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Content Based Chemical Engineering

Vent Sizing For Vessels

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.

- Steam Condensing on Tank Surfaces

BASIS: Necessary air inflow through the vent must be sufficient to replace the volume of steam condensed within the tank.

This spreadsheet covers three cases:

Case A: - Cylindrical Tank, Steam Condensing on Roof and Shell
Case B: - Cylindrical Tank, Steam Condensing on Roof, Shell, and Bottom
Case C: - General Case, Steam Condensing on Tank Surface

1.) Enter the identification at [C4].
2.) Use the drop-box to select the case, A, B, or C.
3.) Enter tank MAV at [D7].
4.) For Cases A and B: enter height at [D8] and diameter at [D9]. For Case C: enter total condensing area at [D14].
The required vent area is indicated at C25, add this to any other venting requirements. Note that this area is valid for 'natural' reliefs only (short nozzles). For long or complex vents, eg. with a vapor seals the required air inflow rate for this hazard is shown at F31. This rate can be used with the DARCY spreadsheets to determine appropriate piping size, etc...

- Cold Water Spray - Steam Condensing

BASIS: This spreadsheet allows for input of a varying degrees of minimum water temperatures used for rinsing tanks such as used in CIP operations. Venting considerations of a "cold summer" rain shower on exterior surfaces are also a consideration of needed air inflow.

1.) Enter the identification at [C4].
2.) Enter tank MAV at [C6].
3.) Enter the MINIMUM POSSIBLE water temperature at [F6] (consider winter water temperatures).
4.) Enter water mass spray rate at [F7] the equivalent volumetric rate is reflected at [F8].
The required vent area is indicated at E18, add this to any other venting requirements. Note that this area is valid for 'natural' reliefs (short nozzles) only. For long or complex vents, eg. with a vapor seals the required air inflow rate for this hazard is shown at F26. This rate can be used with the Darcy spreadsheet to determine appropriate piping size, etc...

- Vacuum Hazard from Draindown & Pumpout

BASIS: Drain valves are calculated as liquid orifices, the vent area is calculated using the an orifice coefficient of 0.60 (equivalent of a short nozzle).

1.) Enter identification at [C4].
2.) Enter MAV at [C6].
3.) Enter tank maximum liquid height at [C7].
4.) Enter fluid at [G6].
5.) Enter specific gravity at [G7].
6.) Enter drain valve "Ko" at [G11] if different from 0.8.
7.) Enter the inside diameter for each drain at [D14]....[D18] (see piping table).
8.) Enter pump names/reference at [C24]....[C28] and their maximum flows [G24]..[G28].
The required vent area is indicated at F38, add this to any other venting requirements. Note that this area is valid for 'natural' reliefs (short nozzles) only. For long or complex vents, eg. with a vapor seals the required air inflow rate for this hazard is shown at F47. This rate can be used with the Darcy spreadsheet to determine appropriate piping size, etc...

- Tank Venting for Gas & Liquid Inflows

BASIS: The program sizes a natural relief for gas inflow, plus the gas displaced by liquid inflows; NOT for combined gas/liquid flow through the vent. An adequate overflow is assumed.

1.) Enter identification at [C4].
2.) Enter MAP at [C6].
3.) Enter allowable overpressure at [F6].
4.) Enter gas name at [C14], or " = " and schroll down to the appropriate gas in the lookup table starting at cell [E49].
5.) Enter the mass flow rate, at [C15]. The molecular weight (mw), specific heat ratio (k), are automatically added from the lookup table, if the fluid was listed.
6.) Input the temperature at [C16]. If the fluid is steam the spreadsheet will determine temperature. The specific volume will be calculated and shown at [G15].
7.) Enter Ko at [G10], use the Comment Box info to select Ko.
8.) Enter liquid name at [C24], or " = " and schroll down to the appropriate liquid in the lookup table starting at cell [A49].
9.) Enter the mass flow rate at [C25] the volumetric rate is calculated and reflected at [C26]. The specific gravity is automatically added from the lookup table, if the fluid was listed. The volumetric flow is calculated and shown at [F18].

NOTE: The gas displaced by liquid is calculated and shown at [E30], and the total vent flow at [E35]. This total flow may be used with DARCY for complex or piped vent arrangements.
The required vent area shows at [F39], and its diameter at [G41]. A recommended vent size based on schd 40 pipe is shown at [C44].

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

Print out using direct EXCEL commands.

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Tank Vent Requirement - Steam Condensation on Tank Surface

TANK: Hot Water Vessel, VE-8002

CASE: Steam Condensing on Roof, Shell, and Bottom

MAV =	3.000	psi		
Height =	132.0	inches or	11.00	ft.
Diameter =	96.0	inches or	8.00	ft.

Ab =	50	ft^2	bottom area assumed flat
Ar =	50	ft^2	roof area assumed flat
As =	276	ft^2	shell surface area
Acond =	377	ft^2	total condensing area

····· vent sizing ·····

P1a =	14.7	psia	P2a/P1a =	0.796	
P2a =	11.7	psia	lambda =	965	for Air
			for (P2a/P1a < .975)		

d = 2.8·(Acond/lambda)^0.5

d = 1.75 in.

Av = 2.404799 in^2 required vent area

····· required air inflow ·····

$$W := K_o \cdot A \cdot \lambda \cdot \sqrt{\left(\frac{P1_a}{V_1}\right)} = 1463 \text{ lb/hr}$$

04/25/04

Tank Vent Requirement - Steam Condensation on Tank Surface

TANK: Hot Water Vessel, VE-8002

CASE: Steam Condensing on Roof and Shell

MAV =	20684	Pa		
Height =	3352.8	millimeter or	3.3528	meter
Diameter =	2438.4	millimeter or	2.4384	meter

Ar =	4.67	meter²	roof area assumed flat
As =	25.68	meter²	shell surface area
Acond =	30.35	meter²	total condensing area

····· vent sizing ·····

P1a =	101325	Pa.abs	P2a/P1a =	0.796	
P2a =	80641	Pa.abs	lambda =	965	for Air
			for (P2a/P1a < .975)		

d = 0.233 · (Acond/lambda)^0.5

d = 41.315379 millimeter

Av = 1340.644 millimeter² required vent area

····· required air inflow ·····

$$W := 5.88 \cdot K_o \cdot A \cdot \lambda \cdot \sqrt{\frac{P1_a}{v_1}} \cdot 10^{-4} \quad = 0.1593 \text{ kg/sec}$$

Tank Vent Requirement - Cold Water Spray

TANK: Final Mix Tank - HAZARD 7

MAV =	0.87	psig	Tw =	48	ºF, minimum cold temp
=	13.826	psia	W =	15000	lb/hr, spray rate
Tsat =	209.2398	ºF	Q =	30.00	gpm, spray rate
			ΔT =	161.23984	ºF, temp differential

····· vent sizing ·····

P1a =	14.7	psia
P2a =	13.83	psia
P2a/P1a =	0.941	
λ =	569	

$$A := \left(\frac{0.002439 \cdot \Delta T \cdot W}{\lambda}\right) = 10.371977 \text{ in}^2$$ required vent area

this area = 3.634 in. diameter

····· required air inflow ·····

$$W := K_o \cdot A \cdot \lambda \cdot \sqrt{\left(\frac{P1_a}{V_1}\right)} = 3716.5419 \text{ lb/hr}$$

Tank Vent Requirement - Cold Water Spray

TANK: Final Mix Tank - HAZARD 7

MAV =	5998.4	Pa	Tw =	8.89	ºC, minimum cold temp
=	95326.6	Pa..abs	W =	1.890	kg/sec, spray rate
Tsat =	100.5722	ºC	Q =	6.80	m^3/hr, spray rate
			ΔT =	91.68	ºC, temp differential

····· vent sizing ·····

P1a =	101325	Pa..abs
P2a =	95326.561	Pa..abs
P2a/P1a =	0.941	
λ =	569	

$$A := \left(\frac{0.0225 \cdot \Delta T \cdot W}{\lambda}\right) = 6854.4438 \ mm^2$$ required vent area

this area = 93.420 mm diameter

····· required air inflow ·····

$$W := 5.88 \cdot K_o \cdot A \cdot \lambda \cdot \sqrt{\frac{P1_a}{v_1}} \cdot 10^{-4} = 0.4798993 \text{ kg/sec}$$

04/25/04

Vacuum Hazard - From Drain Down and Pump Out

VESSEL : Brine Tank; 50-D-90226

MAV:	0.2	psi	Fluid:	BRINE, CALCIUM CHLORIDE 25%	
Liquid Height:	100	inches or 8.33 feet	Sp Gr:	1.230	specific gravity
Liquid Head:	4.437	psi, liquid	Density:	76.752	lb/cu ft

····· for drains ····· Ko = 0.8

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

drain #1:	1.610	in.Ø ---------------- W_1 :	72435.165	lb/hr
drain #2:	0.000	in.Ø ---------------- W_2 :	0	lb/hr
drain #3:	0	in.Ø ---------------- W_3 :	0	lb/hr
drain #4:	0	in.Ø ---------------- W_4 :	0	lb/hr
drain #5:	0	in.Ø ---------------- W_5 :	0	lb/hr
			72435.165	total lb/hr

SUB TOTAL - DRAINS : 117.8 gpm, drains

····· for pumps ·····

pump #1:	Brine Regeneration Pump	--------- Q_1 :	100	gpm
pump #2:		--------- Q_2 :	0	gpm
pump #3:		--------- Q_3 :	0	gpm
pump #4:		--------- Q_4 :	0	gpm
pump #5:		--------- Q_5 :	0	gpm

SUB TOTAL - PUMPS : 100 gpm, pumps

TOTAL OUTFLOW : 217.78076 gpm

····· required vent area to relieve draindown/pumpout

Ko = 0.6

$$A := GPM \cdot 0.075 \cdot \frac{60}{\left[\frac{7.48}{\left[\frac{2410}{\left(\frac{Ko}{\sqrt{MAV \cdot 0.075}}\right)}\right]}\right]} = 0.740 \ \text{in}^2$$

or, Ø = 0.971 inch diameter

····· required air inflow ·····

$$W := K_o \cdot A \cdot \lambda \cdot \sqrt{\left(\frac{P1_a}{V_1}\right)} = 130.2351 \ \text{lb/hr}$$

Vacuum Hazard - From Drain Down and Pump Out

VESSEL : Brine Tank; 50-D-90226

MAV:	1378.9515	Pa	Fluid:	BRINE, CALCIUM CHLORIDE 25%	
Liquid Height:	2540	mm or 2.54 meter	Sp Gr:	1.230	specific gravity
Liquid Head:	30637.936	Pa, liquid	Density:	1230	kg/cu meter

····· for drains ·····

Ko = 0.8

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

drain #1:	40.94	- mmØ -------------- W_1 :	9.180	kg/sec
drain #2:	0	· mmØ -------------- W_2 :	0.000	kg/sec
drain #3:	0	· mmØ -------------- W_3 :	0.000	kg/sec
drain #4:	0	- mmØ -------------- W_4 :	0.000	kg/sec
drain #5:	0	· mmØ -------------- W_5 :	0.000	kg/sec
			9.1800743	total kg/sec

SUB TOTAL - DRAINS : 26.86851 m^3/hr, drains

····· for pumps ·····

pump #1:	Brine Regeneration Pump	--------- Q_1 :	22.712471	m^3/hr
pump #2:		--------- Q_2 :	0	m^3/hr
pump #3:		--------- Q_3 :	0	m^3/hr
pump #4:		--------- Q_4 :	0	m^3/hr
pump #5:		--------- Q_5 :	0	m^3/hr

SUB TOTAL - PUMPS : 22.712471 m^3/hr, pumps

TOTAL OUTFLOW : 49.580981 m^3/hr

····· required vent area to relieve draindown/pumpout

Ko = 0.6

$$A := \frac{m^3}{hr} \cdot 1.20 \cdot 1000 \cdot \frac{1000}{\left[\frac{3600}{\left[\frac{1.42}{\left[\frac{K_o}{\left(\sqrt{MAV \cdot 1.20}\right)}\right]}\right]}\right]} = 476.858 \ mm^2$$

or, Ø = 24.641 mm diameter

····· required air inflow ·····

$$W := 5.88 \cdot K_o \cdot A \cdot \lambda \cdot \sqrt{\frac{P1_a}{v_1} \cdot 10^{-4}} = 0.0164061 \text{ kg/sec}$$

Tank Venting Requirements For Gas and Liquid Inflows

SERVICE: 50% CAUSTIC STORAGE TANK VENTING FROM AIR BLOW

MAP =	1.00	psig	% OP =	10.0	over pressure
P1 =	1.100	psig	P1a =	15.800	psia
P2 =	0.000	psig	P2a =	14.696	psia
			Ko =	0.8	

..... **compressible inflow** .....

Fluid:	STEAM				
Mass Flow Rate:	14675	W, lb/hr	$\upsilon 1$ =	14.41	cu ft/lb
T1:	246.85	ºF	T1a =	706.4462	ºR
Ratio of Sp. Ht.:	1.32	k	PRcrit =	0.5430	
MW:	18.02	molecular wt.	λ =	612	
PR:	0.9301	pressure ratio	crit λ =	1144	

..... **noncompressible inflow** .....

Fluid:	WATER				
Mass Flow Rate:	25083	W, lb/hr	Sp. Gr.:	1.00	specific gravity
Volumetric Rate:	50.2	Q, gpm	Density:	62.40	lb/cu ft

$$W_L := \left(\frac{Q}{7.48}\right)\cdot\left(\frac{60}{\upsilon_1}\right) = 27.932848 \text{ lb/hr, gas displaced}$$

..... **required area** .....

$W_{tot} = W_g + W_L =$ 14703 lb/hr, total required vent flow

$$A := \frac{W_{tot}}{K_o \cdot \lambda \cdot \sqrt{\left(\frac{P1_a}{\upsilon_1}\right)}} = 28.65 \text{ in}^2$$

or 6.040 inch inside diameter

Use a 6 inch Schedule 40 or Equivalent Size Vent.

04/25/04

Tank Venting Requirements For Gas and Liquid Inflows

SERVICE: 50% CAUSTIC STORAGE TANK VENTING FROM AIR BLOW

MAP =	6894.76	Pa	% OP =	10.0	over pressure
P1 =	7584.233	Pa	P1a =	108909.23	Pa..abs
P2 =	0.000	Pa	P2a =	101325	Pa..abs
			Ko =	0.8	

····· compressible inflow ·····

Fluid:	STEAM				
Mass Flow Rate:	1.8490189	W, kg/sec	$\upsilon 1$ =	0.90	m^3/kg
T1:	119.36	ºC	T1a =	392.509	ºK
Ratio of Sp. Ht.:	1.32	k	PRcrit =	0.5430	
MW:	18.02	molecular wt.	λ =	612	
PR:	0.9304	pressure ratio	crit λ =	1144	

····· noncompressible inflow ·····

Fluid:	WATER				
Mass Flow Rate:	3.1604048	W, kg/sec	Sp. Gr.:	1.00	specific gravity
Volumetric Rate:	11.377457	Q, m^3/hr	Density:	1000.00	kg/m^3

$$W_L := 1.29 \cdot \left(\frac{Q}{3600} \right) \quad = 0.0040769 \text{ kg/sec, gas displaced}$$

····· required area ·····

$$W_{tot} = W_g + W_L = 1.8530958 \text{ kg/sec, total required vent flow}$$

$$A := \frac{\left(W_{tot} \cdot 10^4\right)}{5.88 \cdot K_O \cdot \lambda \cdot \sqrt{\left(\frac{P1_a}{v_1}\right)}} \quad = 18511.31 \text{ mm}^2$$

or 153.52 mm inside diameter

Use a 150 mm Schedule 40 or Equivalent Size Vent.

FLUID PROPERTIES	
liquid	spec. grav
ACETIC ACID 100%	1.050
ACETIC ACID 70%	1.010
ACETONE	0.789
AMMONIA 26%	0.905
AMMONIA 100%	0.682
BENZENE	0.844
BRINE, CALCIUM CHLORIDE 25%	1.230
BRINE, SODIUM CHLORIDE 25%	1.190
CARBON DIOXIDE	1.102
CAUSTIC 20%	1.223
CAUSTIC 50%	1.530
CHLORINE LIQUID	1.467
CONDENSATE	1.000
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 HARDENED	0.920
OIL, VEGETABLE UNHARDENED	0.880
SULPHUR DIOXIDE	1.434
SULPHURIC 110%, FUMING	1.840
SULPHURIC ACID 60%	1.500
SULPHURIC ACID 98%	1.830
TOLUENE	0.862
TURPENTINE	0.864
WATER	1.000

GAS PROPERITIES			
gas	chem	sp.ht. ratio	mw
ACETIC AC	CH3COOH	1.30	60.05
ACETYLEN	C2H2	1.30	26.00
AIR		1.40	28.97
AMMONIA	NH3	1.30	17.030
ARGON	A	1.40	39.90
BENZENE	C6H6	1.30	78.11
BROMINE	Br2	1.30	159.83
BUTANE	C4H10	1.30	58.10
CARBON D	CO2	1.30	44.010
CARBON D	CS2	1.30	76.13
CARBON M	CO	1.40	28.010
CHLORINE	CL2	1.30	70.910
CHLOROF	CHCl3	1.30	119.39
CYANOGEN	(CN)2	1.30	52.02
CYCLOHEX	C6H12	1.30	84.16
ETHANE	C2H6	1.30	30.00
ETHYL AL	C2H5OH	1.30	46.07
ETHYL CHL	C2H5CL	1.30	64.50
ETHYL ETH	(C2H5)2O	1.30	74.12
ETHYLENE	C2H4	1.30	28.000
FREON 11	F-11	1.30	137.40
FREON 114	F-114a	1.30	170.90
FREON 12	R-12	1.30	120.93
FREON 22	R-22	1.30	86.48
FREON HF	CH2FCF3	1.30	102.03
FUEL OIL (#2)		1.30	96.00
GASOLINE		1.30	86.00
HELIUM	He	1.40	4.00
HEPTANE	C7H16	1.30	100.20
HEXANE	C6H14	1.30	86.17
HYDROCH	HCl	1.40	36.47
HYDROGEN	H2	1.40	2.02
HYDROGEN	HBr	1.40	80.92
HYDROGEN	HCl	1.40	36.47
HYDROGEN	HCN	1.30	27.03
HYDROGEN	HI	1.40	127.91
HYDROGEN	H2S	1.30	34.08
IODINE	I2	1.30	253.84
ISOBUTAN	C4H10	1.30	58.10
ISOPENTAN	C5H12	1.30	72.10
MERCURY	Hg	1.40	200.60
METHANE	CH4	1.30	16.040
METHYL A	CH3COOCH	1.30	74.08
METHYL A	CH3OH	1.30	32.04
METHYL C	CH3Cl	1.30	50.49
METHYL E	(CH3)2 O	1.30	46.07
NATURAL	typical	1.30	19.50
NEON	Ne	1.40	20.20
NITRIC OX	NO	1.40	30.010
NITROGEN	N2	1.40	28.020
NITROUS (	N2O	1.30	44.020
OCTANE	O2	1.30	114.22
OXYGEN	O2	1.40	32.000
PENTANE	C5H12	1.30	72.10
PHOSPHOR	P	1.30	30.97
POTASSIU	K	1.40	39.10
PROPANE	C3H8	1.30	44.10
PROPENE	C3H6	1.30	42.10
SODIUM	Na	1.40	22.99
STEAM	H2O	1.32	18.020
SULPHUR D	SO2	1.30	64.070
TOLUENE	C6H5CH3	1.30	92.13

ASME Steam Table - 1967 (Keenan & Keyes)		
Applicable from 0 - 850 psig	Imperial	Metric
Pressure, gauge : psi | Pa	**13.83**	95326.9
Pressure, abs : psi | Pa	28.52	196651.9
Temperature : ºF | ºC	246.85	119.4
Temperature, abs : ºR | ºK	706.52	392.5
Steam Enthalpy : btu/lb|kJ/k	1162.9	4868.8
Water Enthalpy : btu/lb|kJ/k	215.4	901.8
Evap Enthalpy : btu/lb|kJ/k	947.5	3967.0
am Specific Volume : t^3/lb|m^3/kg	14.4060	0.8993
Steam Density : b/ft^3|kg/m	0.0694	1.1119
Water Density : b/ft^3|kg/m	58.875	943.080
ter Specific Volume : t^3/lb|m^3/kg	0.01699	0.00106
Ratio of Spec Heat : Cp/Cv	1.315	1.315

Pipe Size LookUp Table		
nom dia	ID sch 40	next ID
	0.001	3/4
1/2	0.622	3/4
3/4	0.824	1
1	1.049	1 1/4
1 1/4	1.38	1 1/2
1 1/2	1.61	2
2	2.067	2 1/2
2 1/2	2.469	3
3	3.068	3 1/2
3 1/2	3.548	4
4	4.026	6
6	6.065	8
8	7.981	10
10	10.02	12
12	11.938	14
14	13.124	16
16	15	18
18	16.867	20
20	18.812	22
22	21.25	24
24	23.25	26
26	25.25	28
28	27.25	30
30	29.25	32
32	31.25	34
34	33.25	36
36	35.25	VERY BIG