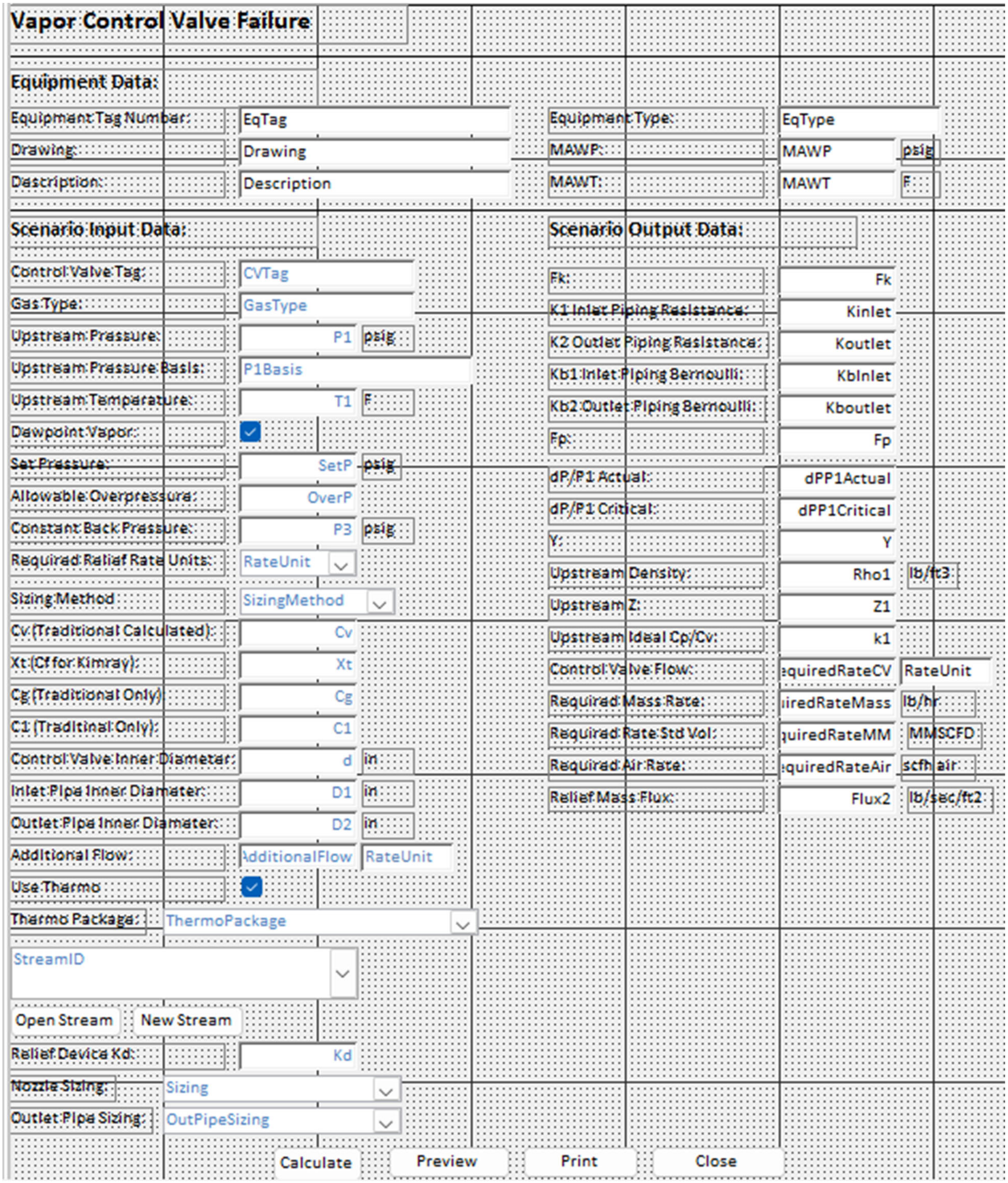
Vapor Control Valve Failure Open



Vapor Control Valve Failure

Equipment Data:

Equipment Tag Number:	EqTag	Equipment Type:	EqType
Drawing:	Drawing	MAWP:	MAWP psig
Description:	Description	MAWT:	MAWT F

Scenario Input Data:

Control Valve Tag:	CVTag
Gas Type:	GasType
Upstream Pressure:	P1 psig
Upstream Pressure Basis:	P1Basis
Upstream Temperature:	T1 F
Dewpoint Vapor:	☑
Set Pressure:	SetP psig
Allowable Overpressure:	OverP
Constant Back Pressure:	P3 psig
Required Relief Rate Units:	RateUnit
Sizing Method	SizingMethod
Cv (Traditional Calculated):	Cv
Xt (Cf for Kimray):	Xt
Cg (Traditional Only):	Cg
C1 (Traditinal Only):	C1
Control Valve Inner Diameter:	d in
Inlet Pipe Inner Diameter:	D1 in
Outlet Pipe Inner Diameter:	D2 in
Additional Flow:	AdditionalFlow RateUnit
Use Thermo	☑
Thermo Package:	ThermoPackage
StreamID	
Open Stream	New Stream
Relief Device Kd:	Kd
Nozzle Sizing:	Sizing
Outlet Pipe Sizing:	OutPipeSizing

Scenario Output Data:

Fk:	Fk
K1 Inlet Piping Resistance:	Kinlet
K2 Outlet Piping Resistance:	Koutlet
Kb1 Inlet Piping Bernoulli:	KbInlet
Kb2 Outlet Piping Bernoulli:	Kboutlet
Fp:	Fp
dP/P1 Actual:	dPP1Actual
dP/P1 Critical:	dPP1Critical
Y:	Y
Upstream Density:	Rho1 lb/ft3
Upstream Z:	Z1
Upstream Ideal Cp/Cv:	k1
Control Valve Flow:	equiredRateCV RateUnit
Required Mass Rate:	iiredRateMass lb/hr
Required Rate Std Vol:	quiredRateMM MMSCFD
Required Air Rate:	equiredRateAir scfh air
Relief Mass Flux:	Flux2 lb/sec/ft2

Calculate | Preview | Print | Close

Equipment Data:

The six fields under Equipment Data are specified on the Overpressure Scenario Form.

Input Data:

The form fields for inputs are blue and organized under the Scenario Input column. The are described below:

CVTag – Control valve or regulator tag number typically from P&ID or other description such as LCV-100 1" Bypass.

GasType – Generic description of gas such as fuel gas or field gas.

P1 – Pressure at control valve inlet. From most to least conservative: MAWP, PSV Set, PSHH, Max Operating

P1Basis – Description for choice of P1. PSV-100 Set Pressure, PSHH Setpoint, etc.

T1 – Temperature at control valve inlet for PT Flash Only. Calculated for PQ Flash.

Dewpoint Vapor – PQ flash with Q = 1.0 if checked. Otherwise, PT Flash based on T1.

SetP – PSV set pressure used to determine relief pressure.

OverP – Allowable overpressure typically 10% used to determine relief pressure.

P3 – Constant back pressure when PSV is closed.

RateUnit – Flow units for required relief rate that is reported back to the Overpressure Scenario Form.

Sizing Method – Universal, Traditional Fisher and Kimray equations are available.

Cv – Manufacturer's published Cv used for IEC and Kimray equations.

Xt - Manufacturer's published Xt used for IEC or Cf used for Kimray. 1.0 is conservative if unknown.

Cg – Manufacturer's published Cg used for Fisher equations only.

C1 - Manufacturer's published C1 used for Fisher equations only.

d = Control valve or regulator inner diameter

D1 = Inlet pipe inner diameter

D2 = outlet pipe inner diameter

AdditionalFlow – Any extra flow to be added to control valve flow such as through a bypass. Enter negative value to take credit for outflow downstream

UseThermo – Use selected ThermoPackage if checked.

ThermoPackage – Thermo package used for properties. VMG (Symmetry) packages or REFPROP 10.0 from NIST

StreamID – The stream to be used for properties. A new stream can be added here. See Stream Definition Form.

Kd – Manufacturer's certified vapor Kd or 0.975 for API STD 520 default.

Nozzle Sizing – PSV sizing method: API STD 520 Vapor or API Numerical Integration (recommended when Z <= 0.8).

OutPipeSizing – Outlet pressure drop method: Adiabatic, Omega Method and Numerical Integration.

Calculation Method:

This form supports control valve vapor and gas capacity calculations based on the IEC, Original Fisher and Kimray equations as described below.

Universal Method IEC Equations

The following IEC equations are from the Fisher Control Valve Handbook 6th Edition Section 5.

Section 5.8.1

Note that Fp can conservatively be assumed to be 1.0 by setting the inlet and outlet pipe ID equal to the nominal pipe size of the control valve or regulator. The $_1$ and $_2$ subscripts are replaced with inlet and outlet on the form.

$$K_1 = 0.5\left(1 - \frac{d^2}{{D_1}^2}\right)^2$$

$$K_2 = 1.0\left(1 - \frac{d^2}{{D_2}^2}\right)^2$$

$$K_{B1} = 1 - \left(\frac{d}{D_1}\right)^4$$

$$K_2 = 1.0\left(1 - \frac{d^2}{{D_2}^2}\right)^2$$

$$\Sigma K = K_1 + K_2 + K_{B1} - K_{B2}$$

$$F_P = \left[1 + \frac{\Sigma K}{N_2}\left(\frac{C_v}{d^2}\right)^2\right]^{-1/2}$$

Where:

d = Control valve ID (inches)

D_1 = Inlet pipe ID (inches)

D_2 = Inlet pipe ID (inches)

C_v = Valve C_v from Manufacturer

N_2 = Unit conversion constant (890) from Fisher

Section 5.9.1

$$x_{TP} = \frac{\frac{x_T}{F_P{}^2}}{1 + \frac{x_T(K_1 + K_{B1})}{N_5}\left(\frac{C_v}{d^2}\right)^2}$$

Where:

x_T = Valve x_T from Manufacturer, 1.0 is conservative if unknown

N_5 = Unit conversion constant (1,000) from Fisher

$$F_\gamma = \frac{\gamma}{1.4}$$

Where:

γ = k1, Ideal Specific Heat Ratio

$$x_{choked} = F_\gamma \cdot x_{TP}$$

$x = \Delta P / (P_1 + P_{atm})$

$\Delta P = P_1 - P_2$

x_{sizing} = Lesser of x and x_{choked}

$Y = 1 - x_{sizing} / 3 \cdot x_{choked}$

$w = (Cv \cdot N_8 \cdot F_P \cdot P_1 Y)^2 \cdot x_{sizing} \cdot M / (T_1 + 460) / Z_1$

Where:

C_v = Valve Cv from Manufacturer

N_8 = Unit conversion constant (19.3) from Fisher

M = Vapor Molecular Weight

P1 – Pressure at control valve inlet. From most to least conservative: MAWP, PSV Set, PSHH, Max Operating

T_1 = Temperature at control valve inlet for PT Flash Only. Calculated for PQ Flash.

Z_1 = Compressibility at control valve inlet.

Traditional Method Fisher Equations

The following equations are taken from the Fisher Control Valve Handbook and utilize C_g and C_1 in lieu of C_v and X_T. The F_p factor is calculated in the same manner as the Universal Method with the C_v being calculated ($C_v = C_g \cdot C_1$)

$$Q_{lb/hr} = 1.06\sqrt{d_1 P_1}\ C_g\ \mathrm{SIN}\left(\frac{3417}{C_1}\right)\left(\sqrt{\frac{\Delta P}{P_1}}\right)\mathrm{Deg}$$

Where:

d_1 = Upstream density (lb/ft^3)

P_1 = Pressure at control valve inlet. From most to least conservative: MAWP, PSV Set, PSHH, Max Operating

C_g = Valve C_g from Manufacturer

C_1 = Valve C_1 from Manufacturer

$\Delta P = P_1 - P_2$, if sine term < 90°, otherwise set sine term = 90° and solve for ΔP

Kimray Sizing Equations

The following equations are taken from the documentation for Kimray's Kimsize Gas Sizing documentation. The C_f factor is similar to x_T.

$$y = \frac{1.63}{C_f}\sqrt{\frac{\Delta P}{P_1}} \leq 1.50$$

Where:

P_1 = Pressure at control valve inlet. From most to least conservative: MAWP, PSV Set, PSHH, Max Operating

C_f = Valve C_f from Manufacturer

$\Delta P = P_1 - P_2$, if $y \leq 1.50$, otherwise set $y = 1.5$ and solve for ΔP

$$Q = \frac{834 C_v C_f P_1 (y - 0.148y^3)}{41666 \sqrt{GT}}$$

C_v = Valve C_v from Manufacturer

T = Temperature at control valve inlet (T_1 + 460° F) for PT Flash Only. Calculated for PQ Flash.

G = Vapor Specific Gravity Relative to Air

Scenario Output Data:

The form fields for scenario-specific outputs are organized under the Scenario Output column. These are described below:

F_k (Universal Calculation Method Only) - See calculation method for F_γ.

Kinlet - Inlet pipe resistance factor

Koutlet - Outlet pipe resistance factor

Kbinlet - Inlet pipe Bernoulli factor

Kboutlet - Outlet pipe Bernoulli factor

F_p - Piping geometry factor. Conservatively can be set to 1.0 by setting D1 and D2 = d.

dpP1Actual - $(P_1 - P_2) / ((P_1 + P_{atm})$

dpP1Critical – See Calculation Methods for determination of critical flow pressure like x_{choked} for Universal Method.

Y (Universal and Kimray Methods) Expansion Factor – See calculation methods.

rho1 - Upstream density in lb/ft3 typically from thermo engine.

Z1 - Upstream compressibility typically from thermo engine.

K1 - Upstream ideal C_p/C_v typically from thermo engine.

RequiredRateCv - Calculated flow through control valve or regulator in selected rate units.

RequiredRateMass - RequiredRateCv + AdditionalFlow converted to lb/hr, if necessary.

RequiredRateMM - RequiredRateCv + AdditionalFlow converted to MMSCFD, if necessary.

RequiredRateAir - RequiredRateCv + AdditionalFlow converted to scfh air.

Flux2 – RequiredRateMass · RequiredArea * 144 / 3600

Scenario Calculation Results:

The form fields for overall scenario results are organized in the Scenario Calculation Results Section. These outputs are typical of most of the scenario calculations and are detailed under Typical Scenario Calculation Results.

QA/QC Benchmarks:

The Universal Method was benchmarked against the Fisher Specification Manager using a 1" Fisher D with ½" m-form trim and the Kimray Method was benchmarked against Kimsize using a 1" Kimray EAC3P which has ½" =% trim. The Traditional Method was compared to the Universal Method using a typical, assumed C_1. Each calculation method was also checked against an internally developed Excel spreadsheet. The calculation is based on full open flow coefficients with upstream conditions or 800 psig and 120 F and the downstream relief pressure of 165 psig. The relief valve is a 3K4 pilot-operated with typical inlet and outlet piping. Device capacity was determined based on the API Vapor Equation, Area and Kd.

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Scenario Description:

TThe maximum upstream pressure is 800 psig as dictated by the set point of PSHH-1000. As such, a failure open of PCV-1000 could result in overpressure and the required relief rate was based on the recovery residue gas compostion at 800 psig and 120 F upstream of control valve with the relief pressure of 165 psig downstream. Flow coefficients were based on a 1" Fisher D4 with 1/2" m-form trim and the control valve is installed in a 2" line.

Scenario Calculation Results:

Required Rate:	9,399.1	lb/hr	Device Choke Pressure:	83.7	psig
Actual Capacity:	19,807.6	lb/hr	Outlet Temperature:	75.9	F
Required Area:	0.872	in2	Outlet Mass Quality:	1.000	
Actual Area:	1.838	in2	Outlet Density:	0.043	lb/ft3
Relief Pressure:	165.0	psig	Outlet Ideal Cp/Cv:	1.290	
Relief Temperature:	86.2	F	Outlet Viscosity:	0.011	cP
Relief MW:	16.74		Inlet Non-Recoverble dP:	1.4	psi
Relief Mass Quality:	0.000		Inlet dP % Set:	1.0	% Set
Relief Density:	0.529	lb/ft3	Built-Up Back Pressure:	11.1	psig
Relief SG:	0.577		Built-Up Back P % Set:	7.4	% Set
Relief Z:	0.970		Total Back Pressure:	11.1	psig
Relief Ideal Cp/Cv:	1.290		Total Back P % Set:	7.4	% Set
Relief Viscosity:	0.011	cP	Reaction Force:	258	lbf

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Scenario Input Data:

Control Valve Tag:	PCV-1000	
Gas Type:	Residue Gas	
Upstream Pressure:	800	psig
Upstream Pressure Basis:	PSHH-1000 Set Point	
Upstream Temperature:	120	F
Dewpoint Vapor:	☐	
Set Pressure:	150	psig
Allowable Overpressure:	10.0%	
Constant Back Pressure:	0	psig
Required Relief Rate Units:	lb/hr	
Sizing Method	Universal	
Cv:	6.51	
Xt (Cf for Kimray):	0.549	
C1:	0	
Cg:	0	
Control Valve ID:	0.957	in
Inlet Pipe ID:	1.939	in
Outlet Pipe ID:	1.939	in
Additional Flow:	1,000.0	lb/hr
Use Thermo	☐	
Thermo Package:	Advanced_Peng-Robinson	
Relief Device Kd:	0.975	
Nozzle Sizing:	API 520 Vapor	
Outlet Pipe Sizing:	Omega Method	

Scenario Output Data:

Fk:	0.91	
K1 Inlet Piping Resistance:	0.29	
K2 Outlet Piping Resistance:	0.57	
K1 Inlet Piping Bernoulli:	0.94	
K2 Outlet Piping Bernoulli:	0.94	
Fp:	0.976	
dP/P1 Actual:	0.779	
dP/P1 Critical:	0.502	
Y:	0.667	
Upstream Density:	2.403	lb/ft3
Upstream Z:	0.912	
Upstream Ideal Cp/Cv:	1.279	
Control Valve Flow:	8,399.1	lb/hr
Required Mass Rate:	9,399.1	lb/hr
Required Rate Std Vol:	5.1	MMSCFD
Required Air Rate:	165,918.8	scfh air
Relief Mass Flux:	431.1	lb/sec/ft2

Notes:

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Relief Stream Composition:

Stream Description: Residue Gas

Component	Mole Fraction
methane	0.9577
ethane	0.0320
propane	0.0008
butane	
isobutane	
pentane	
isopentane	
hexane	
heptane	
octane	
nonane	
decane	
carbon dioxide	0.0070
nitrogen	0.0025
methanol	
water	

Valve Sizing Calculation

FISHER EMERSON

Customer:					
Fax:			Phone:		
Contact:			Contact:		
Item: 1	Qty: 1		PO Number:		
Tags:	PCV-1000 Universal		Project:	PCV-1000	
Description:	1 Inch D		P&ID Number:		
Service Description:	PCV-1000 Failure Open		Line Number:		

Sizing Type: Ideal Gas Flow is Turbulent Solving for: Cv Noise is IECAerodynamic Flow is Mass

Variable Name	Units	Minimum- 0	Normal- 1	Maximum- 2	Others- 3
Gas			Residue Gas		
Temperature (T1)	deg F		120.0000		
Inlet Pressure (P1)	psig	1.440.000	800.000		
Pressure Change (dP)	psi		635.000		
Mass flow rate (w)	lb/h		8400.000		
Pressure Drop Ratio Factor (Xt)		0.650	0.549		
Pressure Recovery Factor (Fl)		0.900	0.840		
Valve Style Modifier (Fd)		0.350	0.560		
Atmospheric Pressure	psi	14.69	14.69		
Kinematic Viscosity (Nu)	cSt	0.00001	0.31157		
Pipe Size Up	in	2	2		
Pipe Schedule Up		80	80		
Pipe Size Down	in	2	2		
Pipe Schedule Down		80	80		
Nominal Valve Diameter (dv)	in	1	1		
Specific heats ratio (gamma)			1.279		
Molecular weight /Specific gravity	M		16.740		
Valve/Trim			Globe/Angle		
Rn	ft	3.281	3.00		
Ao	in2		0.719		
T2	deg F		86.0000		
Sizing Coefficient (Cv)			6.445		
Dynamic Viscosity (Mu)	cP		0.012		
Pipe Outside Diam. Up	in	2.375	2.375		
Pipe Outside Diam. Down	in	2.375	2.375		
Gas Flow Rate (Qg)	scfh		190309.745		
Inlet Compressibility Factor (Z1)		1.000	0.912		
Whisper III Trim Level					
LpAeTrim1m	dB(A)		88		
LpAeOutlet1m	dB(A)	- -	74		
LpAeValve1m	dB(A)		89		
LpAeValveRn	dB(A)		89		
Inlet fluid density (Rho1)	lb/ft3		2.404		
M1 Pipe	Mach		0.032		
Mo Valve	Mach		0.613		
M2 Pipe	Mach		0.149		
Outlet fluid density (Rho2)	lb/ft3		0.530		
Upstream Fluid Velocity (V1)	ft/s		47.325		
Downstream Fluid Velocity (V2)	ft/s		214.824		
Z2		1.000	0.970		
Warnings		A value for variable 'Pressure differential' must be provided. Calculate for variable 'Flow Coefficient (Cv)' failed.			

Micro-Form - Flow Up

Equal Percentage Characteristic

Valve Size, NPS	Port Diameter		Total Travel		Flow Coefficient	Valve Opening—Percent of Total Travel										F_L[1]
	mm	Inches	mm	Inches		10	20	30	40	50	60	70	80	90	100	
1	6.4	1/4	19	3/4	C_v	0.070	0.115	0.164	0.224	0.315	0.450	0.641	0.921	1.28	1.66	.87
					K_v	0.061	0.099	0.142	0.194	0.272	0.389	0.554	0.797	1.11	1.44	---
					X_T	0.783	0.783	0.744	0.691	0.625	0.614	0.608	0.611	0.610	0.611	---
					F_d	0.12	0.14	0.17	0.20	0.24	0.29	0.35	0.43	0.55	0.68	---
	9.5	3/8	19	3/4	C_v	0.155	0.260	0.407	0.596	0.858	1.21	1.65	2.22	3.00	4.03	.84
					K_v	0.134	0.225	0.352	0.516	0.742	1.05	1.43	1.92	2.60	3.49	---
					X_T	0.625	0.535	0.534	0.539	0.535	0.535	0.538	0.534	0.537	0.536	---
	12.7	1/2	19	3/4	C_v	0.273	0.436	0.631	0.911	1.30	1.84	2.57	3.65	5.08	6.51	.84
					K_v	0.236	0.377	0.546	0.788	1.13	1.59	2.22	3.16	4.39	5.63	---
					X_T	0.673	0.644	0.641	0.590	0.592	0.587	0.586	0.557	0.523	0.549	---
					F_d	0.11	0.13	0.16	0.19	0.23	0.27	0.33	0.40	0.48	0.56	---
	19.1	3/4	19	3/4	C_v	0.483	0.775	1.25	1.97	2.89	4.13	5.87	8.16	10.9	12.3	.92
					K_v	0.418	0.670	1.08	1.70	2.50	3.57	5.08	7.06	9.43	10.6	---
					X_T	0.571	0.599	0.527	0.473	0.492	0.519	0.537	0.505	0.486	0.628	---
					F_d	0.10	0.39	0.47	0.18	0.22	0.26	0.31	0.37	0.43	0.49	---

PCV-1000 Failure Open - 1" Fisher D4, 1/2" m-form

Vapor Control Valve (Universal Method with Fp Input)
Critical PSV Flow Only

User-Entered Inputs		
P_1	800.0	psig
P_{atm}	14.4	psia
T_1	120.0	F
P_2	165.0	psig
C_v	6.51	
X_t	0.549	
F_p	0.976	
K_d	0.975	

Thermo Inputs		
$Kideal_1$	1.279	
Z_1	0.912	
MW	16.74	lb/lbmole
T_1	120.0	F
T_2	86.2	F
Z_2	0.973	
$Kideal_2$	1.286	
Results		
F_γ	0.913	
$F_\gamma X_t$	0.502	
x	0.780	
Y	0.667	
W_{cv}	8,392	lb/hr
$W_{ADDITIONAL}$	1,000	lb/hr
$W_{REQUIRED}$	9,392	lb/hr
C	345.7	
A_{req}	0.875	in^2

Vapor Control Valve (Universal Method with Fp Calculation)
Critical PSV Flow Only

User-Entered Inputs		
P_1	800.0	psig
P_{atm}	14.4	psia
T_1	120.0	F
P_2	165.0	psig
Cv	6.510	
X_t	0.549	
K_d	0.975	
Valve d	0.957	in
Inlet Pipe D_1	1.939	in
K_1	0.286	
Kb_1	0.941	
Outlet Pipe D_2	1.939	in
K_2	0.572	
Kb_2	0.941	
F_p	0.976	

Thermo Inputs		
$Kideal_1$	1.279	
Z_1	0.912	
MW	16.74	lb/lbmole
T_1	120.0	F
T_2	86.2	F
Z_2	0.973	
$Kideal_2$	1.286	
Results		
F_γ	0.913	
X_{TP}	0.557	
$F_\gamma X_{TP}$ (x_{choked})	0.502	
x_{actual}	0.780	
P_{choked}	391.6	psig
x_{sizing}	0.502	
Y	0.667	
W_{CV}	8,392	lb/hr
$W_{ADDITIONAL}$	1,000	lb/hr
$W_{REQUIRED}$	9,392	lb/hr
C	345.7	
A_{req}	0.875	in^2

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Scenario Description:

TThe maximum upstream pressure is 800 psig as dictated by the set point of PSHH-1000. As such, a failure open of PCV-1000 could result in overpressure and the required relief rate was based on the recovery residue gas compostion at 800 psig and 120 F upstream of control valve with the relief pressure of 165 psig downstream. Flow coefficients were based on a 1" Kimray with 1/2" =% trim and the control valve is installed in a 2" line.

Scenario Calculation Results:

Required Rate:	9,101.9	lb/hr	Device Choke Pressure:	83.8	psig
Actual Capacity:	19,755.4	lb/hr	Outlet Temperature:	75.9	F
Required Area:	0.847	in2	Outlet Mass Quality:	1.000	
Actual Area:	1.838	in2	Outlet Density:	0.043	lb/ft3
Relief Pressure:	165.0	psig	Outlet Ideal Cp/Cv:	1.288	
Relief Temperature:	86.2	F	Outlet Viscosity:	0.011	cP
Relief MW:	16.74		Inlet Non-Recoverble dP:	1.4	psi
Relief Mass Quality:	1.000		Inlet dP % Set:	1.0	% Set
Relief Density:	0.528	lb/ft3	Built-Up Back Pressure:	11.0	psig
Relief SG:	0.577		Built-Up Back P % Set:	7.4	% Set
Relief Z:	0.973		Total Back Pressure:	11.0	psig
Relief Ideal Cp/Cv:	1.286		Total Back P % Set:	7.4	% Set
Relief Viscosity:	0.011	cP	Reaction Force:	257	lbf

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Scenario Input Data:

Control Valve Tag:	PCV-1000
Gas Type:	Residue Gas
Upstream Pressure:	800 psig
Upstream Pressure Basis:	PSHH-1000 Set Point
Upstream Temperature:	120 F
Dewpoint Vapor:	☐
Set Pressure:	150 psig
Allowable Overpressure:	10.0%
Constant Back Pressure:	0 psig
Required Relief Rate Units:	lb/hr
Sizing Method	Kimray
Cv:	6.49
Xt (Cf for Kimray):	0.78
C1:	0
Cg:	0
Control Valve ID:	0.957 in
Inlet Pipe ID:	1.939 in
Outlet Pipe ID:	1.939 in
Additional Flow:	1,000.0 lb/hr
Use Thermo	☑
Thermo Package:	Advanced_Peng-Robinson
Relief Device Kd:	0.975
Nozzle Sizing:	API 520 Vapor
Outlet Pipe Sizing:	Adiabatic

Scenario Output Data:

Fk:	0.91
K1 Inlet Piping Resistance:	0.29
K2 Outlet Piping Resistance:	0.57
K1 Inlet Piping Bernoulli:	0.94
K2 Outlet Piping Bernoulli:	0.94
Fp:	0.977
dP/P1 Actual:	0.779
dP/P1 Critical:	0.515
Y:	1.5
Upstream Density:	2.404 lb/ft3
Upstream Z:	0.912
Upstream Ideal Cp/Cv:	1.279
Control Valve Flow:	8,101.9 lb/hr
Required Mass Rate:	9,101.9 lb/hr
Required Rate Std Vol:	5.0 MMSCFD
Required Air Rate:	160,669.6 scfh air
Relief Mass Flux:	429.9 lb/sec/ft2

Notes:

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Relief Stream Composition:

Stream Description: Residue Gas

Component	Mole Fraction
methane	0.9577
ethane	0.0320
propane	0.0008
butane	
isobutane	
pentane	
isopentane	
hexane	
heptane	
octane	
nonane	
decane	
carbon dioxide	0.0070
nitrogen	0.0025
methanol	
water	

KIMRAY INC.

Gas Sizing Calculation

Created: **Monday, May 20, 2024 16:50**

Condition 1

Condition Label	Normal	
Critical Flow Factor (C_f)	.78	
Flowing Temp.	120	°fahrenheit
Gas Specific Gravity	.577	
Upstream Pressure	800	psig
Downstream Pressure	165	
Flow Coefficient (Cv)	6.49	
Flow Rate	4514.78	mcfd
	8,296.5 lb/hr	

CO

Valves / High Pressure Control Valves / High Pressure Pressure Reducing Package /

EAC3P

Configuration Code:

Description: **1400 SMA PO 1/2EP 30HPPR**

1" Female NPT Angled Body
0.5" Equal Percentage Trim
Process Fluid: **Gas**
Operation: **Pneumatic**
Pilot Type: **Vent**
100% Cv: **6.49**

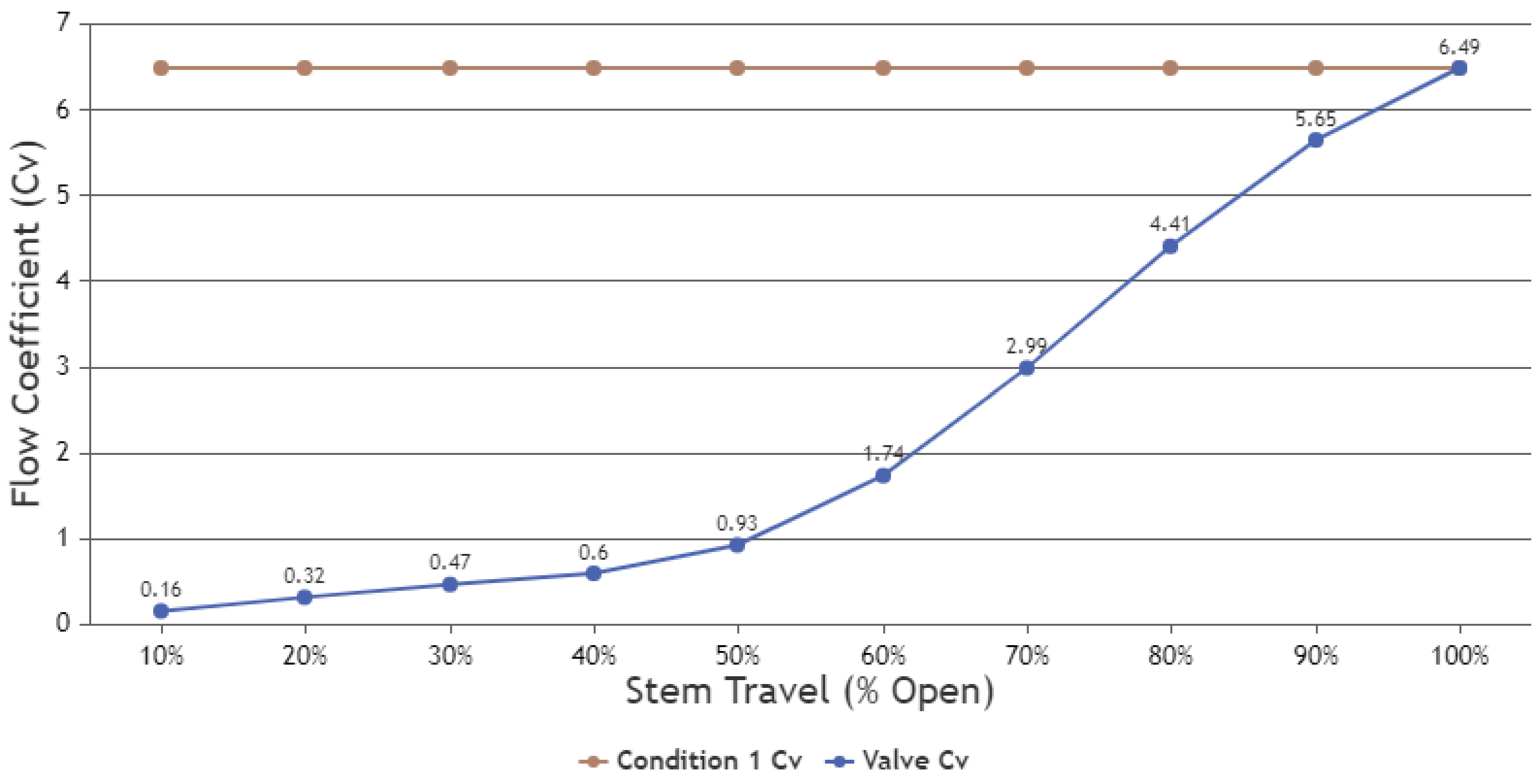
Utilizes process gas to operate integrated pilot. Gas must be clean and dry.

Specifications

TYPE	VALUE
Connection Size:	1 "
Connection Type:	Female NPT
Body Style:	Angled Body
Body Material:	Steel
NACE MR0175:	Option Available
Trim Size:	0.5 "
Trim Type:	Equal Percentage
Leakage Class:	Class IV
Process Fluid:	Gas
Pilot Type:	Vent
Max Working Pressure:	4000 psig
Min Set Point Pressure:	10 psig
Max Set Point Pressure:	300 psig
Fail Position:	Closed
Operation:	Pneumatic
Catalog Page:	01:10.1
Min Cv:	0.32
Max Cv:	6.49
Cf:	0.78

FLOW COEFFICIENT (CV) AT STEM TRAVEL (% OPEN)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0.16	0.32	0.47	0.6	0.93	1.74	2.99	4.41	5.65	6.49



Gas Sizing Formula

$$C_v = \frac{41666Q\sqrt{GT}}{834C_f P_1 (y - 0.148y^3)} \qquad Q = \frac{834C_v C_f P_1 (y - 0.148y^3)}{41666\sqrt{GT}}$$

$$y = \frac{1.63}{C_f}\sqrt{\frac{\Delta P}{P_1}} \leq 1.50$$

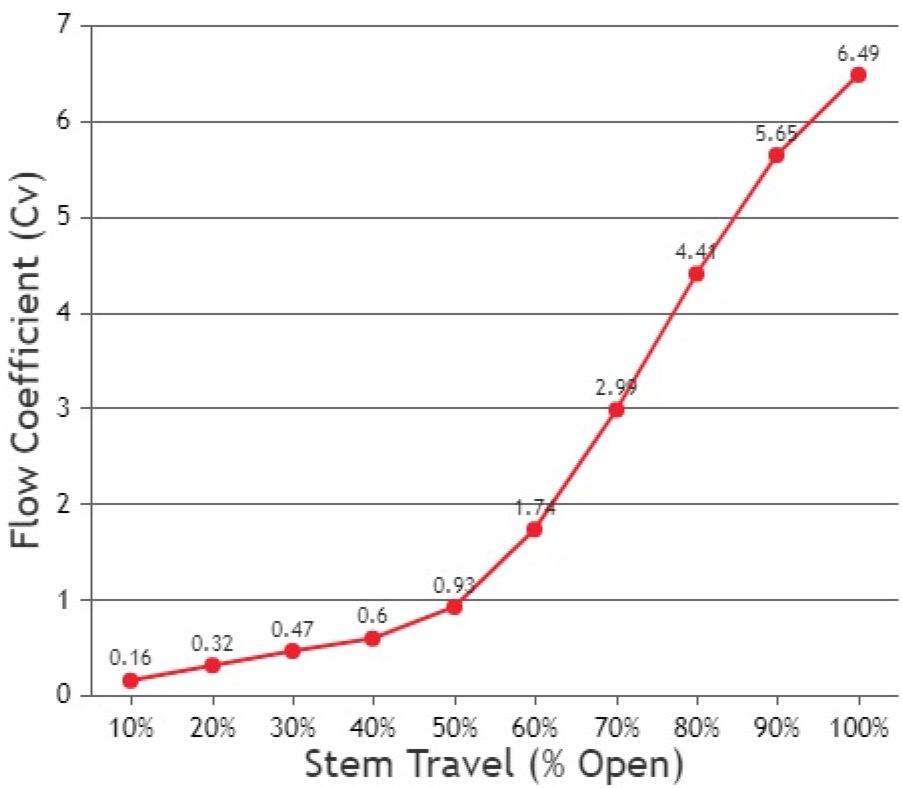
Where:

Cv	=	Valve Flow Coeffiecient
Cf	=	Critical Flow Factor
G	=	Gas specific Gravity (air = 1.0)
P1	=	Upstream Pressure (psia) = Pu + 14.7
Pu	=	Upstream Pressure (psig)
P2	=	Downstream Pressure (psia) = Pd + 14.7
Pd	=	Downstream Pressure (psig)
ΔP	=	P1 - P2
Q	=	Gas Flow Rate in MMCF / Day at 14.7 psia and 60F
T	=	Flowing Temperature in R = Tf +460
Tf	=	Flowing Temperature in F

Product Charts

1 OF 1: FLOW COEFFICIENT (CV) AT STEM TRAVEL (% OPEN)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0.16	0.32	0.47	0.6	0.93	1.74	2.99	4.41	5.65	6.49



Tech Specs

TYPE	VALUE
Connection Size:	1"
Connection Type:	Female NPT
Body Style:	Through Body
Body Material:	Steel
NACE MR0175:	Option Available
Trim Size:	0.5"
Trim Type:	Equal Percentage
Leakage Class:	Class IV
Process Fluid:	Liquid and Gas
Max Working Pressure:	4000 psig
Actuator Spring Nominal Pressure:	30 psig
Max Supply Gas Pressure:	45 psig
Fail Position:	Closed - Field Reversible
Operation:	Pneumatic
Catalog Page:	01:10.1
Face-to-Face Length:	4.44"
Min Cv:	0.32
Max Cv:	6.49
Cf:	0.78

PCV-1000 Failure Open - 1" Kimray Non-Balanced, 1/2" =% Trim

Vapor Control Valve (Kimray Method with Fp Input)
Critical PSV Flow Only

User-Entered Inputs		
P_1	800.0	psig
P_{atm}	14.4	psia
T_1	120.0	F
P_2	165.0	psig
C_v	6.49	
C_f	0.780	
F_p	0.976	
K_d	0.975	
Thermo Inputs		
K_{Ideal1}	1.279	
Z_1	0.910	
MW	16.74	lb/lbmole
T_1	120.0	F
ρ_1	2.41	lb/ft^3
T_2	86.2	F
Z_2	0.973	
K_{Ideal2}	1.286	
Results		
x_{actual}	0.780	
y_{actual}	1.8	
y_{sizing}	1.500	
P_{choked}	380.4	psig
W_{CV}	8,094	lb/hr
$W_{ADDITIONAL}$	1,000	lb/hr
$W_{REQUIRED}$	9,094	lb/hr
C	345.7	
A_{req}	0.847	in^2

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Scenario Description:

The maximum upstream pressure is 800 psig as dictated by the set point of PSHH-1000. As such, a failure open of PCV-1000 could result in overpressure and the required relief rate was based on the recovery residue gas compostion at 800 psig and 120 F upstream of control valve with the relief pressure of 165 psig downstream. The C1 was assumed (not published by Fisher) to be 28.2 and the Cg was back-calculated from the Cv and C1. The control valve is installed in a 2" line.

Scenario Calculation Results:

Required Rate:	9,410.0	lb/hr	Device Choke Pressure:	83.8	psig
Actual Capacity:	19,755.4	lb/hr	Outlet Temperature:	75.9	F
Required Area:	0.876	in2	Outlet Mass Quality:	1.000	
Actual Area:	1.838	in2	Outlet Density:	0.043	lb/ft3
Relief Pressure:	165.0	psig	Outlet Ideal Cp/Cv:	1.288	
Relief Temperature:	86.2	F	Outlet Viscosity:	0.011	cP
Relief MW:	16.74		Inlet Non-Recoverble dP:	1.4	psi
Relief Mass Quality:	1.000		Inlet dP % Set:	1.0	% Set
Relief Density:	0.528	lb/ft3	Built-Up Back Pressure:	11.0	psig
Relief SG:	0.577		Built-Up Back P % Set:	7.4	% Set
Relief Z:	0.973		Total Back Pressure:	11.0	psig
Relief Ideal Cp/Cv:	1.286		Total Back P % Set:	7.4	% Set
Relief Viscosity:	0.011	cP	Reaction Force:	257	lbf

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Scenario Input Data:

Control Valve Tag:	PCV-1000	
Gas Type:	Residue Gas	
Upstream Pressure:	800	psig
Upstream Pressure Basis:	PSHH-1000 Set Point	
Upstream Temperature:	120	F
Dewpoint Vapor:	☐	
Set Pressure:	150	psig
Allowable Overpressure:	10.0%	
Constant Back Pressure:	0	psig
Required Relief Rate Units:	lb/hr	
Sizing Method	Traditional Fisher	
Cv:	6.51	
Xt (Cf for Kimray):		
C1:	28.2	
Cg:	183.6	
Control Valve ID:	0.957	in
Inlet Pipe ID:	1.939	in
Outlet Pipe ID:	1.939	in
Additional Flow:	1,000.0	lb/hr
Use Thermo	☑	
Thermo Package:	Advanced_Peng-Robinson	
Relief Device Kd:	0.975	
Nozzle Sizing:	API 520 Vapor	
Outlet Pipe Sizing:	Adiabatic	

Scenario Output Data:

Fk:	0	
K1 Inlet Piping Resistance:	0.29	
K2 Outlet Piping Resistance:	0.57	
K1 Inlet Piping Bernoulli:	0.94	
K2 Outlet Piping Bernoulli:	0.94	
Fp:	0.976	
dP/P1 Actual:	0.779	
dP/P1 Critical:	0.552	
Y:	0	
Upstream Density:	2.404	lb/ft3
Upstream Z:	0.912	
Upstream Ideal Cp/Cv:	1.279	
Control Valve Flow:	8,410.0	lb/hr
Required Mass Rate:	9,410.0	lb/hr
Required Rate Std Vol:	5.1	MMSCFD
Required Air Rate:	166,108.3	scfh air
Relief Mass Flux:	429.9	lb/sec/ft2

Notes:

Vapor Control Valve Failure: PCV-1000

Equipment Data:

Equipment Tag:	**V-1000**	Type:	Pressure Vessel
Drawing:	PID-1000	MAWP:	150 psig
Description:	Slug Catcher	MAWT:	250 F

Relief Stream Composition:

Stream Description: Residue Gas

Component	Mole Fraction
methane	0.9577
ethane	0.0320
propane	0.0008
butane	
isobutane	
pentane	
isopentane	
hexane	
heptane	
octane	
nonane	
decane	
carbon dioxide	0.0070
nitrogen	0.0025
methanol	
water	

PCV-1000 Failure Open - 1" Fisher D4, 1/2" m-form

Vapor Control Valve (Traditional Method with Fp Input)
Critical PSV Flow Only

User-Entered Inputs		
P_1	800.0	psig
P_{atm}	14.4	psia
T_1	120.0	F
P_2	165.0	psig
C_g	183.6	
C_1	28.2	
F_p	0.976	
K_d	0.975	
Thermo Inputs		
K_{Ideal1}	1.279	
Z_1	0.912	
MW	16.74	lb/lbmole
T_1	120.0	F
T_2	86.2	F
Z_2	0.973	
K_{Ideal2}	1.286	
Results		
x_{actual}	0.780	
Sine Term Based on x_{actual}	107.0	Degrees
x_{choked} (Sine Term = 90)	0.552	
x_{sizing}	0.552	
Sine Value for Sizing	1.000	
P_{choke}	350.7	psig
ρ_1	2.40	lb/ft^3
W_{CV}	8,401	lb/hr
$W_{ADDITIONAL}$	1,000	lb/hr
$W_{REQUIRED}$	9,401	lb/hr
C	345.7	
A_{req}	0.876	in^2