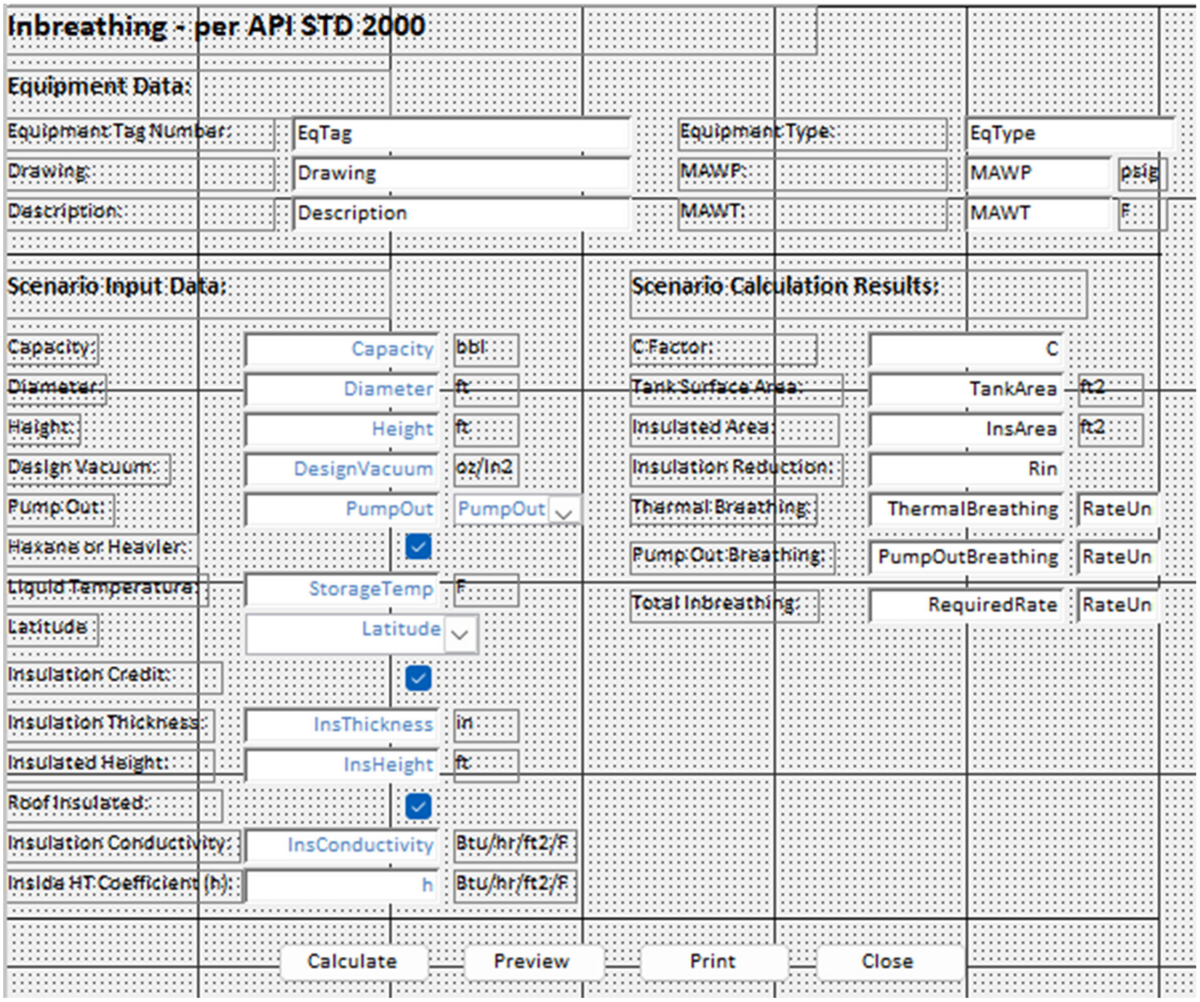
API STD 2000 Inbreathing



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:

Capacity – Tank nominally rated storage capacity in bbl

Diameter – Tank diameter generally taken as the outer diameter

Height – Tank height from floor to roof connection assumes vertical orientation

DesignVacuum – Vacuum design pressure in oz/in2

PumpOut – Maximum rate of liquid removal from the tank

PumpOutUnits – Flow units for liquid removal from the tank (gpm or bpd)

Hexane or Heavier – Fluid designation used in determination of thermal breathing requirement

StorageTemp – Fluid temperature in tank used in determination of thermal breathing requirement. Above 77 F trips higher vent requirements

Latitude – Tank location latitude used in determination of thermal breathing requirement. Less than 42° is most conservative

Insulation Credit – Yes will determine the Insulation Reduction Factor based on the input insulation details

InsulationThickness – Insulation thickness inches

InsHeight – Height of insulation above tank floor in feet

Roof Insulated – If yes, roof area is included in the Insulated Area

InsConductivity– Conductivity of insulation material in Btu/hr/ft/F

h = Inside heat transfer coefficient in Btu/hr/ft2/F with a typical default of 0.7

Calculation Method:

The calculation method for inbreathing is the sum of the thermal and pump-out inbreathing requirements both of which are well established in API STD 2000. The thermal inbreathing requirement depends on a constant C from Table 2 below which is based on the average storage temperature, tank location latitude and vapor pressure relative to hexane.

Table 2 — *C*-factors

Latitude	*C*-factor for various conditions			
	Vapour pressure			
	Hexane or similar		Higher than hexane, or unknown	
	Average storage temperature °C			
	< 25	≥ 25	< 25	≥ 25
Below 42°	4	6,5	6,5	6,5
Between 42° and 58°	3	5	5	5
Above 58°	2,5	4	4	4

If no credit is to be taken for insulation, the thermal inbreathing requirement (
V_{IT} can be evaluated using the following equation and assuming R_i = 1.0.

$$V_{IT} = 3.08 \; x \; C \; x \; V_T^{0.7} \; x \; R_i$$

If credit is to be taken for insulation, R_{in} which is the insulation reduction factor for a fully insulated tank can be quantified per the following equation.

$$R_{in} = \frac{1}{\left(1+\frac{h \, x \, l_{in}}{\lambda_{in}}\right)}$$

h – Inside heat transfer coefficient default value 0.7 Btu/hr/ft^2/F

l_{in} – Insulation thickness in ft

λ_{in} – Insulation conductivity in Btu/hr/ft/F

R_I is equal to R_{in} for fully insulated tanks or R_I is calculated for partially insulated tanks as follows:

$$R_i = \frac{A_{inp}}{A_{TTS}} x R_{in} + \left(1 - \frac{A_{inp}}{A_{TTS}}\right)$$

A_{inp} = Insulated surface area of tank ft^2

A_{TTS} = Total surface area of tank including roof ft^2

The required inbreathing rate due to removal of fluid (pump-out) from the tank (V_{IP}) is then quantified and added to the thermal inbreathing requirement from above to determine the overall inbreathing requirement.

$$V_{IP} = 8.02 \; x \; V_{oe}$$

V_{pe} = Volume of liquid removal in gpm

Scenario Output Data:

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

C – Constant per API STD 2000 Table 2

TankArea – Calculated total tank area including the roof ft^2

InsArea – Calculated total insulated tank area ft^2

Rin – Insulation reduction factor – 1.0 if not insulated

ThermalBreathing – Inbreathing requirement associated with reduction in ambient temperature or solar

PumpOutBreathing – Inbreathing requirement associated with liquid removal from the tank

RequiredRate – Sum of ThermalBreathing and PumpOutBreathing in scfh air

QA/QC Benchmarks:

Given the relative simplicity of the calculations, the thermal and pump-out inbreathing requirements were benchmarked against an internal RKR spreadsheet for a 400 bbl Gasoline Storage Tank was assumed to have 2” of insulation to a height of 19’. Both the thermal and pump-out inbreathing requirements (1,873 scfh air and 2,406 scfh air, respectively) were identical along with the total inbreathing requirement of 4,279 scfh air.

Inbreathing - API STD 2000

T-6000 Inbreathing

Equipment Data:

Equipment Tag:	**T-6000**	Type:	API 12F Tank
Drawing:	PID-6000	MAWP:	1 psig
Description:	Gasoline Storage Tank	MAWT:	120 F

Scenario Description:

The 400 BBL storage tank could be subject to vacuum in the event of liquid movement out of the tank and/or drops in ambient temperature. The required inbreathing rate was based on API STD 2000.

Scenario Input Data:

Capacity:	400	bbl
Diameter:	12	ft
Height:	20	ft
Design Vacuum:	0.5	oz/in2
Pump Out Rate:	300	gpm
Hexane or Heavier:	☐	
Liquid Temperature:	90	F
Latitude:	<42 Degrees	
Credit for Insulation:	☑	
Insulation Thickness:	2.00	in
Insulation Height:	19.00	ft
Roof Insulated:	☐	
Insulation Conductivity:	0.05	Btu/hr/ft/F
Inside Heat Transfer Coefficient:	0.70	Btu/hr/ft2/F

Scenario Output Data:

C Factor:	6.5	
Tank Surface Area:	867	ft2
Insulated Area:	716	ft2
Insulation Reduction:	0.422	
Thermal Breathing:	1,873	scfh air
Pump Out Breathing:	2,406	scfh air
Required Rate:	4,279	scfh air

Notes:

API STD 2000 Inbreathing

Thermal Inbreathing

T	90	F
C6+	No	
Latitude	40	°
Tank Volume	400	bbl
Tank Diameter	12	ft
Tank Height	20	ft
h	0.7	Btu/(hr*ft^2*F)
l_{in}	2	in
λ_{in}	0.25	Btu/(hr*ft*F)
Ins_{height}	19	ft
Include Roof	No	
A_{inp}	716.3	ft^2
C	6.5	
V_{TK}	2246	ft^3
A_{TTS}	867.1	ft^2
R_{in}	0.682	
R_{inp}	0.737	
V_{IT}	3273.5	scfh air

Pump-Out Breathing

Pump-Out Rate	300	gpm
V_{ip}	2406	scfh air

Total Inbreathing 5679.5 scfh air