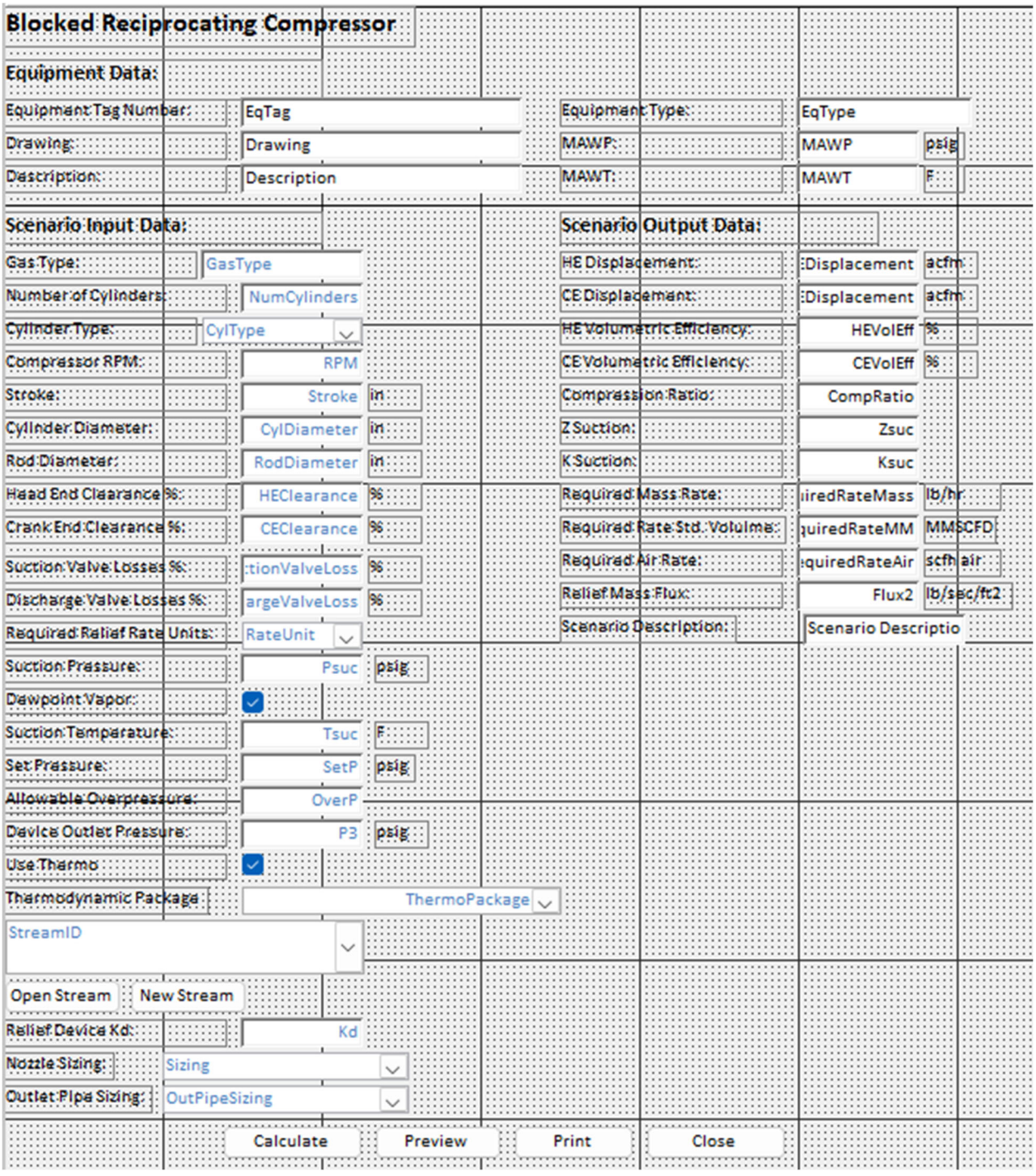
Blocked Reciprocating Compressor



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. These are described below:

GasType – Generic description of the gas (inlet gas, residue gas, propane, etc.)

NumCylinders – Number of cylinders in this service

CylType – Double-acting, head-end only or crank-end only

RPM – Compressor speed used to determine volumetric displacement

Stroke – Cylinder stroke used to determine volumetric displacement

CylDiameter – Cylinder bore used to determine volumetric displacement

RodDiameter – Rod diameter to subtract from crank-end volume.

HEClearance – Clearance % for determination of head-end volumetric efficiency (minimum most conservative)

CEClearance – Clearance % for determination of crank-end volumetric efficiency (minimum most conservative)

SuctionValveLoss – Pressure loss % across suction valves

DischargeValveLoss – Pressure loss % across discharge valves

RateUnit – Flow units in which the required relief rate will be reported.

Psuc – Suction line pressure to compressor

PsucBasis – Basis for suction pressure such as PSV set point, PSHH setting, maximum operation, etc.

Dewpoint Vapor – If yes, PQ Flare performed at Psuc and Q = 1.0, if no, Tsuc must be entered and TP Flash will be performed

Tsuc – Suction line temperature to compressor required if not dewpoint vapor otherwise calculated

SetP – Set pressure that will be used along with overpressure to determine relief pressure.

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

P3 – Constant back pressure when PSV is closed.

Use Thermodynamics - If false, additional property inputs are required.

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

StreamID – The stream to the suction of the compressor. 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.

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

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

Calculation Method:

The calculations for a blocked reciprocating compressor follow the Ariel Performance methodology which is consistent with other generally accepted methods. The first step is determination of the head-end and crank-end volumetric displacements it acfm. Note that the help assumes double-acting cylinder service to fully demonstrate all the calculations.

$$HE_{displacement} = \pi \left(\frac{Cyl_{diameter}}{24}\right)^2 x \frac{Stroke}{12} x\ RPM\ x\ NumCylinder$$

$$CE_{displacement} = \pi \left(\frac{Cyl_{diameter}{}^2 - Rod_{diameter}{}^2}{24}\right) x \frac{Stroke}{12} x\ RPM\ x\ NumCylinder$$

An estimate of the discharge temperature is then obtained per below.

$$T_{di} = T_{si}(R_i)^{\frac{k-1}{k}}$$

T_{di} – initial estimate of internal discharge temperature

T_{si} – internal suction temperature

R_i – internal absolute compression ratio P_{di} / P_{si}

k – ideal Cp/Cv at suction conditions

The estimate of internal discharge temperature is then refined using the Suction Temperature Preheat (T_{sph}).

$$T_{sph} = T_s + \left[\left(0.02 + (0.002 * Cyl_{diameter})\right) x\ (T_{di} - T_s)\right]$$

$$T_d = T_{sph}\ x\ (R_i)^{\frac{k-1}{k}}$$

T_d – discharge temperature

Scenario Output Data:

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

HEDisplacement – displacement in acfm on the head end of compressor

CEDisplacement – displacement in acfm on the crank end of the compressor

HEVolEff – volumetric efficiency calculated for the head end of the cylinder

VEVolEff – volumetric efficiency calculated for the crank end of the cylinder

CompRatio – P2 / Psuc with pressure in psia

Zsuc – Calculated compressibility at suction conditions

Ksuc – Ideal Cp/Cv at suction conditions

RequiredRateMass – Required rate in lb/hr

RequiredRateMM – Required rate in MMSCFD

RequiredRateAir – Required rate 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 Blocked Reciprocating Compressor calculation was benchmarked against Ariel's Performance software. The required relief rates were 13.9 MMSCFD in Pressio versus 14.0 MMSCFD in Ariel with some differences in discharge temperature (253 F versus 267 F) which are attributable to the difference between the ideal k value used by Pressio versus the Ratio of Sp Ht (N) value used by Ariel.

Blocked Reciprocating Compressor

C-5500 3rd Discharge Blocked

Equipment Data:

Equipment Tag:	**V-5350**	Type:	Reciprocating Compressor
Drawing:	PID-5000	MAWP:	1440 psig
Description:	Inlet Gas Compressor 3rd Discharge Bottle	MAWT:	350 F

Scenario Description:

In the event that the discharge from this positive displacement compressor is blocked, overpressure could occur. The required relief rate is based on the mechanical characteristics of the compressor at calculated speed of 1,400 RPM and minimum clearances. The suction conditions were based on the normal gas composition at the 2nd Stage Discharge PSHH-5530 setting of 625 psig and 120 F. The relief pressure is 1,584 psig.

Scenario Calculation Results:

Required Rate:	29,500.9	lb/hr	Device Choke Pressure:	882.8	psig
Actual Capacity:	45,948.9	lb/hr	Outlet Temperature:	192.6	F
Required Area:	0.324	in2	Outlet Mass Quality:	1.000	
Actual Area:	0.503	in2	Outlet Density:	0.041	lb/ft3
Relief Pressure:	1584.0	psig	Outlet Ideal Cp/Cv:	1.228	
Relief Temperature:	253.2	F	Outlet Viscosity:	0.013	cP
Relief MW:	19.34		Inlet Non-Recoverble dP:	23.3	psi
Relief Mass Quality:	1.000		Inlet dP % Set:	1.6	% Set
Relief Density:	4.416	lb/ft3	Built-Up Back Pressure:	106.0	psig
Relief SG:	0.667		Built-Up Back P % Set:	7.4	% Set
Relief Z:	0.92		Total Back Pressure:	106.0	psig
Relief Ideal Cp/Cv:	1.216		Total Back P % Set:	7.4	% Set
Relief Viscosity:	0.014	cP			

Blocked Reciprocating Compressor

C-5500 3rd Discharge Blocked

Equipment Data:

Equipment Tag:	**V-5350**	Type:	Reciprocating Compressor
Drawing:	PID-5000	MAWP:	1440 psig
Description:	Inlet Gas Compressor 3rd Discharge Bottle	MAWT:	350 F

Scenario Input Data:

Gas Type:	Inlet Gas	
Number of Cylinders:	2	
Cylinder Type:	Double Acting	
Compressor RPM	1400	
Compressor Stroke	5	in
Cylinder Diameter:	5.375	in
Rod Diameter:	2	in
Head End Clearance %:	21.17	%
Crank End Clearance %:	30.21	%
Suction Valve Losses %:	6	%
Discharge Valve Losses %:	5	%
Required Relief Rate Units:	lb/hr	
Suction Pressure:	625	psig
Suction Pressure Basis:	PSHH-5330 Setpoint	
Dewpoint Vapor:	☐	
Suction Temperature:	120	F
Set Pressure:	1440	psig
Allowable Overpressure:	10.0%	
Device Outlet Pressure:	0	psig
Use Thermo	☑	
Thermo Package:	Advanced_Peng-Robinson	
Relief Device Kd:	0.975	
Nozzle Sizing:	API 520 Vapor	
Outlet Pipe Sizing:	Adiabatic	

Scenario Output Data:

HE Displacement:	183.8	acfm
CE Displacement:	158.4	acfm
HE Volumetric Efficiency:	69.26	%
CE Volumetric Efficiency:	59.76	%
Compression Ratio:	2.499	
Suction Z:	0.898	
Suction Ideal Cp/Cv:	1.243	
Required Mass Rate:	29,500.9	lb/hr
Required Rate Std. Voluime:	13.89	MMSCFD
Required Air Rate:	553,628.4	scfh air
Relief Mass Flux:	3637.0	lb/sec/ft2

Notes:

Blocked Reciprocating Compressor

C-5500 3rd Discharge Blocked

Equipment Data:

Equipment Tag:	**V-5350**	Type:	Reciprocating Compressor
Drawing:	PID-5000	MAWP:	1440 psig
Description:	Inlet Gas Compressor 3rd Discharge Bottle	MAWT:	350 F

Relief Stream Composition:

Stream Description: Inlet Gas

Component	Mole Fraction
methane	0.8750
ethane	0.0600
propane	0.0300
isobutane	0.0100
butane	0.0150
isopentane	0.0050
pentane	0.0050
hexane	
heptane	
octane	
nonane	
decane	
carbon dioxide	
hydrogen sulfide	
methanol	
water	

Compressor Data:

Elevation,ft:	50.00	Barmtr,psia:	14.669	Ambient,F:	100.00	**Driver Data:**	
Frame: **(ELP)**	KBT/2	Stroke, in:	5.00	Rod Dia, in:	2.000	Type:	Unselected
Max RL Tot, lbf:	92000	Max RL Tens, lbf:	46000	Max RL Comp, lbf:	50000	Mfg:	
Rated RPM:	1500	Rated BHP:	1840.0	Rated PS FPM:	1250.0	Model:	
Calc RPM:	1400.0	BHP:	797	Calc PS FPM:	1166.7	BHP:	0
						Avail:	0

PACKING COOLING

Services	**3rd Stage**	
Gas Model	VMG-APRNGL2	
Stage Data:	**1**	---
Target Flow, MMSCFD	13.000	---
Flow Calc, MMSCFD	14.400	---
BHP per Stage	787.5	---
Specific Gravity	0.6677	---
Ratio of Sp Ht (N)	1.2670	---
Comp Suct (Zs)	0.8971	---
Comp Disch (Zd)	0.9074	---
Pres Suct Line, psig	625.00	---
Pres Suct Flg, psig	625.00	---
Pres Disch Flg, psig	1584.00	---
Pres Disch Line, psig	1584.00	---
Pres Ratio F/F	2.499	---
Temp Suct, F	120.00	---
Temp Clr Disch, F	120.00	---
Cylinder Data:	**Throw 1**	**Throw 2**
Cyl Model	5-3/8T:20	5-3/8T:20
Cyl Bore, in	5.375	5.375
Cyl RDP (API), psig	2286.4	2286.4
Cyl MAWP, psig	2515.0	2515.0
Cyl Action	DBL	DBL
Cyl Disp, CFM	171.1	171.1
Pres Suct Intl, psig	586.00	586.00
Temp Suct Intl, F	125	125
Pres Disch Intl, psig	1671.42	1671.42
Temp Disch Intl, F	267	267
HE Suct Gas Vel, FPM	8319	8319
HE Disch Gas Vel, FPM	7364	7364
HE Spcrs Used/Max	0/2	0/2
HE Vol Pkt Avail	0.65+42.40	0.65+42.40
Vol Pkt Used	0.00 (V) %	0.00 (V) %
HE Min Clr, %	20.52	20.52
HE Total Clr, %	21.17	21.17
CE Suct Gas Vel, FPM	7167	7167
CE Disch Gas Vel, FPM	6345	6345
CE Spcrs Used/Max	0/2	0/2
CE Min Clr, %	30.21	30.21
CE Total Clr, %	30.21	30.21
Suct Vol Eff HE/CE, %	71.7/61.9	71.7/61.9
Disch Event HE/CE, ms	8.1/8.6	8.1/8.6
Suct Pseudo-Q HE/CE	6.7/4.9	6.7/4.9
Gas Rod Ld Comp, %	53.3 C	53.3 C
Gas Rod Ld Tens, %	41.9 T	41.9 T
Gas Rod Ld Total, %	49.9	49.9
Xhd Pin Deg/%Rvrsl lbf	168/64.9	168/64.9
Flow Calc, MMSCFD	7.200	7.200
Cyl BHP	393.8	393.8