

# **TANKJKT**

## **Heat Transfer Calculations for Jacketed Tanks**

### **SCREEN SHOTS**

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The following page shows the Data Input worksheet. Pop-up comment boxes and dynamic prompts guide your data entry.

**Heat Transfer in Jacketed Vessels**  
Version 3



by Stephen M. Hall, PE  
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All cells are locked except user-defined data; unlock sheet from Tools menu (no password required)  
VIEW-COMMENTS to see some additional explanations.  
Scroll down and to the right to enter data.

Project Data			
Prepared by	xx	Client	xx
Date	xx	W.O.	xx
		Unit	xx
		Area	xx
		Equip No	xx
<input type="radio"/> Customary US <input checked="" type="radio"/> SI			

To restore a saved calculation, select it from the drop-down box below, then click the "Restore Saved Calculation" button

Calculate

Temperature Conversion		
Enter value to convert:	=	287.8 °C
550 °F	=	287.8 °C
270 °C	=	518.0 °F

Vessel Data			
Calc Title or Description	Garvin Example from Table 2		
Orientation	vertical	vol to tangent	
Total working volume	liters	1,497	1,497
Inside diameter	mm	1,200.0	
Tangent-to-tangent	mm	1,200.0	
Heads	ASME Torispherical Dished		
Material of construction	316 SS		
Thickness	mm	7.000	
Lining	Glass		
Thickness	mm	0.00000	
Internal surface roughness	mm	0.00130	
Outside surface roughness	mm	0.00130	
Internal fouling factor	m <sup>2</sup> -°C/W	0.00020	
Outside fouling factor (jacket)	m <sup>2</sup> -°C/W	0.00020	
<input checked="" type="checkbox"/> Tank is Baffled			

Jacket Fluid Data			
Fluid name	Syltherm 800		
Temperature at jacket inlet	°C	95.0	
Properties from data table:			
Thermal Conductivity	W/m-°C	0.121	
Specific Heat	Joules/kg-°C	1,737.5	
Density	g/cm <sup>3</sup>	0.867	
Viscosity	Pa-s	0.00320	
Latent Heat of Vap		N/A	
Prandtl Number	dimensionless	45.9	
Vapor Pressure	kPa abs		
	at inlet	2.64	
	at wall	0.30	
	at outlet	1.05	

Vessel Fluid Data		
Name	Water	
Bulk Temp	°C	22.0
<input checked="" type="checkbox"/> Use properties of water		
Thermal Conductivity	W/m-°C	0.607
Specific Heat	Joules/kg-°C	4,183.9
Density	g/cm <sup>3</sup>	0.997
Viscosity @20C	Pa-s	0.00099
Note: k, Cp and density assumed constant at all temperatures Viscosity is adjusted, but better to enter 3 values below and check box		

Side-Wall Jacket			
<input type="radio"/> No Jacket <input type="radio"/> Conventional			
<input checked="" type="radio"/> Half-Pipe Coil <input type="radio"/> Dimple			
Inlet/Outlet Nozzle Size	DN	75	
Number of Zones		2	
Portion of side-wall covered by jacket		1	
<input type="checkbox"/> Aiding flow (upflow during cooling/downflow during heating)			

Flow Rate in Side-Wall Jacket			
Enter a value for each heat transfer surface. When one parameter is entered (flow, velocity, or pressure drop) the other two are calculated. Red value shows user entry.			
	<u>Total Flow</u>	<u>Velocity</u>	<u>Pressure Drop</u>
Sidewall Jacket	336.7 liters/min	3.0 m/s	8.8 kPa
Bottom Jacket	112.2 liters/min	2.0 m/s	2.3 kPa
Internal Coil	0.0	0.0	0.0

Agitator Data		
Impeller Type	Turbine (Rushton)	
Impeller Diameter	mm	384.0
Blade Height	mm	72.0
Blade Pitch (90 deg = upright)	degrees	90
Number of blades		6
Agitator Rotational Speed	rpm	180

### Half-Pipe Coil Jacket Data

Nominal Pipe Diameter DN

Cross section angle (180 or 120 deg) **120.0**

Spacing between Coils mm **25.0**

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### Conventional Jacket Data

**Not Applicable**

Annular space dimension mm **40.0**

Standard  Baffled  Agit. Nozzles

Number of agitation nozzles per zone **2**

Throat diameter for each nozzle mm **5.000**  
**60.0**

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### Dimple Jacket Data

**Not Applicable**

Annular space dimension mm **20.0**

Number of passes **1**

Center-to-center distance between adjacent dimples

Longitudinal mm **100.0**

Transverse mm **100.0**

Mean dimple diameter mm **75.0**

Dimple pitch  Triangular  Square

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### Bottom Head Jacket

No Jacket  Conventional

Half-Pipe Coil  Dimple

Same type as Side-Wall Jacket

**#REF!**  Series Flow

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### Internal Coil

No Coil  Hairpin

Helical  Baffle or Harp Coil

**78.7**

**4**

**2**

### Quick Results

Heat Transfer Coefficients	Process Side	HTF Side	Overall U
From Vessel to Sidewall Jacket	4,496	1,293	543 W/m <sup>2</sup> ·°C
From Vessel to Bottom Jacket	3,469	904	446 W/m <sup>2</sup> ·°C
From Vessel to Coil			

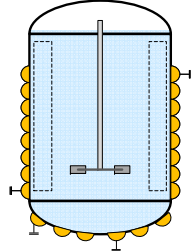
  

Fluid Flow	Flow Rate	Velocity	Pressure Drop
Sidewall Jacket (each zone)	168.3 liters/min	3.0 m/s	8.8 kPa
Sidewall Jacket (combined)	336.7 liters/min	3.0 m/s	8.8 kPa
Bottom Jacket (in parallel with sidewall)	112.2 liters/min	2.0 m/s	2.3 kPa
Internal Coil			

Temperature Effects	Inlet	Outlet	Heat Transferred
Sidewall Jacket	95.0	78.6 °C	137,909 W
Bottom Jacket	95.0	81.1 °C	39,106 W
Internal Coil			
Top Head			-164 W
Agitator	Estimated power	0.4 kW	
	x percent transferred as heat	35%	147 W
Vessel Contents	22.0		W

Vessel contents will heat at the rate of 1.70°C per minute



### Environmental Conditions

Air temperature °C **-5.0**

Wind speed m/s **2.0**

Tank insulation Type

Covering (on insulated surfaces)

(if uninsulated, enter "0" thickness) Thickness

	mm	Thickness
Sidewall	<b>25.0</b>	
Bottom head	<b>25.0</b>	
Top head	<b>0.0</b>	

### Viscosity for Fluid inside the Vessel

Viscosity data at three temperatures  Use this data

Temp. °F	Temp. °K	Visc. cP
<b>68</b>	293	<b>0.578</b>
<b>104</b>	313	<b>0.446</b>
<b>140</b>	333	<b>0.347</b>

0.97

Viscosity coefficients

	A	B	C
	-16.56	19,462.31	922.21

Temperature of interest **77 °F**

Predicted viscosity 0.54 cP

298.15 °K

### Use this section when you have experimental pressure drop data

Input the known conditions

	Flowrate liter/min	Viscosity mPa-s	Density g/cm <sup>3</sup>	Press Drop kPa	Use Experimental Pressure Drop Data
Sidewall (one zone)	<b>39.6</b>	<b>1</b>	<b>62.4</b>	<b>19.6</b>	<input type="checkbox"/> Sidewall
Bottom Head	<b>22.5</b>	<b>1</b>	<b>62.4</b>	<b>6.5</b>	<input type="checkbox"/> Bottom Head

See the instruction manual for further information about the use of this pressure drop technique

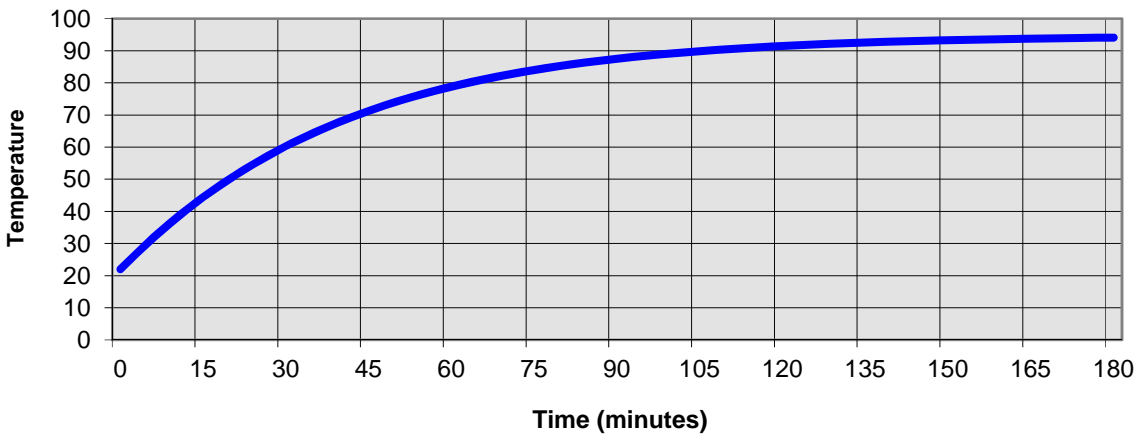
Two pre-formatted reports are included. The first summarizes the input data, and presents the calculation results. The second includes a timeline, calculated using 60 “time slices” at a user-defined interval.

Because this is a spreadsheet, it’s easy to customize the reports. Add your logo and address.

The report formats complement chemengsoftware’s other products such as PIPESIZE, VentManifold, and others.

chemeng software.com				JACKETED VESSEL HEAT TRANSFER		
				CLIENT	EQUIP. NO	PAGE
				xx	xx	
REV	PREPARED BY	DATE	APPROVAL	W.O.	REQUISITION NO.	SPECIFICATION NO.
0	xx	xx		xx		
1				UNIT	AREA	PROCURED BY
2				xx	xx	INSTALLED BY
<b>Garvin Example from Table 2</b>						
1	<b>Vessel Data</b>					
2	Orientation	vertical, cylindrical			<b>Contents</b>	Water
3	Total working volume	1,497 liters			Bulk Temperature	22 °C
4	Inside diameter	1,200 mm			Thermal Conductivity	0.607 W/m-°C
5	Tangent-to-tangent	1,200 mm			Specific Heat	4,184 Joules/kg-°C
6	Heads	ASME Torispherical Dished			Density	0.997 g/cm <sup>3</sup>
7	Material of construction	316 SS			Viscosity @20C	0.00099 Pa-s
8	Thickness	7 mm				
9	Lining	Glass				
10	Thickness	mm				
11	Internal surface roughness	0.0013 mm			<b>Agitator Type</b>	Turbine (Rushton)
12	Outside surface roughness	0.0013 mm			Impeller Diameter	384 mm
13	Internal fouling factor	0.0002 m <sup>2</sup> -°C/W			Speed	180 rpm
14	Outside fouling factor (jacket)	0.0002 m <sup>2</sup> -°C/W				
15	Vessel is baffled					
16	<b>Jacket Fluid</b>					
17	Method for determining flow rate in jacket or coil:			<b>Fluid Name</b>	Syltherm 800	
18	Target Velocity			Temperature at jacket ii	95 °C	
19	Value 3 m/s			Thermal Conductivity	0.122 W/m-°C	
20	Pressure drop in sidewall determines flow in bottom jacket			Specific Heat	1,725.8 Joules/kg-°C	
21	Syltherm 800			Density	0.874 g/cm <sup>3</sup>	
22	Dow Chemical Co.			Viscosity	0.00350 Pa-s	
23	Polydimethyl-siloxane					
24	Estimated vessel wall temp. 29.745 °C			Prandtl Number	46 dimensionless	
25	Approx. max. vapor pressure 2.6396 kPa abs					
26	<b>Jacket and Coil Data</b>					
27	Sidewall Jacket Type	Half-Pipe Coil	Pipe size: 3 DN; 120 deg included angle; 25 mm between loops			
28	11 loops divided into 2 zones; 4 m <sup>2</sup> total heat transfer area					
29	Bottom Jacket Type	Half-Pipe Coil	Pipe size: 3 DN; 120 deg included angle; 25 mm between loops			
30	1 m <sup>2</sup> heat transfer area; piped in parallel with sidewall					
31	Internal Coil Type	No Coil				
32						
33	Environmental: -5°C, 2 m/s; Sidewall, Bottom, Calcium Silicate insulation					
34	<b>Calculated Results</b>					
35	<b>Heat Transfer Coefficients</b>		Process Side	Wall	HTF Side	Overall U
36	From Vessel to Sidewall Jacket		4,496	1,181	1,293	543 W/m <sup>2</sup> -°C
37	From Vessel to Bottom Jacket		3,469	1,182	904	446 W/m <sup>2</sup> -°C
38	From Vessel to Coil					
39						
40	<b>Fluid Flow</b>		Flow Rate	Velocity	Pressure Drop	
41	Sidewall Jacket (each zone)		168.3 liters/min	3.0 m/s	8.8 kPa	
42	Sidewall Jacket (combined)		336.7 liters/min	3.0 m/s	8.8 kPa	
43	Bottom Jacket (in parallel with sidewall)		112.2 liters/min	2.0 m/s	2.3 kPa	
44	Internal Coil					
45	<b>Temperature Effects</b>		Inlet	Outlet	Surface	Heat Transferred
46	Sidewall Jacket		95.0	78.6 °C	13.0 °C	137,909 W
47	Bottom Jacket		95.0	81.1 °C	13.0 °C	39,106 W
48	Internal Coil					
49	Top Hea	95.0	95.0	95.0	95.0	8.5 °C
50	Agitator	0 kW		x 35%		147 W
51	Vessel Contents	22.0 °C				176,998 W
52	Vessel contents will heat at the rate of 1.7 degC per minute					

chemeng software.com				JACKETED VESSEL HEAT TRANSFER		
REV	PREPARED BY	DATE	APPROVAL	CLIENT	EQUIP. NO	PAGE
0	xx	xx		xx	xx	
1				W.O.	REQUISITION NO.	SPECIFICATION NO.
2				xx	xx	
				UNIT	AREA	PROCURED BY
				xx	xx	INSTALLED BY
<b>Garvin Example from Table 2</b>						
1	<b>Vessel Data</b>					
2	Orientation	vertical, cylindrical			<b>Contents</b>	Water
3	Total working volume	1,497 liters			Bulk Temperature	22 °C
4	Inside diameter	1,200 mm			Thermal Conductivity	0.607 W/m-°C
5	Tangent-to-tangent	1,200 mm			Specific Heat	4,184 Joules/kg-°C
6	Heads	ASME Torispherical Dished			Density	0.997 g/cm³
7	Material of construction	316 SS			Viscosity @20C	0.00099 Pa-s
8	Thickness	7 mm				
9	Lining	Glass				
10	Thickness	mm				
11	Internal surface roughness	0.0013 mm			<b>Agitator Type</b>	Turbine (Rushton)
12	Outside surface roughness	0.0013 mm			Impeller Diameter	384 mm
13	Internal fouling factor	0.0002 m²-°C/W			Speed	180 rpm
14	Outside fouling factor (jacket)	0.0002 m²-°C/W				
15	Vessel is baffled					
16	<b>Jacket Fluid</b>					
17	Method for determining flow rate in jacket or coil:				<b>Fluid Name</b>	Syltherm 800
18	Target Velocity				Temperature at jacket ii	95 °C
19	Value 3 m/s				Thermal Conductivity	0.122 W/m-°C
20					Specific Heat	1,725.8 Joules/kg-°C
21	Pressure drop in sidewall determines flow in bottom jacket				Density	0.874 g/cm³
22					Viscosity	0.00350 Pa-s
23						
24	Estimated vessel wall temp.	29.745 °C			Prandtl Number	45.9 dimensionless
25						
26	<b>Jacket and Coil Data</b>					
27	Sidewall Jacket Type	Half-Pipe Coil	Pipe size: 3 DN; 120 deg included angle; 25 mm between loops			
28			11 loops divided into 2 zones; 4 m2 total heat transfer area			
29	Bottom Jacket Type	Half-Pipe Coil	Pipe size: 3 DN; 120 deg included angle; 25 mm between loops			
30			1 m2 heat transfer area; piped in parallel with sidewall			
31	Internal Coil Type	No Coil				
32						
33	Environmental: -5°C, 2 m/s; Sidewall, Bottom, Calcium Silicate insulation					
34	<b>Timeline (calculated at 3-minute intervals)</b>					
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Calculations are performed in open-source Visual Basic for Applications (VBA) macros. The results are collected into an array that is output to a worksheet. This makes it easy to review the results without any clutter.



## Heat Transfer in Jacketed Vessels

Version 3

### Result Details

	1	2	3	4	
	Sidewall	Bottom	Coil	Top Head	
HTF Film Coefficient, ho	1,293	904	0.0000		W/m2-C
Process Film Coefficient, hi	4,496	3,469	0.0000	7.95	W/m2-C
Overall Coefficient, U	543	446	0.0000	3.96	W/m2-C
Heat Transferred, Q	137,909	39,106	0	-164	W
HTF Flow Rate	17,511	5,837	0.0000		kg/h
HTF Pressure Drop	8.76	2.28	0.0000		kPa
HTF Velocity	3.0	2.0	0.000		m/s
HTF Temperature In	95.0	95.0	0.0		C
HTF Temperature Out	78.6	81.1	0.0		C
HTF Temperature Average	86.8	88.0	0.0		C
HTF Temperature Wall	59.9	55.7	0.0		C
Process Temperature	22.0	22.0	22.0	22.0	C
Process Temperature Wall	29.7	30.4	22.0	8.5	C
Wall Coefficient, hw	1,181.3	1,181.6	0.00000	1,511.8	W/m2-C
Agitator Power	419.9	147.0			W
Environmental film coefficient, he	9.176	2.850		7.948	W/m2-C
Jacket-to-environment Ue	1.80	1.26			W/m2-C
Jacket-to-environment Qe	-749	-156			W
Process-to-environment Ue				3.96	W/m2-C
Process-to-environment Qe				-164	W
Surface Temperature	13.0	36.0		8.5	C