21.562