



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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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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RUPTURE DISK - PRESSURE RELIEF - LIQUID
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**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 in<sup>2</sup>, based on sch 40 pipe!

RUPTURE DISK - PRESSURE RELIEF - LIQUID
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**SERVICE:** FIRE EXPOSURE; METHANOL DRYER

**FLUID:** METHANOL 100%

Flow Rate, W: 0.7559873 kg/sec	Flow: 3.4190379 Q, m <sup>3</sup> /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**

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

Use 15 mm diameter disk; Area = 196.2 mm<sup>2</sup>, based on sch 40 pipe!

## 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	°F	Temperature abs:	529.6	T1a, °R
Press Ratio:	0.3785	PR	Prcrit:	0.5266	
lambda:	1172	λ	crit lambda:	1172.165	

### ... Area Calculation

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

**Use 8 inch diameter disk; Area = 50.03 in<sup>2</sup>, based on sch 40 pipe!**

<b>RUPTURE DISK - PRESSURE RELIEF - GAS</b>
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**SERVICE:** METHANOL DRYER - Over Pressure Protection

**FLUID:** STEAM

Flow Rate, W:	5.4148849	kg/sec	Volumetric Flow, W:	12.8289	Nm <sup>3</sup> /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 <sup>3</sup> /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	°C	Temperature abs:	423.6263	T1a, °K
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 mm<sup>2</sup>, based on sch 40 pipe!

				<b>RUPTURE DISK &amp; HEAD</b>					
				SPEC NO:			SHT 1 of 1		
				NO	BY	DATE	REVISION		
				D	DMC	4/12/2002	Purchase		
			BY	CHK	APPR				
			DMC						
<b>Rupture Disk</b>				<b>Safety Head</b>					
1.)	Disk Type :	Reverse Buckling Solid Metal		7.)	Assembly No :	RB-7R			
2.)	Design Code :	ASME		8.)	Base Material :	Carbon Steel			
3.)	Basis for Selection :	Blocked Flow		9.)	Holddown Material	NA			
4.)	Material :	Aluminum		10.)	Size :	3-Inch			
5.)	Coating - Inlet / Outlet :	None		11.)	Flange Rating :	150-LB ANSI			
6.)	Manufacturer & Model No :	BS&B / RB-90		12.)	1/2 in. NPT Tap in Holddown Flange - Yes or No :	NA			
<b>GENERAL</b>	13.)	Tag Number	<b>RD-0526</b>						
	14.)	Service	Compressed Air						
	15.)	P&ID	C-26002-23						
	16.)	Line Number	3"-CAGB-001-004						
<b>FLUID DATA</b>	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						
<b>SERVICE</b>	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						
<b>VACUUM SUPPORT</b>	37.)	Model #	NA						
	38.)	Material	NA						
	39.)	Quantity per Assembly	NA						
	40.)	Attached to Disc: Yes or No	NA						
<b>OPTIONS</b>	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						
<b>Notes:</b>									
45.) _____									
46.) _____									
47.) _____									
48.) _____									

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	Size (in)	Area
Sq. In.		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
#####		

Gas/Vapor Properties			PIPE TABLE - schd 40			ASME Steam Table - 1967	
GAS	k	MW	index	size	area	Applicable from 0 - 850 psig	
ACETIC ACID	1.150	60.05	0.000	1/2	0.304	Pressure, psig :	<b>3.0</b>
ACETYLENE	1.260	26.00	0.304	1	0.864	Pressure, psia :	17.7
AIR	1.410	28.97	0.864	1 1/2	2.036	Temperature, °F :	221.4
AMMONIA	1.310	17.03	2.036	2	3.355	Temperature, °R :	681.0
ARGON	1.670	39.90	3.355	3	7.393	Steam Enth, btu/lb :	1153.9
BENZENE	1.118	78.11	7.393	4	12.73	Water Enth, btu/lb :	189.6
BROMINE	1.320	159.83	12.730	6	28.89	Evap Enth, btu/lb :	964.3
BUTANE	1.094	58.10	28.890	8	50.03	Stm Spec Vol, ft <sup>3</sup> /lb :	22.5117
CARBON DIOXIDE	1.304	44.01	50.030	10	78.86	Stm Density, lb/ft <sup>3</sup> :	0.0444
CARBON DISULFIDE	1.210	76.13	78.860	12	111.93	Water Density, lb/ft <sup>3</sup> :	59.571
CARBON MONOXIDE	1.404	28.01	111.930	14	135.28	Wtr Spec Vol, ft <sup>3</sup> /lb :	0.01679
CHLORINE	1.355	70.91	135.280	16	176.72	atio of Spec Heat, k :	1.317
CHLOROFORM	1.150	119.39	176.720	18	223.68		
CYANOGEN	1.256	52.02	223.680	20	278.00		
CYCLOHEXANE	1.080	84.16	278.000	24	402.07		
ESTERS; C16-0/C-18	1.200	297.00	402.070				
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 SULPHII	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					