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President
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Content Based
Chemical Engineering

Rupture Disk Sizing Calculations, Pressure And Vacuum Relief

BASIS: Rupture Disc Sizing & Selection based on Calculation of Flow Through an Orifice

REFERENCES: Marks' Mechanical Engineers Handbook; Perry'S Chemical Engineers Handbook; Fluid Flow by Sabersky & Acosta; Asme Code, Sec. Viii, Div.1, Unfired Pressure Vessels; General Catalog, Rupture Disk And Safety Head Technology By Bs&B Safety Systems, Inc.

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.

The spreadsheets within this workbook cover three cases: pressure relief of liquid; pressure relief of gas/vapor; and vacuum relief by use of the gas spreadsheets.

1.) Enter identification at [C4].
2.) Enter fluid at [C5]. For fluids in the tables, use [=], then go to fluid name in gas or liquid table. For gas, "k" and "MW", or for liquid "sp. gr." are automatically looked up. If fluid is not in tables, directly enter the fluid name and properties at [G8], [G9] (for gas), and [G8] for liquid.
3.) Enter the mass flow at [C7]. Note for vacuum this is the total required air inflow.
4.) The orifice coefficient "Ko", at [C8], is set at .62, the ASME required value (NOTE: Comment Box).
5.) For pressure relief, enter MAP, or vacuum, MAV at [C9]. The MAV must be entered as a positive number.
6.) For pressure relief, allowable overpressure "OP", at [C10], defaults to 10%, the code allowable for a single device. Enter other code allowable overpressures, eg. 16% for multiple relief device installations or 20% for fire exposure venting, directly at [C10]. For vacuum relief "OP" is 0%.
7.) The disk inlet pressure, "P1", is calculated and shown at [C11]. Per ASME, for overpressure relief, this is the MAP plus the greater of allowable overpressure or 3 psi (4 psi for multi-device); for vacuum relief, "P1" is atmospheric (0 psig).
8.) The disk outlet pressure, "P2", appears at [C12] (Gas Spreadsheet). For pressure relief, default is atmospheric (0 psig). The code permits a minimal amount of piping without detail design, but if the disk has significant outlet piping, or flow is manifolded with others, the disk/piping "system" must be designed so allowable overpressure is not exceeded. For those situations enter the piping system backpressure directly at [C12], and check system design parameters. For vacuum relief, "P2" is the MAV rating below atmospheric.
9.) For gas or vacuum enter temperature at [C13].
10.) The required rupture disk area shows at [F16] (Liquid) & [F21] (Gas/Vacuum) . A recommended diameter based on schd. 40 pipe, shows at [B21] (Liquid) & [B27] (Gas & Vacuum). The calculated area is the net free area. Installations with vacuum support, etc., may require a larger disk. The recommended diameter table is based on typical BS&B disks.

Print out using direct EXCEL commands.

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The originator of these spreadsheet(s) specifically excludes all warranties, expressed or implied, as to the accuracy of the data and other information set forth and assumes NO liability for any losses or damage resulting from the use of the materials or application of the data.

Consistent with GOOD ENGINEERING PRACTICE, the burden rests with the USER of these spreadsheets to review ALL calculations, and assumptions. The USER IS FULLY RESPONSIBLE for the results or decisions based on calculations.

This Spreadsheet Requires MACROS to be ENABLED to ASSURE proper operation. See the Workbook Help Sheet for Additional Instructions on Use.

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04/24/04

RUPTURE DISK - PRESSURE RELIEF - LIQUID

SERVICE: FIRE EXPOSURE; METHANOL DRYER
FLUID: METHANOL 100%

Flow Rate, W:	6000	lb/hr	Flow:	15	Q, gpm
Orifice Coefficient:	0.62	Ko	Specific Gravity:	0.796	
MAP:	50.0	psig	Density:	49.670	lb/cu ft
Over Pressure:	10.0	%			
P1:	55.0	psig	P2:	5.0	psig

⋯ Area Calculation

$$A := \frac{W}{2410 \cdot K_o \cdot \sqrt{(P1 - P2) \cdot D}} = 0.08058 \text{ in}^2$$

Use 1/2 inch diameter disk; Area = 0.304 in², based on sch 40 pipe!

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04/24/04

RUPTURE DISK - PRESSURE RELIEF - LIQUID

SERVICE: FIRE EXPOSURE; METHANOL DRYER
FLUID: METHANOL 100%

Flow Rate, W:	0.7559873	kg/sec	Flow:	3.4190379	Q, m^3/hr
Orifice Coefficient:	0.62	Ko	Specific Gravity:	0.796	
MAP:	344737.9	Pa	Density:	796	kg/cu meter
Over Pressure:	10.0	%			
P1:	379211.6	Pa	P2:	34473.8	Pa

⋯ Area Calculation

$$A := \frac{W}{1.42 \cdot K_0 \cdot \sqrt{(P1 - P2) \cdot D}} = 5.2E\text{-}05 \ \text{meter}^2$$

Use 15 mm diameter disk; Area = 196.2 mm², based on sch 40 pipe!

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04/24/04

RUPTURE DISK - PRESSURE RELIEF - GAS

SERVICE: METHANOL DRYER - Over Pressure Protection
FLUID: AIR

Flow Rate, W:	42976	lb/hr	Volumetric Flow, W:	9550	scfm
Orifice Coefficient:	0.62	Ko	Spec Heat Ratio:	1.410	k
MAP:	0.0	psig	Molecular Weight:	28.97	MW
Over Pressure:	10.0	%	Specific Volume:	11.082	V1, cu ft/lb
Upstream, P1:	3.0	psig	Upstream abs:	17.7	P1a, psia
Downstream, P2:	-8.0	psig	Downstream abs:	6.7	P2a, psia
Temperature, T1:	70.0	ºF	Temperature abs:	529.6	T1a, ºR
Press Ratio:	0.3785	PR	Prcrit:	0.5266	
lambda:	1172	λ	crit lambda:	1172.165	

··· Area Calculation

$$A := \frac{W}{K_o \cdot \lambda \cdot \sqrt{\left(\frac{P1_a}{V_1}\right)}} = 46.79 \quad in^2$$

Use 8 inch diameter disk; Area = 50.03 in², based on sch 40 pipe!

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04/24/04

RUPTURE DISK - PRESSURE RELIEF - GAS

SERVICE: METHANOL DRYER - Over Pressure Protection
FLUID: STEAM

Flow Rate, W:	5.4148849	kg/sec	Volumetric Flow, W:	12.8289	Nm^3/s
Orifice Coefficient:	0.62	Ko	Spec Heat Ratio:	1.310	k
MAP:	344737.9	Pa	Molecular Weight:	18.04	MW
Over Pressure:	10.0	%	Specific Volume:	0.389	V1, m^3/kg
Upstream, P1:	379211.6	Pa	Upstream abs:	480537.0	P1a, Pa..abs
Downstream, P2:	34473.8	Pa	Downstream abs:	135799.1	P2a, Pa..abs
Temperature, T1:	150.5	ºC	Temperature abs:	423.6263	T1a, ºK
Press Ratio:	0.2826	PR	Prcrit:	0.5440	
lambda:	1142	λ	crit lambda:	1142.383	

··· Area Calculation

$$A := \frac{W \cdot 10^4}{5.88 \cdot K_o \cdot \lambda \cdot \sqrt{\frac{P1_a}{v_1}}} = 0.0117 \text{ meter}^2$$

Use 150 mm diameter disk; Area = 18638.7 mm², based on sch 40 pipe!

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RUPTURE DISK & HEAD

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

Rupture Disk

1.)	Disk Type :	Reverse Buckling Solid Metal
2.)	Design Code :	ASME
3.)	Basis for Selection :	Blocked Flow
4.)	Material :	Aluminum
5.)	Coating - Inlet / Outlet :	None
6.)	Manufacturer & Model No :	BS&B / RB-90

Safety Head

7.)	Assembly No :	RB-7R
8.)	Base Material :	Carbon Steel
9.)	Holddown Material	NA
10.)	Size :	3-Inch
11.)	Flange Rating :	150-LB ANSI
12.)	1/2 in. NPT Tap in Holddown Flange - Yes or No :	NA

GENERAL	13.)	Tag Number	**RD-0526**	
	14.)	Service	Compressed Air	
	15.)	P&ID	C-26002-23	
	16.)	Line Number	3"-CAGB-001-004	
FLUID DATA	17.)	Fluid	Compressed Air	
	18.)	Fluid State	Gas	
	19.)	Maximum Flow	22500-lb/hr	
	20.)	Normal Flow	NA	
	21.)	Pressure (max/norm)	135/90	
	22.)	Temperature °F(max/norm)	160/120	
	23.)	Specific Gravity @ Base	1	
	24.)	Operating Specific Gravity	1	
	25.)	Supercomp. factor	NA	
	26.)	Mol. Weight	29	
	27.)	Operating Viscosity (cps)	0.019 CPS	
	28.)	Quality % or °Superheat	NA	
	29.)	Constant Back Pressure	0-psig	
SERVICE	30.)	Relief: Primary or Secondary	Primary	
	31.)	Corrosive Agents	NA	
	32.)	Desired Burst Pressure	125-psig	
	33.)	Bursting Pressure Range	5%	
	34.)	Estimated Burst Press. @ 72 °F	118-125-psig	
	35.)	Vacuum: Operating / Max.	NA	
	36.)	Pressure: Static or Pulsating	Static	
VACUUM SUPPORT	37.)	Model #	NA	
	38.)	Material	NA	
	39.)	Quantity per Assembly	NA	
	40.)	Attached to Disc: Yes or No	NA	
OPTIONS	41.)	Studs & Nuts: Yes or No	No	
	42.)	Pre-assembly Screws: Yes or No	Yes	
	43.)	Pressure Gauge: Yes or No	No	
	44.)	Jack Screws: Yes or No	Yes	

Notes:

45.) _____

46.) _____

47.) _____

48.) _____

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LIQUID	G
AMMONIA 26%	0.890
AMMONIA 100%	0.682
BRINE 26%	1.190
CARBON DIOXIDE	1.102
CAUSTIC 3%	1.030
CAUSTIC 10%	1.100
CAUSTIC 20%	1.219
CAUSTIC 50%	1.525
CHLORINE	1.467
ETHANOL 40%	0.935
ETHANOL 95%	0.804
ETHANOL 100%	0.789
FUEL OIL #2	0.876
FUEL OIL #6	0.993
GASOLINE	0.751
HYDROCHLORIC 31.5%	1.159
ISOPROPYL ALCOHOL	0.785
KEROSENE	0.815
METHANOL 40%	0.937
METHANOL 90%	0.824
METHANOL 100%	0.796
NITROGEN	0.807
PHOSPHORIC 50%	1.335
PHOSPHORIC 75%	1.580
SULPHUR DIOXIDE	1.434
SULPHURIC 98%	1.830
TURPENTINE	0.864
VEGETABLE OIL	0.897
WATER	1.000

Pipe Data Table		
Index Sq. In.	Size (in)	Area Sq. In.
index	**size**	**area**
0.000	1/2	0.304
0.304	1	0.864
0.864	1 1/2	2.036
2.036	2	3.355
3.355	3	7.393
7.393	4	12.73
12.730	6	28.89
28.890	8	50.03
50.030	10	78.86
78.860	12	111.93
#####	14	135.28
#####	16	176.72
#####	18	223.68
#####	20	278.00
#####	24	402.07
#####		

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Gas/Vapor Properties		
GAS	k	MW
ACETIC ACID	1.150	60.05
ACETYLENE	1.260	26.00
AIR	1.410	28.97
AMMONIA	1.310	17.03
ARGON	1.670	39.90
BENZENE	1.118	78.11
BROMINE	1.320	159.83
BUTANE	1.094	58.10
CARBON DIOXIDE	1.304	44.01
CARBON DISULFIDE	1.210	76.13
CARBON MONOXIDE	1.404	28.01
CHLORINE	1.355	70.91
CHLOROFORM	1.150	119.39
CYANOGEN	1.256	52.02
CYCLOHEXANE	1.080	84.16
ESTERS; C16-0/C-18	1.200	297.00
ETHANE	1.220	30.00
ETHYL ALCOHOL	1.130	46.07
ETHYL CHLORIDE	1.130	64.50
ETHYL ETHER	1.080	74.12
ETHYLENE	1.255	28.00
FREON 11	1.110	137.40
FREON 114a	1.080	170.90
FREON 12	1.130	120.90
FREON 22	1.160	86.50
FUEL OIL (#2)	1.110	96.00
GASOLINE	1.054	86.00
HELIUM	1.660	4.00
HEPTANE	1.052	100.20
HEXANE	1.080	86.17
HYDROCHLORIC AC	1.410	36.47
HYDROGEN	1.410	2.02
HYDROGEN BROMID	1.420	80.92
HYDROGEN CHLORI	1.410	36.47
HYDROGEN CYANID	1.310	27.03
HYDROGEN IODIDE	1.400	127.91
HYDROGEN SULPHI	1.320	34.08
IODINE	1.300	253.84
ISOBUTANE	1.110	58.10
ISOPENTANE	1.076	72.10
MERCURY	1.670	200.60
METHANE	1.310	16.04
METHYL ACETATE	1.140	74.08
METHYL ALCOHOL	1.203	32.04
METHYL CHLORIDE	1.200	50.49
METHYL ETHER	1.110	46.07
NATURAL GAS	1.270	19.50
NEON	1.640	20.20
NITRIC OXIDE	1.400	30.01
NITROGEN	1.404	28.02
NITROUS OXIDE	1.303	44.02
OCTANE	1.046	114.22
OXYGEN	1.401	32.00
PENTANE	1.060	72.10
PHOSPHOROUS	1.170	30.97
POTASSIUM	1.770	39.10
PROPANE	1.150	44.10
PROPENE	1.140	42.10
SODIUM	1.680	22.99
STEAM	1.32	18.04
SULPHUR DIOXIDE	1.290	64.07
TOLUENE	1.090	92.13

PIPE TABLE - schd 40		
index	size	area
0.000	1/2	0.304
0.304	1	0.864
0.864	1 1/2	2.036
2.036	2	3.355
3.355	3	7.393
7.393	4	12.73
12.730	6	28.89
28.890	8	50.03
50.030	10	78.86
78.860	12	111.93
111.930	14	135.28
135.280	16	176.72
176.720	18	223.68
223.680	20	278.00
278.000	24	402.07
402.070		

ASME Steam Table - 1967	
Applicable from 0 - 850 psig	
Pressure, psig :	**3.0**
Pressure, psia :	17.7
Temperature, ºF :	221.4
Temperature, ºR :	681.0
Steam Enth, btu/lb :	1153.9
Water Enth, btu/lb :	189.6
Evap Enth, btu/lb :	964.3
Stm Spec Vol, ft^3/lb :	22.5117
Stm Density, lb/ft^3 :	0.0444
Water Density, lb/ft^3 :	59.571
Wtr Spec Vol, ft^3/lb :	0.01679
atio of Spec Heat, k :	1.317

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