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Content Based
Chemical Engineering

FIRE VENTING & THERMAL EXPANSION REQUIREMENTS

REFERENCES: NFPA 30 Flammable and Combustible Liquids Code & API PRACTICE 520, CHEMICAL PROCESS SAFETY: FUNDAMENTALS with APPLICATIONS, Prentice Hall International Series in the Physical and Chemical Engineering Sciences

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.

1.) Enter identification at [C4]
2.) Select the case as appropriate.
3.) Enter the venting pressures at appropriate cells. This is 121% of the MAP for API and ASME tanks and 2.5-psi maximum for UL-142 tanks.
4.) The fluid evaporation or expansion rates are reflected to size relief valves, rupture disks, vent lines, etc ...
5.) For fluids with **UNKNOWN** latent heats, the NFPA Handbook recommends sizing based on hexane's properties. For these fluids the Hexane vent rate is given in the liquid spreadsheet.
The wetted area of the tanks are calculated on the basis of 55 percent of the total exposed area of a sphere or spheroid, 75 percent of the total exposed area of a horizontal tank, 100 percent of the exposed shell and floor area of a rectangular tank, but excluding the top surface of the tank, and the first 30 ft (9 m) above grade of the exposed shell area of a vertical tank.

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04/17/04

Venting Of Liquid Filled Vessels - Fire Exposure

TANK: Bulk Alcohol Storage Tank #26

CASE: Horizontal Tank

Calculation Basis :	75% (shell + ends)		Fluid =	Alcohol, Isopropyl, (CH3)2CHOH	
Venting Pressure =	0.9	psi	Boiling Point =	179.6	temp, ºF
=	6205.27	Pa	=	82.0	temp, ºC
Length =	20.00	ft. or 6.10 meter	Latent Heat =	234.0	Btu/lb
Diameter =	20.00	ft. or 6.10 meter	=	544284	J/kg
			MW =	60.10	mol. weight

A = 1413.7 ft^2, or 131.3385 $meter^2$

Q = 963,400 · A^0.338

= 11184823 Btu/hr, or 11800660 kJ/hr

W = Q / L

= 47,798 lb/hr, or 6.022502 kg/sec

= 77,672 lb/hr, or 9.786565 kg/sec (using hexane sizing basis)

Orifice Calc

$$CFH = 60 \cdot \frac{W}{\left(4.5 \cdot \sqrt{\frac{M}{29}}\right)}$$

CFH = 442,704 scfh air

= 12,536 Nm^3/h air

NFPA Calc

$$CFH = 70.5 \cdot \left(\frac{Q}{L \cdot \sqrt{M}}\right)$$

CFH = 434,675 scfh air

= 12,309 Nm^3/h air

For Liquids using the Hexane Sizing Basis:

W = 589,899 SCFH air (based on hexane)

= 16,704 Nm^3/h air

04/17/04

Relief - Unwetted Vessel Surface - Fire Exposure

TANK: Air Receiver - Relief Rate Based on External Heat

CASE: Flat Bottom Tank on Grade Calc Basis : shell (to 30 ft elevation)

Height =	5.80	ft. or 70 in.	Fluid =	AIR	
=	1.768	meter	Gas Norm Temp =	90.0	Tn, ºF
Diameter =	2.00	ft. or 24 in.	=	32.2	Tn, ºC
=	0.610	meter	Gas Norm Pressure =	120.0	Pn, psig
Wall Temp =	1100.0	Tw, ºF	=	13.79	Pn, bar ga
=	593.3	Tw, ºC	C =	356.94	Gas Constant
Set Pressure =	200	P, psi	Discharge Coefficient =	0.953	K_D
=	13.79	P, bar ga	Relieving Pressure =	256.70 psia, or 17.70 bar ga	

· · Exposed Vessel Surface Area

A' = 36.4 ft^2, or 3.385615 $meter^2$

· · Safety Valve Factor (minimum = 0.01)

$$F' = \frac{0.1406}{C \cdot K_D} \cdot \frac{(T_w - T_1)^{1.25}}{T_1^{0.6506}}$$

F' = 0.0100

· · Gas Temperature @ Relieving Pressure, deg. R

$T_1 = P_1 \cdot T_n / P_n$

T_1 = 1048.14

· · Relief Area Required

$A = F' \cdot A' / P_1^{0.5}$

A = 0.023 sq. in, or 14.674 sq. mm

· · Relief Volume Required

W = 360 lb/hr -- or -- W = 0.045395 kg/sec

Relief - Hydraulic Expansion - Liquid Filled

Service: Shell & Tube Heat Exchanger - Water Trapped, Steam Heated

FLUID =	WATER		G =	1.00	specific gravity
Heat Input, H =	510,000	Btu/Hr.	Cp =	1.00	specific heat
=	538,081	kJ/hr	β =	0.000115	cubical expansion coefficient

the volumetric expansion rate is given as.....

$$Q = \beta \cdot H / (500 \cdot G \cdot C_p)$$

$$= \quad 0.12 \quad \text{gpm, or } 0.444 \text{ liter/min}$$

Drop-Down Calculation Information				
Case	**Selection**	**Area Calc**	**Calculation Basis**	**Measure**
Flat Bottom Tank on	Horizontal Tank	1256.6	shell (to 30 ft elevatio	Height =
Horizontal Tank		1413.7	75% (shell + ends)	Length =
Spherical Tank		691.2	55% shell	
Vertical Tank on Legs		1570.8	shell (to 30 ft elevatio	Height =
Selected				
	1413.7	75% (shell + ends)	Length =	

NFPA calc table			Trouton's Rule		
Area	**Q, Rate**	**Equation Basis**	**Calculation**		
0	400000	400,000	**Boiling Point :**	282.2	**°F**
20	28274334	20,000 · A		412.15	**°K**
200	12095182	199,300 · A^0.566	**MW :**	249.24	**mol. weight**
1000	11184823	963,400 · A^0.338	**L, BTU/lb :**	65.5	**latent heat**
2800	14090000	21,000 · A^0.82			

NAME	MW	°F, B.P.	L, BTU/lb
Acetaldehyde, C_2H_4O	44.05	43.6	251
Acetic Acid, CH_3COOH	60.05	244.6	174
Acetone, C_3H_60	58.08	128	239
Alcohol, Allyl, C_3H_6O	58.08	85.9	296
Alcohol, Amyl, $C_5H_{12}O$	88.15	244	176
Alcohol, Ethanol, SDA-23A 200 Proof	46.069	165	298.3
Alcohol, Ethanol, SDA-40-2 190 Proof	46.069	176.82	304
Alcohol, Ethanol, SDA-40-2 200 Proof	46.069	172.9	302.1
Alcohol, Ethanol, SDA-40B 190 Proof	46.069	176	303.56
Alcohol, Ethyl, C_2H_6O	46.069	172.4	369
Alcohol, iso-Butyl, $C_4H_{10}O$	74.12	224.6	203
Alcohol, Isopropyl, $(CH_3)_2CHOH$	60.1	179.6	234
Alcohol, Methyl, CH_4O	32.04	150.8	474
Alkyl Bromide, C12H25Br	249.24	282.2	65.5
Aniline, $C_6H_5NH_2$	93.12	363	198
Benzene, C_6H_6	78.11	176.3	169.4
Butyric Acid, $C_4H_8O_2$	88.11	122.8	205.2
Carbon Disulfide, CS_2	76.13	115.3	150.8
Decane, $C_{10}H_{22}$	142.29	346	110
Diamine, 1,3-cyclohexanedimethanamine	142.2	471	144
Dimethylamine, C_2H_7N	45.08	44.4	250
Epichlorohydrin, C_3H_5ClO	92.53	239	166.12
Ethyl Acetate, $C_4H_8O_2$	88.11	168.8	157
Fatty Alcohol, Neodol 23	194	500	110.4
Fuel Oil No.1	--	300+	70.19
Fuel Oil No.2	--	300+	75.68
Fuel Oil No.4	--	300+	79.76
Fuel Oil No.5	--	300+	84.92
Fuel Oil No.6	--	300+	88.45
Gasoline (Regular Grade)	96	158	142
Glycol, Diethylene, $C_4H_{10}O_3$	106.1	473.8	393
Glycol, Dipropylene $C_6H_{14}O_3$	134.2	450	257
Glycol, Ethylene, $C_2H_6O_2$	62.1	387	449
Glycol, Propylene $C_3H_8O_2$	76.1	369.3	379
Glycol, Tetraethylene, $C_8H_{18}O_5$	194.2	618.1	273
Glycol, Triethylene, $C_6H_{14}O_4$	150.2	550	270
Glycol, Tripropylene $C_9H_{20}O_4$	192.8	509.2	200
Hexane, C_6H_{14}	86.17	158	144
Maleic Anhydride, $C_4H_2O_3$	98.05	387	190
Methyl Acetate, $C_3H_6O_2$	74.08	63.7	155
MultiTherm 100, Flushing Fluid	242	550	91.8
MultiTherm 503, Heat Transfer Fluid	272	570	106
MultiTherm IG-2, Heat Transfer Fluid	440	780	85
MultiTherm Paratherm, HE Heat Xfer Fluid	443	779	62
MultiTherm Paratherm, NF Heat Xfer Fluid	350	650	70
MultiTherm PG-1, Heat Transfer Fluid	350	555	92
Naphthalene, $C_{10}H_8$	128.06	424.2	135.7
Propyl Alcohol, C_2H_7OH	60.09	86.2	299
Sulfur, S	32.06	279.2	651.6
Toluene, C_7H_8	92.13	230.5	150.3
Turpentine	--	309.2	133.3
Vinyl Acetate,$C_4H_6O_2$	86.09	161.6	159.2
Water, H_2O	18.015	212	970.3
Xylene, C_8H_{10}	106.168	288	147

Drop-Down Calculation Information				
Case	**Selection**	**Area Calc**	**Calculation Basis**	**Measure**
Flat Bottom Tank on Gr	Flat Bottom Tank on Gr	36.4	shell (to 30 ft elevation)	Height =
Horizontal Tank		32.0	75% (shell + ends)	Length =
Spherical Tank		6.9	55% shell	
Vertical Tank on Legs		39.6	shell (to 30 ft elevation)	Height =
Selected				
	36.4	shell (to 30 ft elevation)	Height =	

Gas	Formula	C
AIR		356.9
AMMONIA	NH3	347.9
ARGON	A	377.9
BENZENE	C6H6	328.7
BUTANE	C4H10	326.1
CARBON DIOXIDE	CO2	347.4
CARBON MONOXIDE	CO	356.4
CHLORINE	CL2	352.0
CYCLOHEXANE	C6H12	324.6
ETHANE	C2H6	339.2
ETHYL ALCOHOL	C2H5OH	330.0
ETHYLENE	C2H4	342.7
FREON 11	F-11	327.8
FREON 114a	F-12	324.6
FREON 12	F-22	330.0
FREON 22	F-114a	333.1
HELIUM	He	377.1
HEPTANE	C7H16	321.4
HEXANE	C6H14	324.6
HYDROCHLORIC ACID	HCl	356.9
HYDROGEN	H2	356.9
HYDROGEN BROMIDE	HBr	357.8
HYDROGEN SULPHIDE	H2S	348.8
ISOPENTANE	C5H12	324.1
METHYL ALCOHOL	CH3OH	337.5
METHYL CHLORIDE	CH3Cl	337.2
NATURAL GAS	typical	344.1
NITROGEN	N2	356.4
NITROUS OXIDE	N2O	347.3
OCTANE	C8H18	320.7
OXYGEN	O2	356.1
PENTANE	C5H12	322.3
PROPANE	C3H8	332.1
SULPHUR DIOXIDE	SO2	346.0
TOLUENE	C6H5CH3	325.7

NFPA calc table		
Area	**Q, Rate**	**Equation Basis**
0	400000	400,000
20	728849.5	20,000 · A
200	1525377.5	199,300 · A^0.566
1000	3248105.3	963,400 · A^0.338
2800	400624.72	21,000 · A^0.82

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ased on the followinç

$$C := 520 \cdot \sqrt{k \cdot \left(\frac{2}{k+1}\right)^{\left(\frac{k+1}{k-1}\right)}}$$

k	C
1.29	346

Liquid	sp. gr.	sp. heat	b
ACETIC ACID	1.050	0.450	0.001071
AMMONIA 100%	0.770	1.107	0.001360
AMMONIA 26%	0.905	1.000	0.001360
BENZENE	0.844	0.410	0.001240
CARBON DIOXIDE	1.102	0.440	0.007780
CARBON DISULFIDE	1.290	0.280	0.001218
ETHANOL 100%	0.789	0.600	0.001120
ETHYLENE GLYCOL	1.117	0.569	0.000638
FORMIC ACID	1.230		0.001025
FREON, CCL2F2	1.547	0.211	0.001460
FUEL OIL #2	0.876	0.440	
FUEL OIL #6	0.993	0.400	
GASOLINE	0.751	0.530	
GLYCERIN	1.260	0.584	0.000510
HYDROCHLORIC 31.5%	1.159	0.600	0.000455
METHANOL 100%	0.796	0.650	0.001200
METHYL ACETATE			0.001427
METHYL FORMATE			0.001563
RAPESEED OIL	0.910		0.000500
SULPHUR DIOXIDE	1.434	0.325	0.001080
SULPHURIC ACID 98%	1.830	0.350	0.000450
TOLUENE	0.870		0.001099
TURPENTINE	0.864	0.420	0.000970
VEGETABLE OIL	0.920		0.000721
WATER	1.000	1.000	0.000115
?	?		