

**THERMAL DESIGN (HTRI)
CALCULATION FOR
LUBE OIL COOLER
(ITEM NO.117-EE-487)**

 Enriching Lives	REFRIGERATION PACKAGE 117-LZ-480	KIRLOSKAR PNEUMATIC CO. LTD.
TITLE: HTRI FOR OIL COOLER (ITEM NO: 117-EE-487)		Doc. No: PRJ/9742/04 Rev. 1

No. of Pages 13 Including this sheet

OWNER : BCPL- LEPETKATA, DIBRUGARH ASSAM

PROJECT : BRAHMAPUTRA PETROCHEMICAL COMPLEX PROJECT

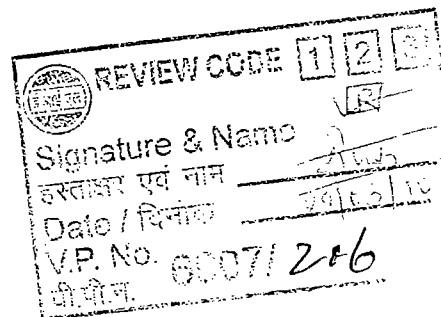
UNIT : 220 KTA-LLDPE/HDPE

PMC : ENGINEERS INDIA LIMITED, NEW DELHI

EIL JOB NO. : 6907

VENDOR : KIRLOSKAR PNEUMATIC CO. LTD, PUNE

KPCL JOB NO. : 9742



1	SHELL IN/OUT NOZZLE SIZE REVISED	KK	KK	RCS	04/03/2010
0	ISSUED FOR INFORMATION	KK	KK	RCS	18/01/2010
Rev.	Description	Prepared by	Reviewed by	Approved by	Approved Date

Output Summary

Page 1

Released to the following HTRI Member Company:

KPCL

Kannan

Xist Ver. 6.00 SP1 20/01/2010 19:15 SN: 1500214140

MKH Units

Lube Oil Cooler

Rating - Horizontal Multipass Flow TEMA BEM Shell With Single-Segmental Baffles

No Data Check Messages.

Process Conditions		Hot Shellside		Cold Tubeside	
Fluid name		Lube Oil		Water	
Flow rate (1000-kg/hr)		9.0185		22.0326	
Inlet/Outlet Y (Wt. frac vap.)		0.000	0.000	0.000	0.000
Inlet/Outlet T (Deg C)		100.28	50.00	33.00	43.00
Inlet P/Avg (kgf/cm2A)		25.169	25.085	5.000	4.758
dP/Allow. (kgf/cm2)		0.168	0.300	0.483	0.800
Fouling (m2-hr-C/kcal)		0.000200		0.000400	
Exchanger Performance					
Shell h (kcal/m2-hr-C)		290.39	Actual U (kcal/m2-hr-C)	225.74	
Tube h (kcal/m2-hr-C)		5190.55	Required U (kcal/m2-hr-C)	199.31	
Hot regime (--)		Sens. Liquid	Duty (MM kcal/hr)	0.2199	
Cold regime (--)		Sens. Liquid	Area (m2)	39.080	
EMTD (Deg C)		28.2	Overdesign (%)	13.26	
Shell Geometry			Baffle Geometry		
TEMA type (--)		BEM	Baffle type (--)		Single-Seg.
Shell ID (mm)		400.000	Baffle cut (Pct Dia.)		25.00
Series (--)		1	Baffle orientation (--)		Perpend.
Parallel (--)		1	Central spacing (mm)		100.000
Orientation (deg)		0.00	Crosspasses (--)		36
Tube Geometry			Nozzles		
Tube type (--)		Plain	Shell inlet (mm)		52.502
Tube OD (mm)		20.000	Shell outlet (mm)		52.502
Length (mm)		4100.	Inlet height (mm)		27.934
Pitch ratio (--)		1.2500	Outlet height (mm)		27.934
Layout (deg)		30	Tube inlet (mm)		52.502
Tubecount (--)		154	Tube outlet (mm)		52.502
Tube Pass (--)		6			
Thermal Resistance, %		Velocities, m/s		Flow Fractions	
Shell	77.74	Shellside	0.20	A	0.041
Tube	5.44	Tubeside	1.23	B	0.444
Fouling	15.81	Crossflow	0.29	C	0.066
Metal	1.02	Window	0.16	E	0.290
				F	0.159

Final Results

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MKH Units

Lube Oil Cooler

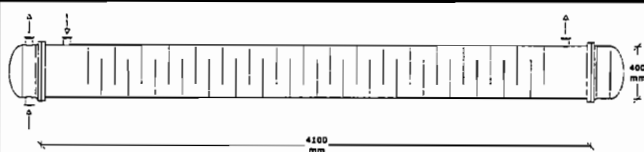
Rating - Horizontal Multipass Flow TEMA BEM Shell With Single-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name	Lube Oil			Water	
Fluid condition		Sens. Liquid		Sens. Liquid	
Total flow rate	(1000-kg/hr)	9.0185		22.0326	
Weight fraction vapor, In/Out	(--)	0.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	100.28	50.00	33.00	43.00
Temperature, Average/Skin	(Deg C)	75.14	45.06	38.00	39.91
Wall temperature, Min/Max	(Deg C)	36.91	53.93	36.77	53.31
Pressure, In/Average	(kgf/cm2A)	25.169	25.085	5.000	4.758
Pressure drop, Total/Allowed	(kgf/cm2)	0.168	0.300	0.483	0.800
Velocity, Mid/Max allow	(m/s)	0.20		1.23	
Mole fraction inert	(--)				
Average film coef.	(kcal/m2-hr-C)		290.39		5190.55
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(m2-hr-C/kcal)		0.000200		0.000400

Overall Performance Data

Overall coef., Req'd/Clean/Actual	(kcal/m2-hr-C)	199.31	/	268.14	/	225.74
Heat duty, Calculated/Specified	(MM kcal/hr)	0.2199	/	0.2000		
Effective overall temperature difference	(Deg C)	28.2				
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	30.49	*	0.9257	*	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside (L)	301.2
Approximate tubeside (L)	225.6

Shell Construction Information

TEMA shell type	BEM	Shell ID	(mm)	400.000
Shells Series	1 Parallel 1	Total area	(m2)	39.671
Passes Shell	1 Tube 6	Eff. area	(m2/shell)	39.080
Shell orientation angle (deg)	0.00			
Impingement present	No			
Pairs seal strips	1	Passlane seal rods (mm)	20.000	No. 3
Shell expansion joint	No	Rear head support plate	No	
Weight estimation Wet/Dry/Bundle	1947.8 / 1421.3 / 691.85			(kg/shell)

Baffle Information

Type	Perpend. Single-Seg.	Baffle cut (% dia)	25.00
Crosspasses/shellpass	36	No. (Pct Area)	(mm) to C.L
Central spacing	(mm) 100.000	1	21.44 100.000
Inlet spacing	(mm) 319.407	2	0.00 0.000
Outlet spacing	(mm) 319.407		
Baffle thickness	(mm) 4.763		

Tube Information

Tube type	Plain	Tube count per shell	154
Overall length	(mm) 4100.	Pct tubes removed (both)	3.25
Effective length	(mm) 4039.	Outside diameter	(mm) 20.000
Total tubesheet	(mm) 61.145	Wall thickness	(mm) 2.000
Area ratio	(out/in) 1.2500	Pitch (mm)	25.0000 Ratio 1.2500
Tube metal	Carbon steel	Tube pattern (deg)	30

Final Results

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MKH Units

Lube Oil Cooler

Rating - Horizontal Multipass Flow TEMA BEM Shell With Single-Segmental Baffles

Shellside Performance

Nom vel, X-flow/window 0.29 / 0.16

Flow fractions for heat transfer 0.559

A=0.0414 B=0.4442 C=0.0658 E=0.2898 F=0.1588

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.920	0.920	1.000	0.952	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
75.79	9.41	2.51	Inlet	5.95	9.32
MOMENTUM		0.00	Outlet	6.35	5.95

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F
--------	-------	--------	--------	-------

H. T. Parameters

Shell	Tube
-------	------

Overall wall correction	0.909	1.003
Midpoint Prandtl no.	502.63	4.49
Midpoint Reynolds no.	110	28920
Bundle inlet Reynolds no.	117	24138
Bundle outlet Reynolds no.	29	29181
Fouling layer (mm)		

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
77.74	5.44	15.81	1.02	13.26
Total fouling resistance				7.000e-4
Differential resistance				5.874e-4

Shell Nozzles

Inlet at channel end-Yes	Inlet	Outlet	Liquid Outlet
Number at each position	1	1	0
Diameter (mm)	52.502	52.502	
Velocity (m/s)	1.24	1.20	
Pressure drop (kgf/cm2)	0.010	0.011	
Height under nozzle (mm)	27.934	27.934	
Nozzle R-V-SQ (kg/m-s2)	1433.48	1393.32	
Shell ent. (kg/m-s2)	280.34	272.48	

Tube Nozzle

	Inlet	Outlet	Liquid Outlet
	RADIAL	RADIAL	
Diameter (mm)	52.502	52.502	
Velocity (m/s)	2.84	2.85	
Pressure drop (kgf/cm2)	0.045	0.029	
Nozzle R-V-SQ (kg/m-s2)	8032.82	8062.53	

Annular Distributor

	Inlet	Outlet
Length (mm)		
Height (mm)		
Slot area (mm2)		

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
3.1750	20.1513	0.7938

Supplementary Results

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MKH Units

Lube Oil Cooler

Rating - Horizontal Multipass Flow TEMA BEM Shell With Single-Segmental Baffles

Externally Enhanced Tube Geometry			Internally Enhanced Tube Geometry		
Type		Plain	Type		None
Fin density	(fin/meter)		Thickness	(mm)	
Fin height	(mm)		Pitch	(L/D)	
Fin thickness	(mm)				
Root diameter	(mm)				
Area/length	(m2/m)	0.1880			

Mean Metal Temperatures

Mean shell temperature 68.57 (C)

Mean tube metal temperature in each tubepass, (C)

<u>Tube Pass</u>	<u>Inside</u>	<u>Outside</u>	<u>Radial</u>
1	39.79	40.12	39.97
2	40.81	41.13	40.98
3	43.37	43.71	43.55
4	44.40	44.73	44.57
5	45.44	45.71	45.58
6	46.34	46.60	46.48

Vibration Analysis

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MKH Units

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Rating - Horizontal Multipass Flow TEMA BEM Shell With Single-Segmental Baffles

Shellside condition		Sens. Liquid	(Level 2.3)	
Axial stress loading	(kg/mm2)	0.000	Added mass factor	1.761
Beta		4.000		
Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(mm)	419.	200.	419.
Length/TEMA maximum span	(--)	0.266	0.127	0.266
Number of spans	(--)	18	18	18
Tube natural frequency	(Hz)	396.2	938.1	394.4 +
Shell acoustic frequency	(Hz)			
Flow Velocities		Inlet	Center	Outlet
Window parallel velocity	(m/s)	0.16	0.15	0.15
Bundle crossflow velocity	(m/s)	6.102e-2	0.20	5.931e-2
Bundle/shell velocity	(m/s)	2.740e-2	9.044e-2	2.663e-2
Fluidelastic Instability Check		Inlet	Center	Outlet
Log decrement	HTRI	0.038	0.038	0.060
Critical velocity	(m/s)	12.73	55.69	15.85
Baffle tip cross velocity ratio	(--)	0.0051	0.0039	0.0040
Average crossflow velocity ratio	(--)	0.0048	0.0036	0.0037
Acoustic Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)			
Chen number	(--)			
Turbulent buffeting ratio	(--)			
Tube Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.001	0.005	0.001
Parallel flow amplitude	(mm)	0.000	0.000	0.000
Crossflow amplitude	(mm)	0.000	0.000	0.000
Tube gap	(mm)	5.000	5.000	5.000
Crossflow RHO-V-SQ	(kg/m-s2)	3.48	38.50	3.38
Bundle Entrance/Exit			Entrance	Exit
(analysis at first tube row)				
Fluidelastic instability ratio	(--)		0.007	0.006
Vortex shedding ratio	(--)		0.004	0.004
Crossflow amplitude	(mm)		0.00004	0.00003
Crossflow velocity	(m/s)		0.16	0.16
Tubesheet to inlet/outlet support	(mm)		None	None
Shell Entrance/Exit Parameters			Entrance	Exit
Impingement plate			No	
Flow area	(m2)		4.895e-3	4.895e-3
Velocity	(m/s)		0.55	0.53
RHO-V-SQ	(kg/m-s2)		280.34	272.48
Shell type	BEM	Baffle type	Single-Seg.	
Tube type	Plain	Baffle layout	Perpend.	
Pitch ratio	1.2500	Tube diameter, (mm)	20.000	
Layout angle	30	Tube material	Carbon steel	
		Supports/baffle space		

Program Messages

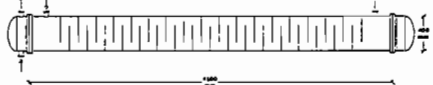
+ Frequency ratios are based upon lowest natural or acoustic frequency

* Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case using the procedure described in Online Help; You may find that a vibration problem is unlikely.

HEAT EXCHANGER RATING DATA SHEET

Page 6

MKH Units

Service of Unit		Lube Oil Cooler		Item No.	
Type	BEM	Orientation	Horizontal	Connected In	1 Parallel 1 Series
Surf/Unit (Gross/Eff)		39.67 / 39.08 m ²		Shell/Unit	1
				Surf/Shell (Gross/Eff)	39.67 / 39.08 m ²
PERFORMANCE OF ONE UNIT					
Fluid Allocation		Shell Side		Tube Side	
Fluid Name		Lube Oil		Water	
Fluid Quantity, Total		1000-kg/hr		9.0185	
Vapor (In/Out)		wt%		0.0	
Liquid		wt%		100.0	
Temperature (In/Out)		C		100.28	
Density		kg/m ³		934.07	
Viscosity		cP		12.439	
Specific Heat		kcal/kg-C		0.5050	
Thermal Conductivity		kcal/hr-m-C		0.1305	
Critical Pressure		kgf/cm ² A		25.169	
Inlet Pressure		kgf/cm ² A		5.000	
Velocity		m/s		0.20	
Pressure Drop, Allow/Calc		kgf/cm ²		0.300	
Average Film Coefficient		kcal/m ² -hr-C		290.39	
Fouling Resistance (min)		m ² -hr-C/kcal		0.000200	
Heat Exchanged		0.2199 MM kcal/hr		MTD (Corrected) 28.2 C	
Transfer Rate, Service		199.31 kcal/m ² -hr-C		Calculated 225.74 kcal/m ² -hr-C	
				Clean 268.14 kcal/m ² -hr-C	
CONSTRUCTION OF ONE SHELL					
		Shell Side		Tube Side	
Design Pressure		kgf/cm ² G		26.699	
Design Temperature		C		120.00	
No Passes per Shell		1		6	
Flow Direction				Upward	
Connections		In mm		1 @ 52.502	
Size & Rating		Out mm		1 @ 52.502	
		Liq. Out mm		@	
					
Tube No.		154 OD 20.000 mm		Thk(Avg) 2.000 mm	
				Length 4100. mm	
				Pitch 25.000 mm	
				Layout 30	
Tube Type		Plain		Material CARBON STEEL (LTCS)	
Shell ID		400.000 mm		Kettle ID mm	
Cross Baffle Type		PERPEND. SINGLE-SEG.		%Cut (Diam) 25.00	
Spacing(c/c)		100.000 mm		Inlet 319.407 mm	
Rho-V2-Inlet Nozzle		1433.48 kg/m-s ²		Shell Entrance 280.34	
				Bundle Entrance 24.06	
Weight/Shell		1421.35		Filled with Water 1947.83	
				Bundle 691.85 kg	
Notes:					
		Thermal Resistance, %		Velocities, m/s	
		Shell 77.74		Shellside 0.20	
		Tube 5.44		Tubeside 1.23	
		Fouling 15.81		Crossflow 0.29	
		Metal 1.02		Window 0.16	
Reported duty and flow rates include a user-specified multiplier of 1.10.				Flow Fractions	
				A 0.041	
				B 0.444	
				C 0.066	
				E 0.290	
				F 0.159	

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MKH Units

Rating - Horizontal Multipass Flow TEMA BEM Shell With Single-Segmental Baffles

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Stream Properties

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MKH Units

Lube Oil Cooler

Rating - Horizontal Multipass Flow TEMA BEM Shell With Single-Segmental Baffles

Cold Tubeside Fluid	Inlet			Outlet		
Fluid name	Water					
Temperature (C)	33.00			43.00		
Pressure (kgf/cm2A)	5.000			4.516		
Weight fraction vapor (--)	0.0000			0.0000		
Vapor Properties						
Density (kg/m3)	--			--		
Viscosity (cP)	--			--		
Conductivity (kcal/hr-m-C)	--			--		
Heat capacity (kcal/kg-C)	--			--		
Molecular weight (--)	--			--		
Liquid Properties						
Density (kg/m3)	994.877			991.210		
Viscosity (cP)	0.7488			0.6177		
Conductivity (kcal/hr-m-C)	0.5328			0.5440		
Heat capacity (kcal/kg-C)	0.9986			0.9985		
Molecular weight (--)	18.02			18.02		
Latent heat (kcal/kg)	--			--		
Surface tension (dyne/cm)	70.7188			69.1044		
Molar Composition						
1 Water (IAPWS 1997)	Vapor	Liquid	K-Value	Vapor	Liquid	K-Value
	--	--	--	--	--	--

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MKH Units

Lube Oil Cooler

Rating - Horizontal Multipass Flow TEMA BEM Shell With Single-Segmental Baffles

Shell Data

Service type	Generic Shell and Tube
TEMA type	BEM
Run mode	Rating
Hot fluid location	Shellside
Number of shells in series	1
Number of shells in parallel	1
Shell inside diameter	400.000 mm
Flow in 1st tubepass	Cocurrent
Train flow direction	Countercurrent

Reboiler Data

Reboiler type	No piping specified
Inlet pressure location	Inlet nozzle

Tube Data

Tube type	Plain
Tube outside diameter	20.000 mm
Tube wall thickness	2.000 mm
Tube pitch	25.000 mm
Tube pitch ratio	1.250
Tubepasses per shell	6
Tube pattern	30 degrees
Tube count method	Rigorous
Tube length	4100. mm
Tube material	Carbon steel

Tubepass Arrangement Data

Force symmetric layout	No
Force cleaning lanes	No
Tubepass layout	Mixed or H-banded
First tubepass location	Program sets
Tubes to remove for tie rods	Calculated

Baffle Data

Baffle type	Single segmental
Baffle orientation	Program sets
Baffle cut percent	25 % shell ID
Central baffle spacing	100.000 mm
Variable baffle spacing	No
Window cut from baffles	No

Clearance Data

Number of seal strip pairs	Calculated
Baffle clearance type	TEMA
Block A stream	No
Block E stream	No
Block F stream	No
Number of passlane seal rods	Calculated

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Nozzle Data

Shellside inlet ID	52.502 mm
Number of shellside inlet nozzles	1
Shellside outlet ID	52.502 mm
Number of shellside outlet nozzles	1
Tubeside inlet ID	52.502 mm
Number of tubeside inlet nozzles	1
Tubeside outlet ID	52.502 mm
Number of tubeside outlet nozzles	1
Radial position on shell inlet nozzle	Top
Longitudinal position on shell of inlet nozzle	At front head
Radial position on shell outlet nozzle	Same side
Tubeside entry type	Radial
Tubeside inlet position	Front head
Tubeside exit type	Same as inlet
Front head location	Left

Impingement Data

Impingement device present	No
Impingement type	Circular plate

Optional Geometry Data

Small exchanger	No
Tubesheet type	Single
Shell expansion joint	No
Floating head support type	None
Insulated longitudinal baffle	No
Tubeside design temperature	80.00 C
Tubeside design pressure	20.600 kgf/cm2G
Shellside design temperature	120.00 C
Shellside design pressure	26.700 kgf/cm2G

Process Conditions Data

	Hot Fluid	Cold Fluid
Phase condition	Sensible liquid	Sensible liquid
Inlet vapor fraction	0	0
Outlet vapor fraction	0	0
Inlet temperature	100.28	33.00 C
Outlet temperature	50.00	43.00 C
Inlet pressure	25.170	5.000 kgf/cm2A
Allowable pressure drop	0.300	0.800 kgf/cm2
Exchanger duty		0.2000 MM kcal/hr
Duty multiplier		1.1

Process Fouling Data

	Hot Fluid	Cold Fluid
Fouling resistance	2.000e-4	4.000e-4 m2-hr-C/kcal

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Hot Fluid Property Data

Fluid name	Lube Oil
Physical property method	Bulk properties via grid
Heat release method	User specified via TP grid
Flash type	Integral
Quantity units	Weight
Temperature interpolation option	Program
Heat release type	Specific enthalpy

Hot Fluid Physical Property Data

Pressure Set, 24.000 kgf/cm2A				
Temp.	Liquid Density	Liquid Dynamic Viscosity	Liquid Thermal Cond.	Liquid Heat Capacity
C	kg/m3	cP	kcal/hr-m-C	kcal/kg-C
37.78	973.020	61.5600	0.1339	0.4600
65.56	949.054	38.5800	0.1324	0.4800
93.33	937.071	15.6000	0.1309	0.5000

Pressure Set, 26.000 kgf/cm2A				
Temp.	Liquid Density	Liquid Dynamic Viscosity	Liquid Thermal Cond.	Liquid Heat Capacity
C	kg/m3	cP	kcal/hr-m-C	kcal/kg-C
37.78	973.020	61.5600	0.1339	0.4600
65.56	949.054	38.5800	0.1324	0.4800
93.33	937.071	15.6000	0.1309	0.5000

Cold Fluid Property Data

Fluid name	Water
Physical property method	Component by component properties
Heat release method	Program calculated
Flash type	Integral
Quantity units	Weight
Temperature interpolation option	Program
Number of components	1
Property package	HTRI

Cold Fluid Component Data

Component number	1
Component name	Water (IAPWS 1997)
Comp. bank name	Water (IAPWS 1997)
Component bank	HTRI
Component code	1
Component phase	Liquid
Component quantity	1

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Control Name Data

Case name	Lube Oil Cooler
Service	Lube Oil Cooler
Customer	BCPL
Plant	Assam

Control Methods Data

Shellside friction factor method	Commercial
Tubeside friction factor method	Commercial
Pure longitudinal flow	No
Pure component condensation	No
Condensing correlation	HTRI Proration
Mole fraction inerts	0
Momentum exclusion	0 %
Pure component boiling	No
Check film boiling	Yes
Nucleate boiling method	Physical property/theoretical boiling range
Component boiling method	Nucleate and convective

Control User-Defined Methods Data

Add non-nucleate boiling	Yes
--------------------------	-----

Control Vibration Data

Damping factor method	HTRI Method
Include inlet vibration support	No
Include outlet vibration support	No