

Athlon Solutior Bayport Texas				Date: Revision:	05/01/19 A					Created By: hecked By:		
				B.P.	. Damile	0						
				Reliei	Requirements	Summary						
PSV Number	New PSV				D.	otected Eq	uinmont			I		
P&ID	New P&ID	<u> </u>	٦	Equipment #		quipment D		1	MAWP	ļ		
Set Pressure	30 psig		-	T-31		Storage				psig @	250	°E
Manufacturer	Consolidated		1	1-01		Otorage	Tank		30	psig @	230	°F
Model #	1905QC-32		1							psig @		°F
Orifice	P		1							psig @		°F
Area	6.380	Multivalve								P - 9 - C		
Style	Conventional	YES	1 '									
	•	•	Relief	R	equired Relief		Capacity	Inlet Pres	sure Loss	Outlet Pr	essure Loss	Mitigation
	Relief Condition		Description	Mass (lb/hr)	Volume (gpm)	Area (in ²)	(lb/hr)	(psi)	(%)	(psi)	(%)	required
01: Closed Ou	tlet on Vessels			, ,	(01 /	\	,	V /	0.00%		0.00%	
02: Cooling-wa	ater Failure								0.00%		0.00%	
03: Top-tower	Reflux Failure								0.00%		0.00%	
	n Reflux Failure								0.00%		0.00%	
	ailure to Absorber								0.00%		0.00%	
	ion of Noncondensable								0.00%		0.00%	
	of Highly Volatile Materi								0.00%		0.00%	
	Storage or Surge Vess	el							0.00%		0.00%	
	Automatic Control		Nitrogen	275		0.045	21,262		0.00%		0.00%	
10: Abnormal I	Heat or Vapor Input								0.00%		0.00%	
11: Split Excha									0.00%		0.00%	
12: Internal Ex 13: Chemical F			HCI	40.000		5.040	40.057	0.00	0.00% 0.29%		0.00% 1.23%	
14: Hydraulic E			пСі	12,932		5.912	13,957	0.09	0.29%	0.37	0.00%	
15: Exterior Fir			Product Vapor	40,756		7.621	34,121	0.20	0.67%	0.02		
	ure (steam, electric, air	r or other)	Floudet vapoi	40,730		7.021	34,121	0.20	0.00%	0.02	0.00%	
17: Inadverten	t Valve Operation	i, or other)							0.00%		0.00%	
18: Other	t valvo operation								0.00%		0.00%	
									0.00%		0.00%	
									0.00%		0.00%	
									0.00%		0.00%	
NOTES	eering, Management, &	Inconcetion	ooumon!									Rev 1.28.6a



thlon Solutions ayport Texas	Date: 05/01/19 Revision: A	Created By: DES Checked By: 0
	Calculation - Vapor Relief	
SV INFORMATION		
PSV Number: Vessel Item #	New PSV T-31	
Vessel Description:	Storage Tank	
Flow Sheet Reference #:	New P&ID	
Relieving State: Sizing Basis:	Vapor 13: Chemical Reaction	_
Sizing Dasis.	15. Offerfilear (Ceachoff	
PUTS		_
Flowrate, W (lb/hr) =	12932.3	
Relieving Temperature, T (deg F) =	212	
Allowable Overpressure =	10	<u> </u>
Ratio of Specific Heats, k =	1.38	$C = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$
Coefficient of the ratio of specific heats ⁽¹⁾ , C =	354.6	$C = 520\sqrt{k}\left(\frac{2}{k+1}\right)^{k-1}$
Compressibility Factor, Z =	1	γ (n+1)
Molecular Weight, M =	36.46	
Ratio of P_2/P_1 , $\mathbf{r} =$	0.3711	$F_2 = \sqrt{\left(\frac{k}{k-1}\right)(r)^{\frac{2}{k}} \left[\frac{1-r^{\frac{(k-1)}{k}}}{1-r}\right]}$
Coefficient of Subcritical Flow ⁽²⁾ , $\mathbf{F_2} =$	0.5733	$F_2 = \int \left \frac{\kappa}{k-1} \left (r) \right \right \frac{1-r}{1-r}$
Critical Flow Pressure Ratio ⁽³⁾ , $P_{cf} / P_1 =$	0.531	\\(\lambda^{\chi}\)
Set Pressure, P (psig) =	30	<u> </u>
PSV Type (conv, pilot, bellows) =	Conventional	<u> </u>
Back Pressure, P2 (psig) =	3	
Back Pressure Correction Factor, $\mathbf{K_b} =$	1.0	K _b =1.0 for conventional
Manufacturer Coefficient of Discharge ⁽⁵⁾ , $\mathbf{K_d}$ =	0.617	
		Kc=1.0 if rupture disk not installed, else 0.9,
Combination Correction Factor for Rupture Disks, K _c =	0.9	MFG not available
ALCULATIONS:		
Upstream Relieving Pressure: P ₁ (psig) =	33	Set Pressure + Allowable Overpressure
2 7		. 2
Critical Flow Area Calculation ⁽²⁾ , A =	5.912	in²
		$A = \frac{W}{CK_d P_1 K_b K_c} \sqrt{\frac{TZ}{M}}$
		- <i>a</i> 1 <i>b c</i> ·
Sub-critical Flow Area Calculation ⁽⁴⁾ , A =	Critical Flow	in ²
, , , , , , ,		
		$A = \frac{W}{735 * F_2 K_d K_c} \sqrt{\frac{ZT}{MP_1 (P_1 - P_2)}}$
		7 - 2 - d - c V 1(-1 - 2)
Available Orifice Area, $\mathbf{A_v}$ =	6.380	in²
Valve Maximum Flowrate = W * (Av / A)	13956.6	lbs/hr
	10000.0	



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		ontrol Valve Calculation - Vapor	
		milion valve Calculation - vapor	
PSV INFORMATION			
F3V INI OKWATION	PSV Number:	New PSV	
	Vessel Item #	T-31	
	Vessel Description:	Storage Tank	
	Flow Sheet Reference #:	New P&ID	
	Relieving State:	Vapor 09: Failure of Automatic Control	
	Sizing Basis:	09. Failure of Automatic Control	
0 1 11/1 0 1			
Control Valve Data	Occational Makes Nevertham	NI Niidon mani	
	Control Valve Number:	New Nitrogen	
	Manufacturer:		
	Model:	Y690A	
	Size:	1/8"	
	Flow Characteristic:	Linear	
INPUT DATA			
	Cg = 12.3	Gas Sizing Coefficient (from Valve	Manufacturer)
	MW = 29	Gas Molecular Weight	
	$C_1 = \frac{35}{}$	Ratio of gas to liquid sizing coefficion	ents (=Cg/Cv)
	T = 535 °R	Absolute Temperature of Gas at Inl	let (=°F+460)
	$P_1 = \frac{660}{164.7} \text{ ps}$	-	,
	$P_2 = \frac{47.7}{47.7} \text{ ps}$	is Valve Outlet Pressure (=psig 114.7)	,
)
	$Q_{N} = \frac{0}{10} lb/l$	hr Normal flow rate through the valve	
CALCULATED RESU	ILTS		
	$G = \underbrace{1.000}_{\text{deltaP}} = \underbrace{1.7}_{\text{ps}} \text{ps}$	Gas Specific Gravity = MW / 29	
	deltaP = 117 psi	i Pressure Drop Across Valve	
	(4)		
($Q_{SCFH}^{(1)} = 1979.1 SC$	CFH Vapor Relieving Requirement	
	0 0	$\sqrt{\frac{520}{G\times T}} \times P_1 \times \sin\left\{\pi \times \left(\frac{3417}{C_1} \times \sqrt{\frac{\Delta P}{P_1}}\right) \times \frac{1}{180}\right\} - \left\{\frac{520}{G\times T} \times P_1 \times \sin\left\{\pi \times \left(\frac{3417}{C_1} \times \sqrt{\frac{\Delta P}{P_1}}\right) \times \frac{1}{180}\right\}\right\} - \left\{\frac{520}{G\times T} \times P_1 \times \sin\left\{\pi \times \left(\frac{3417}{C_1} \times \sqrt{\frac{\Delta P}{P_1}}\right) \times \frac{1}{180}\right\}\right\}\right\}$	(2 379)
	$Q_{SCFH} = Cg_{\chi}$	$\frac{1}{G \times T} \times P_1 \times \sin(\pi \times \frac{\pi}{G}) \times \frac{\pi}{P} \times \frac{\pi}{180} \rightarrow \frac{\pi}{180}$	$\left(Q_{N}\overline{MW}\right)$
	'	$C_1 \qquad \left(\begin{array}{cc} C_1 & \gamma I_1 \end{array} \right) \text{ 189}$	(1/1111)
	82.29 °		
	<u>82.29</u> °	When this value equals or exceeds	
	82.29_°		s 90°, critical flow is indicated. This s then becomes unity since sin(90°) =1.
	<u>82.29</u> °		
		quantity must be limited to 90°. This	
	82.29 ° $Q_{LB/HR} = 151.4 b/l$	quantity must be limited to 90°. This	
		quantity must be limited to 90°. This	
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NOTES	Q _{LB/HR} = 151.4 lb/l	quantity must be limited to 90°. This	s then becomes unity since sin(90°) =1.
REFERENCES	Q _{LB/HR} = 151.4 lb/l	quantity must be limited to 90°. This	s then becomes unity since sin(90°) =1.
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REFERENCES	Q _{LB/HR} = 151.4 lb/l	quantity must be limited to 90°. This	s then becomes unity since $\sin(90^\circ)$ =1.

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Orifice Case SV INFORMATION PSV Number: Vessel Item #	alculation - Vapor Relief	
SV INFORMATION PSV Number:	alculation - vapor itchei	
PSV Number:		
	==./	
	New PSV T-31	
Vessel Description:	Storage Tank	
Flow Sheet Reference #:	New P&ID	
Relieving State: Sizing Basis:	Vapor 09: Failure of Automatic Con	trol
Oizing Dasis.	09. I allule of Automatic Con	
PUTS		_
Flowrate, W (lb/hr) =	151.4	
Relieving Temperature, T (deg F) =	100	
Allowable Overpressure =	10	<u> </u> %
Ratio of Specific Heats, k =	1.40	$\left(\begin{array}{ccc} 2 & \frac{k+1}{k-1} \end{array}\right)$
Coefficient of the ratio of specific heats ⁽¹⁾ , C =	356.1	$C = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$
Compressibility Factor, Z =	1	γ (<i>κ</i> +1)
Molecular Weight, M =	28	
Ratio of P_2/P_1 , $\mathbf{r} =$	0.3711	$ \left[\begin{pmatrix} k \end{pmatrix}, 2 \right] = \frac{(k-1)}{k}$
Coefficient of Subcritical Flow ⁽²⁾ , $\mathbf{F_2} =$	0.5771	$F_2 = \sqrt{\left(\frac{k}{k-1}\right)(r)^{\frac{2}{k}} \left[\frac{1-r^{\frac{(k-1)}{k}}}{1-r}\right]}$
Critical Flow Pressure Ratio ⁽³⁾ , P_{cf}/P_1 =	0.528	
Set Pressure, P (psig) =	30	<u></u>
PSV Type (conv, pilot, bellows) =	Conventional	
Back Pressure, P2 (psig) =	3	
Back Pressure Correction Factor, $\mathbf{K_b} =$	1.0	K _b =1.0 for conventional
Manufacturer Coefficient of Discharge ⁽⁵⁾ , $\mathbf{K_d}$ =	0.975	
	2.2	Kc=1.0 if rupture disk not installed, else 0.9,
Combination Correction Factor for Rupture Disks, K _c =	0.9	MFG not available
ALCULATIONS:		
Upstream Relieving Pressure: P ₁ (psig) =	33	Set Pressure + Allowable Overpressure
Critical Flow Area Calculation ⁽²⁾ , A =	0.045	in ²
		$A = \frac{W}{CK_d P_1 K_b K_c} \sqrt{\frac{TZ}{M}}$
		$CK_d I_1 K_b K_c \vee M$
Sub-critical Flow Area Calculation ⁽⁴⁾ , A =	Critical Flow	in ²
		$A = \frac{W}{}$
		$A = \frac{W}{735 * F_2 K_d K_c} \sqrt{\frac{ZI}{MP_1 (P_1 - P_2)}}$
Available Orifice Area, $\mathbf{A_v}$ =	6.380	in²
Valve Maximum Flowrate = W * (Av / A)	21261.5	lbs/hr
valve Maximum Howrate – W (AV/A)	21201.5	ID3/III



Date: 05/01/19 Created By: DES Revision: A Checked By: 0 Athlon Solutions Bayport Texas Fire Case Relief Requirement Calculation for Vessels - Adequate Drainage & Fire Fighting Equipment PSV INFORMATION **PSV Number:** New PSV T-31 Vessel Item # Vessel Description: Storage Tank Flow Sheet Reference #: New P&ID Relieving State: Vapor 15: Exterior Fire Sizing Basis: INPUTS Spherical Vessel Code: Vessel Orientation = H = Horizontal, V = Vertical, S = Spherical Number of Ends(Heads) = Number of Ends (Heads) exposed to the Fire. Type of Ends = F = Flat, H = Hemispherical, E = Elliptical 10.00 ft D = Vessel diameter HLL = 26.00 ft High liquid level Length of vessel, T/T $^{\left(1\right)}$ L= 26.00 ft 5 ft Vessel elevation Environmental factor⁽²⁾ F= 1.00 Latent Heat of Vap., λ = 122 btu/lb From process simulation calculations (at relieving conditions) CALCULATIONS Spherical Vessel, A_{Sws} = ____ ft² Total Wetted Area of a Spherical Vessel Per API 521 Spherical Vessel, A_{Sws} = Total Wetted Area of a Spherical Vessel Per API 2000 Effective liquid level (up to 25 ft from the flame source) E_{vertical} = 20.0 ft ⁽³⁾Total Wetted Area of a Vertical Vessel with FLAT Ends Vertical Vessel, A_{Vws} = ft² Vertical Vessel, A_{Vws} = (3)Total Wetted Area of a Vertical Vessel with HEMISPHERICAL Ends ft² 785.4 Vertical Vessel, A_{vws} = ft² (5) Total Wetted Area of a Vertical Vessel with ELLIPTICAL Ends E_{horizontal} = ft Effective liquid level (up to 25 ft from the flame source) ⁽³⁾Total Wetted Area of a Horizontal Vessel with FLAT Ends Horizontal Vessel, A_{Hws} = ft² (3)Total Wetted Area of a Horizontal Vessel with HEMISPHERICAL Ends Horizontal Vessel, A_{Hws} = Horizontal Vessel, A_{Hws} = (5)Total Wetted Area of a Horizontal Vessel with ELLIPTICAL Ends ft² $A_{ws} = 785 \text{ ft}^2$ Total wetted surface area $Q = 21,000*F*A_{...}^{0.82}$ Total heat absorption (input) to the wetted surface⁽⁴⁾ Q = 4,968,131 Btu/hr W = 40,756 lb/hr Required Relief Rate (=Q/λ) NOTES (1) This spreadsheets calculates the wetted area for a HORIZONTAL or VERTICAL vessel. ⁽²⁾ API STD 521, 5th edition, Table 6 "Environmental Factor", pg. 41 Wetted Surface Area Calculations taken from page VS22 in the Consolidated Relief Valve Databook, Valve Sizing Section. 4) API STD 521, 5th edition, "Heat Absorption to Liquids", Equation 6, pg. 40 (with adequate draining and firefighting equipment) ^[5] Wetted Surface Area Calculations taken from page 439 in the Pressure Vessel Handbook, 13th Ed. By Eugene F. Megyesy.

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on Solutions port Texas	Date: 05/01/19 Revision: A	Created By: DES Checked By: 0
	fice Calculation - Vapor Relie	
File Case Offi	ice Calculation - Vapor Relief	
INFORMATION	N. BOY	
PSV Number: Vessel Item #	New PSV T-31	
Vessel Description:	Storage Tank	
Flow Sheet Reference #:	New P&ID	
Relieving State:	Vapor	
Sizing Basis:	15: Exterior Fire	
UTS		
Flowrate, W (lb/hr) =	40755.8	
Relieving Temperature, T (deg F) =	459	
Ratio of Specific Heats, k =	1.06	$\left(\begin{array}{c}2\end{array}\right)^{\frac{k+1}{k-1}}$
Coefficient of the ratio of specific heats ⁽¹⁾ , C =	322.0	$C = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$
Compressibility Factor, Z =	1	V (K+1)
Molecular Weight, M =	126.6	
Ratio of P_2/P_1 , $\mathbf{r} =$	0.3471	<u> </u>
Coefficient of Subcritical Flow ⁽²⁾ , \mathbf{F}_2 =	0.4612	$F_{2} = \sqrt{\left(\frac{k}{k-1}\right)(r)^{\frac{2}{k}}} \left[\frac{1-r^{\frac{(k-1)}{k}}}{1-r}\right]$
Critical Flow Pressure Ratio ⁽³⁾ , $P_{cf} / P_1 =$	0.594	$\frac{1}{2}$ $\sqrt{(k-1)^{(r-1)}}$ $1-r$
Set Pressure, P (psiq) =	30	<u> </u>
, " "	-	
PSV Type (conv, pilot, bellows) =	Conventional	
Back Pressure, P2 (psig) =	3	/ =1 0 for conventional
Back Pressure Correction Factor, $\mathbf{K}_{b} = \mathbf{K}_{b}$	1.0	K _b =1.0 for conventional
Manufacturer Coefficient of Discharge ⁽⁵⁾ , $\mathbf{K_d}$ =	0.975	<u> </u>
Combination Correction Factor for Rupture Disks, $\mathbf{K_c}$ =	0.9	Kc=1.0 if rupture disk not installed, else 0. if MFG not available
.CULATIONS:		
Upstream Relieving Pressure: P ₁ (psig) =	36.3	Set pressure + 21% allowable overpressu
Critical Flow Area Calculation ⁽²⁾ , A =	7.621	in ²
Citical Flow Area Calculation , A -		$A = \frac{W}{CK_d P_i K_b K_a} \sqrt{\frac{TZ}{M}}$
		<i>u</i> 1 <i>v c</i>
Sub-critical Flow Area Calculation ⁽⁴⁾ , A =	Critical Flow	in ²
		$A = \frac{W}{735 * F_2 K_d K_c} \sqrt{\frac{ZT}{MP_1(P_1 - P_2)}}$
		$735*F_2K_dK_c \ VMP_1(P_1 - P_2)$
	6.380	in ²
Available Orifice Area, $\mathbf{A_v}$ =		
Available Orifice Area, $\mathbf{A_v}$ = Valve Maximum Flowrate = W * (Av / A)	34121.3	lbs/hr

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		INI ET DIDINO	CALCIII ATIO	ONIC			
let Piping Segments		INLET PIPING	CALCULATIO	JNS			
izing Basis:	Pipe Size (n	ominal diameter) =	8.00	inches			
5: Exterior Fire		side Diameter, d =	7.981	inches			
		Pipe Spec =					
		Pipe Schedule =	Sch 40				
	(5)Moody	Friction Factor, f =					
	ouy						
	Total Length o	f Straight Pipe, L =	1.0 ft				
		th of 90° Elbows =		# Elbows=		$L_{eq}/d = 30$	
(1)	Equivalent Length of 90° Lon	•		# Elbows=		$L_{eq}/d = 20$	
		gth of 45° Elbows =		# Elbows=		L _{eo} /d = 16	
	(1)Equivalent Length			# Tees=		$L_{eq}/d = 60$	
	(1)Equivalent Length			# Tees=		$L_{eq}/d = 20$	
		gth of Gate Valve=		# Valves=	1	$L_{eq}/d = 8$	
		ngth of Ball Valve =		# Valves=	-	$L_{eq}/d = 3$	
	(4)Equivalent Lengtl	•		K-factor=	0.37	1	
	(1)Equivalent Length			K-factor=	0.5	Crane pg. A-29	
		ength of Reducer =	30.1 ft	(6)K-factor=	0.63	Reduced id = $\frac{6}{100}$	065
		ength of Enlarger =		(6)K-factor=		Enlarged id =	
Other Fitting:		Equivalent Length=		# Fittings=		(8)Cv =	
Other Fitting:		Equivalent Length=		# Fittings=		L _{eq} /d =	
Tota	Equivalent Length of Valves		76.9 ft	as 8 in. pipe	:		
	,	3 / eq					
let Piping Stream Pro	perties						
Relief Rate of Liquid	or Vap Valve Capacity, W =	34,121	-				
	Set Pressure =	459	psig	040.0	0.00		
	Inlet Piping Temperature = Molecular Weight =		lb/lbmol	919.0	°K		
	Density in Inlet Line =	0.65	_				
	Viscosity in Inlet Line =	0.01					
(7)Reynolds	Number (Re) in Inlet Line =		Laminar flow occ	curs when Re	≤ 2000.)		
let Line Pressure Dro	o Calculation						
Total Equivalent Le	ngth (valves & fittings), L _{ea} =	76.9	ft	For valves ar	nd fittings ⁽²⁾ .		
rotar Equivalent Ee	Friction Factor, $f =$	0.014	-		•	3	
	r notion r dotor, r	0.014	-	$\Delta P = 0.00$	$0000336 \frac{f L_{eq}}{\rho a}$	₉ W ²	
To	otal Straight Pipe Length, L =	1.0	ft	psi — 0.00	ρa	l ⁵	
	on Factor (straight pipe), $f =$	0.014	-''	For valves ar			
	nside Diameter of Piping, d =	7.981	-			77.2	
"	iside blameter of ripling, d =	7.901	-""	$\Delta P_{\text{max}} = 0.0$	$0000336\frac{fL}{g}$	<u>v</u>	
				psi	ρ	l ⁵	
	Total Pressure Drop, ΔP _{psi} =	0.20		Note: Resista	nce coefficien		
ΔP _{psi} ,	Percent of Set Pressure =	0.67	- %\-"		, ,	r valves and fittings	
					f*(L/D) for stra	aight pipe	
OTES							
	Part II, Sect. 4.2.2, inlet pipir	na is not to exceed	a pressure drop of	f 3% of the se	et pressure		
ne current inlet piping		.g .eee exceed	a p. 000a. 0 a. op 0	. 0 /0 01 1110 01	r procouro.		
	•						
FERENCES							
Crane Co., "Flow of Flu	ids" Technical Paper No. 410), "Resistance Coe	fficients for Valves	and Fittings"	pages A-26 th	ru A-30	
Phil Leckner, "Equivale	nt Length of Valves and Fittir	igs in Pipeline Pres	sure Drop Calcula	tions" article	Cheresources.	com	
	ids" Technical Paper No. 410						
	on, "Typical K-factors for pipe for steel pipe, for all other pi					root Eriotics Foot	f
Crane Co., page A-26		pe material see Cra	ane pg. A-26 or pg	j. A-∠3, to det	ermine the cor	rect Friction Factor,	I.
	and 2-11. ids" Technical Paper No. 410) nages 1_6 thru 1	7 Friction factor	for straight ni	ne in laminar fl	nw is equal to 64/Da	.
	y combining Crane Co. Tech						··
	, same and the second			94440110 2" 1	. and 2.7 as 10		
0 1 00 11 10 11 0 11 0 12 0 1 0 1 0 1 0		I	д4				
or commence to Egg a s		$\frac{L_{eq}}{D} = 8^{\circ}$	$90.4256 \frac{d^4}{f * Cv^2}$				

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		INLET PIPING	CALCULATI	ONS			
let Piping Segments			_				
izing Basis:	Pipe Size (n	ominal diameter) =	8.00	inches			
3: Chemical Reaction	Pipe In	side Diameter, d =	7.981	inches			
		Pipe Spec =					
		Pipe Schedule =	Sch 40				
	⁽⁵⁾ Moody	Friction Factor, f =	0.014	-			
	Total Length o	f Straight Pipe, L =	1.0 ft				
	⁽¹⁾ Equivalent Lenç	gth of 90° Elbows =	·	# Elbows=		$L_{eq}/d = 30$	
⁽¹⁾ E	quivalent Length of 90° Lon	ig Radius Elbows =	:	# Elbows=		$L_{eq}/d = 20$	
	⁽¹⁾ Equivalent Lenç	gth of 45° Elbows =	:	# Elbows=		L _{eq} /d = 16	
	⁽¹⁾ Equivalent Length			# Tees=		$L_{eq}/d = 60$	
	(1)Equivalent Length			# Tees=		$L_{eq}/d = 20$	
		gth of Gate Valve=		- "	1	$L_{eq}/d = 8$	
		ngth of Ball Valve =		# Valves=		$L_{eq}/d = 3$	
	(4)Equivalent Length			='	0.37		
	(1)Equivalent Length				0.5	Crane pg. A-29	
		ength of Reducer =		-	0.63	Reduced id = 6.065	
011 5:11:	Equivalent Le	ength of Enlarger =		(6)K-factor=		Enlarged id =	
Other Fitting:		Equivalent Length=		# Fittings=		⁽⁸⁾ Cv =	
Other Fitting:	auivalent Langth of Values	Equivalent Length=		# Fittings=		L _{eq} /d =	
Total E	Equivalent Length of Valves	and Fittings, L _{eq} =	76.9 ft	as 8 in. pipe			
let Piping Stream Prope	erties						
Relief Rate of Liquid o	r Vap Valve Capacity, W =	13,957	lb/hr				
,	Set Pressure =		psig				
1	Inlet Piping Temperature =	212	°F	672.0	°R		
	Molecular Weight =	36.46	lb/lbmol				
	Density in Inlet Line =		lb/ft ³				
(7)Doymalda N	Viscosity in Inlet Line =	0.02	- '	ouro whon Do	< 2000)		
**Reynolds I	Number (Re) in Inlet Line =	041,911.32	(Laminar flow oc	curs when he	<u> </u>		
let Line Pressure Drop	Calculation						
Tatal Cardinalant Lana		70.0	_		(2)		
i otal Equivalent Leng	gth (valves & fittings), L _{eq} =	76.9	-	For valves ar	nd fittings(2):		
	Friction Factor, f =	0.014	<u>-</u>	AD 0.00	$f L_{eq}$	W^2	
T-4-	ol Charlant Dia a Laurath	4.0	_	$\Delta P_{psi} = 0.00$	$0000336 \frac{f L_{eq}}{\rho d}$	15	
	al Straight Pipe Length, L =	0.014	_π				
	Factor (straight pipe), f =			For valves ar		?	
IIISI	ide Diameter of Piping, d =	7.981	_in	$\Delta P = 0.0$	$0000336 \frac{fLV}{gg}$	<u>V - </u>	
				psi oro	ρa	l ⁵	
	tal Pressure Drop, ΔP_{psi} =	0.09	-' (0)	Note: Resista	ance coefficient		
ΔP _{psi} , P	Percent of Set Pressure =	0.29	<u></u> % ^(a)		$f T^*(L_{eq}/D)$ for	valves and fittings	
					f*(L/D) for stra	aight pipe	
OTES							
	art II, Sect. 4.2.2, inlet pipir	ng is not to exceed	a pressure drop	of 3% of the se	et pressure.		
Per API 520 5th Edition P	art II, Sect. 4.2.2, inlet pipir s adequate.	ng is not to exceed	a pressure drop o	of 3% of the se	et pressure.		
Per API 520 5th Edition P		ng is not to exceed	a pressure drop o	of 3% of the se	et pressure.		
Per API 520 5th Edition P		ng is not to exceed	a pressure drop o	of 3% of the se	et pressure.		
Per API 520 5th Edition P		ng is not to exceed	a pressure drop o	of 3% of the se	et pressure.		
Per API 520 5th Edition P		ng is not to exceed	a pressure drop o	of 3% of the se	et pressure.		
Per API 520 5th Edition P ne current inlet piping is		ng is not to exceed	a pressure drop o	of 3% of the se	et pressure.		
Per API 520 5th Edition P ne current inlet piping is EFERENCES	s adequate.					ru A 20	
Per API 520 5th Edition P ne current inlet piping is EFERENCES Crane Co., "Flow of Fluid	s adequate. s" Technical Paper No. 410), "Resistance Coe	fficients for Valve	s and Fittings"	pages A-26 th	ıru A-30	
he current inlet piping is EFERENCES Crane Co., "Flow of Fluid Phil Leckner, "Equivalent	s adequate. s" Technical Paper No. 410 Length of Valves and Fittir), "Resistance Coe	fficients for Valve	s and Fittings" ations" article	pages A-26 th	uru A-30 com	
Per API 520 5th Edition P ne current inlet piping is EFERENCES Crane Co., "Flow of Fluid Phil Leckner, "Equivalent Crane Co., "Flow of Fluid	s adequate. s" Technical Paper No. 410 Length of Valves and Fittir s" Technical Paper No. 410), "Resistance Coe igs in Pipeline Pres), "Pressure Drop in	fficients for Valve ssure Drop Calcul n Straight Pipe" p	s and Fittings" ations" article g. 3-2, Eq. 3-5	pages A-26 th	ıru A-30 com	
Per API 520 5th Edition P ne current inlet piping is EFERENCES Crane Co., "Flow of Fluid Phil Leckner, "Equivalent Crane Co., "Flow of Fluid API STD 521, 5th edition	s" Technical Paper No. 410 Length of Valves and Fittir s" Technical Paper No. 416 , "Typical K-factors for pipe), "Resistance Coe igs in Pipeline Pres), "Pressure Drop in fittings and reduce	fficients for Valve sure Drop Calcul n Straight Pipe" p ers", pg. 110 Tabl	s and Fittings" ations" article g. 3-2, Eq. 3-5 e 13 and Tabl	pages A-26 th Cheresources.	com	
Per API 520 5th Edition P ne current inlet piping is EFERENCES Crane Co., "Flow of Fluid Phil Leckner, "Equivalent Crane Co., "Flow of Fluid API STD 521, 5th edition	s" Technical Paper No. 410 Length of Valves and Fittir s" Technical Paper No. 410 , "Typical K-factors for pipe or steel pipe, for all other pi), "Resistance Coe igs in Pipeline Pres), "Pressure Drop in fittings and reduce	fficients for Valve sure Drop Calcul n Straight Pipe" p ers", pg. 110 Tabl	s and Fittings" ations" article g. 3-2, Eq. 3-5 e 13 and Tabl	pages A-26 th Cheresources.	com	
Der API 520 5th Edition P ne current inlet piping is EFERENCES Crane Co., "Flow of Fluid Phil Leckner, "Equivalent Crane Co., "Flow of Fluid API STD 521, 5th edition This calculation is valid for Crane Co., page A-26 an Crane Co., "Flow of Fluid Price	is" Technical Paper No. 410 Length of Valves and Fitti "Technical Paper No. 410 , "Typical K-factors for pipe or steel pipe, for all other pi tid 2-11. s" Technical Paper No. 410	o), "Resistance Coe ngs in Pipeline Pres o), "Pressure Drop in fittings and reduce pe material see Cr. o), pages 1-6 thru 1-	fficients for Valve sure Drop Calcul n Straight Pipe" p ers", pg. 110 Tabl ane pg. A-26 or p -7. Friction factor	s and Fittings" article g. 3-2, Eq. 3-5 e 13 and Tabl g. A-23, to det for straight pi	pages A-26 th Cheresources. is be 14 ermine the cor	rect Friction Factor, f.	
Per API 520 5th Edition P to current inlet piping is per current co., "Flow of Fluid Piping is per current co., "Flow of Fluid API STD 521, 5th edition This calculation is valid for Crane Co., page A-26 and Crane Co., "Flow of Fluid Crane Co., "Flow of Fluid Piping is per current cur	s" Technical Paper No. 410 Length of Valves and Fittir s" Technical Paper No. 410 , "Typical K-factors for pipe or steel pipe, for all other pi nd 2-11.	o), "Resistance Coe ngs in Pipeline Pres o), "Pressure Drop in fittings and reduce pe material see Cr. o), pages 1-6 thru 1-	fficients for Valve sure Drop Calcul n Straight Pipe" p ers", pg. 110 Tabl ane pg. A-26 or p -7. Friction factor	s and Fittings" article g. 3-2, Eq. 3-5 e 13 and Tabl g. A-23, to det for straight pi	pages A-26 th Cheresources. is be 14 ermine the cor	rect Friction Factor, f.	
Per API 520 5th Edition P to current inlet piping is per current co., "Flow of Fluid Piping is per current co., "Flow of Fluid API STD 521, 5th edition This calculation is valid for Crane Co., page A-26 and Crane Co., "Flow of Fluid Crane Co., "Flow of Fluid Piping is per current cur	is" Technical Paper No. 410 Length of Valves and Fitti "Technical Paper No. 410 , "Typical K-factors for pipe or steel pipe, for all other pi tid 2-11. s" Technical Paper No. 410	D, "Resistance Coe ngs in Pipeline Pres D, "Pressure Drop in fittings and reduce pe material see Cr. D, pages 1-6 thru 1- nical Paper No. 410	fficients for Valve sure Drop Calcul n Straight Pipe" p ers", pg. 110 Tabl ane pg. A-26 or p -7. Friction factor	s and Fittings" article g. 3-2, Eq. 3-5 e 13 and Tabl g. A-23, to det for straight pi	pages A-26 th Cheresources. is be 14 ermine the cor	rect Friction Factor, f.	

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			05/01/19			By: DES
thlon Solutions ayport Texas		Revision Relief Valve No.			Checked	і ву:
	OU	TLET PIPING	CALCULATIO	ONS		
utlet Piping Segments izing Basis:	Pino Sizo (n	ominal diameter) =	. 0	00 inches		
5: Exterior Fire	•	side Diameter, d =		81 inches		
0. <u>2</u> xt0.10 0	i ipe iii	Pipe Spec =		licies		
		Pipe Schedule =		40		
	(5)Moody	Friction Factor, f =				
				_		
		f Straight Pipe, L =			- 1	L _{eq} /d = 30
	(1)Equivalent Length of 90° Lon	th of 90° Elbows =		# Elbows	-	$L_{eq}/d = 30$ $L_{eq}/d = 20$
		g radius Elbows - ith of 45° Elbows -		# Elbows		L _{eq} /d = 16
	(1)Equivalent Length			# Tees		$L_{eq}/d = 60$
	(1)Equivalent Length			# Tees		L _{eq} /d = 20
	i	gth of Gate Valve		# Valves		$L_{eq}/d = 8$
		gth of Ball Valve =		# Valves	=	$L_{eq}/d = 3$
	⁽⁴⁾ Equivalent Length	•		K-factor	=	
	⁽¹⁾ Equivalent Le	ngth of Exit Loss =	47.6	6 ft K-factor	= 1	Crane pg. A-29
		ength of Reducer =		⁽⁶⁾ K-factor	=	Reduced id =
	Equivalent Le	ength of Enlarger =	·	⁽⁶⁾ K-factor	=	Enlarged id =
Other Fitting:		Equivalent Length		# Fittings		(9)Cv =
Other Fitting:		Equivalent Length		# Fittings		L _{eq} /d =
	Total Equivalent Length of Valves	and Fittings, L _{eq} =	67.6	6 ft as 8 in. pipe		
Outlet Piping Stream Prop	erties					
	Rate of Liquid or Vap Valve Capacity, W =	34,121	lb/hr			
	Relief Valve Set Pressure =		psig			
	(c)Header Pressure, P _H =	14.70			psig	
Datia	Outlet Piping Temperature, T = of Specific Heats at Outlet Conditions, k =	668	_°R	208.0	<u>0</u> °F	
Ratio	Gas Compressibility Factor, Z =	1.0000			.(W	$(ZT)^{0.5}$
	Gas Relative Molecular Weight, M =		lb/lbmol	$Ma_2 = 1.702$	$2x10^{-5}\left(\frac{W}{n}\right)$	$\frac{1}{2} \left(\frac{M}{M} \right)$
	(2)Mach Number at Pipe Outlet, Ma₂ =	0.205	_		$\langle P_H \alpha_H \rangle$	/ / /
	Set Outlet Line Outlet Pressure, P_o =	14.70	psia	If $Ma_2 < 1.0$,	$P_o = P_H$; how	vever, if Ma $_2$ > 1.0, set P $_o$ = P $_{cri}$
			_ _	1.6		
,	Liquid Density in Outlet Line, ρ _L =	0.19	lb/ft3	$\rho_V = \frac{pM}{2TR}$		
`	/apor Average Density in Outlet Line, ρ_V = Viscosity in Outlet Line =	0.01011	_lb/ft³ cp	ZIK		
	(8)Reynolds Number (Re) in Outlet Line =	2,668,370.94		occurs when Re	≤ 2000.)	
			·		· ·	
Outlet Line Pressure Drop						
T-4-1 F-	Critical absolute pressure, P _{crit} =		_psia _			et Ma 2=1.0 (sonic flow); if the
lotal Ed	uivalent Length (valves and fittings), $L_{eq} = Moody$ Friction Factor, $f = Moody$	67.6 0.014	_	the flow is su		the pipe outlet pressure then
	Line Diameter, d =	8.00	_	the now is sui	osonic.	
	Total Straight Pipe Length, L =	10.0	_	$P_{\text{res}} = 1.702x1$	$0^{-5} \left(\frac{W}{d^2} \right) \left(\frac{Z \cdot T}{M} \right)$	0.5
	Friction Factor (straight pipe), f =	0.014		eni	$d^2 \downarrow M$)
	Inside Diameter of Piping at Header, d_H =	7.981	in	Р -	⊦ P	
	Valve Design Backpressure Allowed =	10%	<u>, </u>	$P_{AVG} = \frac{P_o}{P_o}$	2	
	Max Back Pressure Allowed, P _B =	17.70	psia _	•	_	
Outlet L	ine Avg. Press. at Max BP Allowed, P _{AVG} =	16.20) psia ^(b)	$\Delta P = 0.00$	0000336 <i>fLW</i>	<u>V</u> ²
	(3)0 11 10: : 0 - : -			$\Delta I_{psi} = 0.00$	$0000336 \frac{fLW}{\rho d}$	5
2 1	⁽³⁾ Outlet Piping Pressure Drop, $\Delta P_{psi} =$) psi			
	culated Outlet Piping Back Pressure, BP _C =		psig (a)	$DP_c = \Delta$	$P_{PSI} + P_o$	- 14 . /
P	ressure Drop, Percent of Set Pressure =	2.3000%	<u> </u>			
	Force for Atmospheric Relief Valves, F=	188.03	<u>I</u> lbf	$F = \frac{W}{}$	$\frac{kT}{(k+1)M} + (A$	4P)
•	on is not applicable for non atmospheric			$r = \frac{1}{366} \sqrt{\frac{1}{366}}$	$(k+1)\overline{M}^{\top}$	·· ,
	relief devices)					
NOTES						
	sure drop not to exceed 10% of the set pres	ssure for convention	nal valves (API	STD 521. Sect	7.3.1.3 na. 103	3).
The current outlet piping is				, 5550.	29. 100	,
	Pressure, is used in calculating the outlet l	ine average densit	y, in order to me	ore closely repres	ent the fluid de	ensity in the outlet piping.
	segments, i.e., changes in diameter, the h					

1) Crane Co., "Flow of Fluids" Technical Paper No. 410, "Resistance Coefficients for Valves and Fittings" pages A-26 thru A-30

²⁾API STD 521, 5th edition, "Design of relief device discharging piping", pg. 105 Equation #28: Isothermal outlet Mach number

³⁾ Crane Co., "Flow of Fluids" Technical Paper No. 410, "Pressure Drop in Straight Pipe" pg. 3-2, Eq. 3-5

API STD 521, 5th edition, "Typical K-factors for pipe fittings and reducers", pg. 110 Table 13 and Table 14

5) This calculation is valid for steel pipe, for all other pipe material see Crane pg. A-26 or pg. A-23, to determine the correct Friction Factor, f.

³⁾ Crane Co., page A-26 and 2-11.

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⁷⁾ This calculation should be used as a reference only, a competent mechanical engineer should determine the required support design. API RP 520 Part II, 5th edition, Determining Reaction Forces" Section 4.4.1.1 - for any gas, vapor, or steam discharging to the atmosphere.

Drane Co., "Flow of Fluids" Technical Paper No. 410, pages 1-6 thru 1-7. Friction factor for straight pipe in laminar flow is equal to 64/Re.

⁹⁾ Cv converted to L_{ed}/d by combining Crane Co. Technical Paper No. 410 (08/11 Reprint) equations 2-11 and 2-4 as follows:

 $\frac{L_{eq}}{D} = 890.4256 \frac{d^4}{f * Cv^2}$



		Date:	05/01/19			Created By: DES	
thlon Solutions		Revision:				Checked By:	
ayport Texas		Relief Valve No.:	New PSV				
	OU.	TLET PIPING C	CALCULATI	ONS	3		
outlet Piping Segments							
sizing Basis:	Pipe Size (no	ominal diameter) =	8	3.00 i	inches		
3: Chemical Reaction	Pipe In:	side Diameter, d =	7.	981 i	inches		
		Pipe Spec =					
		Pipe Schedule =	Sch	h 40			
	⁽⁵⁾ Moody F	Friction Factor, f =	0.	014			
	Total Length of	Straight Pipe, L =	10	.0 ft			
	⁽¹⁾ Equivalent Leng			.0 ft	# Elbows=	$L_{eq}/d = 30$	
	(1)Equivalent Length of 90° Long				# Elbows=	L _{eq} /d = 20	
	(1)Equivalent Leng	•			# Elbows=	L _{eq} /d = 16	
	(1)Equivalent Length of				# Tees=	$L_{eq}/d = 60$	
	(1)Equivalent Length o				# Tees=	L _{eq} /d = 20	
		gth of Gate Valve=			# Valves=	$L_{eq}/d = 8$	
		gth of Ball Valve =			# Valves=	$L_{eq}/d = 3$	
	(4)Equivalent Length				K-factor=		
		ngth of Exit Loss =		.6 ft	K-factor=	1 Crane pg. A-29	
	Equivalent Le	ngth of Reducer =			(6)K-factor=	Reduced id =	
	Equivalent Le	ngth of Enlarger =			(6)K-factor=	Enlarged id =	
Other Fitting:		Equivalent Length=			# Fittings=	⁽⁹⁾ Cv =	
Other Fitting:		Equivalent Length=			# Fittings=	L _{eq} /d =	
	Total Equivalent Length of Valves	and Fittings, L _{eq} =	67	.6 ft	as 8 in. pipe		
Outlet Dining Streem Drenautics							
Outlet Piping Stream Properties Relief Rate of	Liquid or Vap Valve Capacity, W =	13,957	lh/hr				
rener reac or	Relief Valve Set Pressure =		psig				
	^(c) Header Pressure, P _H =	14.70				psig	
	Outlet Piping Temperature, T =	907	°R		447.00	°F	
Ratio of Spec	ific Heats at Outlet Conditions, k =	1.4					
	Gas Compressibility Factor, Z =	1.0000			$Ma_{*} = 1.702$	$\times 10^{-5} \left(\frac{W}{n_{vid_{vi}}^2} \right) \left(\frac{ZT}{M} \right)^{0.5}$	
	as Relative Molecular Weight, M =		lb/lbmol		2	$\left(p_H d_H^2\right) \left(M\right)$	
	lach Number at Pipe Outlet, Ma ₂ =	0.182			KM- 440.0		- 0
Se	t Outlet Line Outlet Pressure, P _o =	14.70	psia	,	If Ma ₂ < 1.0, P	$P_0 = P_H$; however, if Ma ₂ > 1.0, set P_0	, = P _{crit}
	Liquid Density in Outlet Line, $\rho_L =$		lb/ft3		nM		
Vapor A	verage Density in Outlet Line, $\rho_V =$	0.06	lb/ft ³		$\rho_V = \frac{pM}{ZTR}$		
	Viscosity in Outlet Line =	0.01703			2111		
⁽⁸⁾ Reyr	olds Number (Re) in Outlet Line =	647,942.20	(Laminar flov	v occ	urs when Re ≤	2000.)	
Outlet Line Pressure Drop Calcula	Critical absolute pressure, P _{crit} =	2.68	naia		Critical absolut	e pressure: set Ma ₂ =1.0 (sonic flow);	if the
Total Equivalent	Length (valves and fittings), L _{eq} =	67.6					
Total Equivalent	Moody Friction Factor, $f =$	0.014	-11		the flow is subs	e is less than the pipe outlet pressure t	nen
	Line Diameter, d =	8.00	in				
	Total Straight Pipe Length, L =	10.0	_		$P_{crit} = 1.702x10$	$J^{-5} \left(\frac{W}{d^2} \right) \left(\frac{Z \cdot T}{M} \right)^{0.5}$	
	Friction Factor (straight pipe), f =	0.014	_			$(d^2)(M)$	
Inside	Diameter of Piping at Header, d_H=	7.981	in		P +	P.,	
Valv	re Design Backpressure Allowed =	10%			$P_{AVG} = \frac{P_o + 1}{2}$	<u>- B</u>	
	Max Back Pressure Allowed, P _B =	17.70	psia		2		
Outlet Line Avg.	Press. at Max BP Allowed, P _{AVG} =	16.20	psia ^(b)		A.D. 0.000	fLW^2	
	-	<u> </u>			$\Delta r_{psi} = 0.000$	$000336 \frac{fLW^2}{\rho d^5}$	
	tlet Piping Pressure Drop, $\Delta P_{psi} =$	0.37	psi				
	Outlet Piping Back Pressure, BP _C =		psig		$BP_{c} = \Delta P$	$P_{PSI} + P_o - 14.7$	
Pressure	Drop, Percent of Set Pressure =	1.2333%	(a)				
(7)Reaction Force for	or Atmospheric Relief Valves, F=	163.53	lbf		_ W [kT	
(Reaction force calculation is no			-		$F = \frac{1}{366} \sqrt{\frac{1}{11}}$	$\frac{kT}{(k+1)M} + (AP)$	
relief de	vices)				200 Y (/	v j.es	
IOTES							
	not to exceed 10% of the set pres	cure for convention	nal valvae (AE	PL STI	D 521 Sect 7	3 1 3 ng 103)	
Outlet piping built-up pressure drop	•	sale for conventio	iiai vaives (Ai		D 021, 000t. 7.	0.1.0 pg. 100).	
he current outlet piping is adequ	ate.		·			ent the fluid density in the outlet piping.	

- ¹⁾Crane Co., "Flow of Fluids" Technical Paper No. 410, "Resistance Coefficients for Valves and Fittings" pages A-26 thru A-30
- ²⁾ API STD 521, 5th edition, "Design of relief device discharging piping", pg. 105 Equation #28: Isothermal outlet Mach number
- ³⁾ Crane Co., "Flow of Fluids" Technical Paper No. 410, "Pressure Drop in Straight Pipe" pg. 3-2, Eq. 3-5
- API STD 521, 5th edition, "Typical K-factors for pipe fittings and reducers", pg. 110 Table 13 and Table 14
- ⁵⁾ This calculation is valid for steel pipe, for all other pipe material see Crane pg. A-26 or pg. A-23, to determine the correct Friction Factor, f.
- ³⁾ Crane Co., page A-26 and 2-11.

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- ⁷⁾ This calculation should be used as a reference only, a competent mechanical engineer should determine the required support design. API RP 520 Part II, 5th edition, Determining Reaction Forces" Section 4.4.1.1 for any gas, vapor, or steam discharging to the atmosphere.
- Drane Co., "Flow of Fluids" Technical Paper No. 410, pages 1-6 thru 1-7. Friction factor for straight pipe in laminar flow is equal to 64/Re.

⁹⁾ Cv converted to L_{ed}/d by combining Crane Co. Technical Paper No. 410 (08/11 Reprint) equations 2-11 and 2-4 as follows:

 $\frac{L_{eq}}{D} = 890.4256 \frac{d^4}{f * Cv^2}$