

**THERMAL DESIGN (HTRI)
CALCULATION FOR CONDENSER
(ITEM NO.117-EE-485)**



Enriching Lives

REFRIGERATION PACKAGE

117-LZ-480

KIRLOSKAR PNEUMATIC CO.
LTD.

TITLE: HTRI FOR CONDENSER
(ITEM NO: 117-EE-485)

Doc. No: PRJ/9742/03

Rev. 1

No. of Pages 13

Including this sheet

OWNER : BCPL- LEPETKATA, DIBRUGARH ASSAM

PROJECT : BRAHMAPUTRA PETROCHEMICAL COMPLEX PROJECT

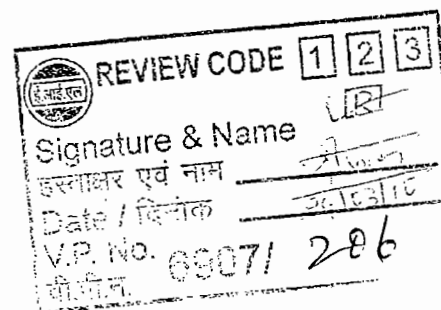
UNIT : 220 KTA-LLDPE/HDPE

PMC : ENGINEERS INDIA LIMITED, NEW DELHI

EIL JOB NO. : 6907

VENDOR : KIRLOSKAR PNEUMATIC CO. LTD, PUNE

KPCL JOB NO. : 9742



1	SHELL INLET NOZZLE 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 18:51 SN: 1500214140

MKH Units

Condenser

Condenser

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

No Data Check Messages.

Process Conditions		Hot Shellside		Cold Tubeside	
Fluid name		Propylene vapour		Cooling water	
Flow rate (1000-kg/hr)		8.2390 *		68.4465	
Inlet/Outlet Y (Wt. frac vap.)		1.000	0.000	0.000	0.000
Inlet/Outlet T (Deg C)		80.02	47.06	33.00	43.00
Inlet P/Avg (kgf/cm2A)		19.680	19.670	5.000	4.602
dP/Allow. (kgf/cm2)		0.018	0.100	0.797	0.800
Fouling (m2-hr-C/kcal)		0.000200		0.000400	
Exchanger Performance					
Shell h (kcal/m2-hr-C)		1496.14	Actual U (kcal/m2-hr-C)	618.59	
Tube h (kcal/m2-hr-C)		6146.71	Required U (kcal/m2-hr-C)	558.03	
Hot regime (--)		Gravity	Duty (MM kcal/hr)	0.7045	
Cold regime (--)		Sens. Liquid	Area (m2)	136.600	
EMTD (Deg C)		9.2	Overdesign (%)	10.85	
Shell Geometry			Baffle Geometry		
TEMA type (--)		BEM	Baffle type (--)		Single-Seg.
Shell ID (mm)		600.000	Baffle cut (Pct Dia.)		30.00
Series (--)		1	Baffle orientation (--)		Parallel
Parallel (--)		1	Central spacing (mm)		300.000
Orientation (deg)		0.00	Crosspasses (--)		17
Tube Geometry			Nozzles		
Tube type (--)		Plain	Shell inlet (mm)		154.051
Tube OD (mm)		20.000	Shell outlet (mm)		102.261
Length (mm)		5600.	Inlet height (mm)		56.187
Pitch ratio (--)		1.2500	Outlet height (mm)		28.001
Layout (deg)		60	Tube inlet (mm)		102.261
Tubecount (--)		394	Tube outlet (mm)		102.261
Tube Pass (--)		6			
Thermal Resistance, %		Velocities, m/s		Flow Fractions	
Shell	41.35	Shellside	0.50	A	0.198
Tube	12.58	Tubeside	1.49	B	0.469
Fouling	43.33	Crossflow	0.72	C	0.044
Metal	2.74	Window	0.78	E	0.134
				F	0.155

Final Results

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MKH Units

Condenser

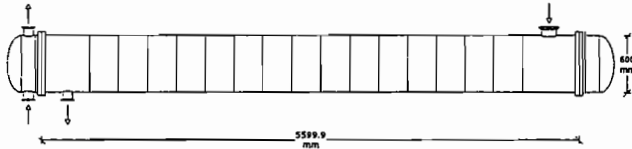
Condenser

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

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		Propylene vapour		Cooling water	
Fluid condition		Cond. Vapor		Sens. Liquid	
Total flow rate	(1000-kg/hr)		8.2390 *		68.4465
Weight fraction vapor, In/Out	(-)	1.000	0.000	0.000	0.000
Temperature, In/Out	(Deg C)	80.02	47.06	33.00	43.00
Temperature, Average/Skin	(Deg C)	63.54	44.37	38.00	40.09
Wall temperature, Min/Max	(Deg C)	39.75	47.69	39.36	47.35
Pressure, In/Average	(kgf/cm2A)	19.680	19.670	5.000	4.602
Pressure drop, Total/Allowed	(kgf/cm2)	0.018	0.100	0.797	0.800
Velocity, Mid/Max allow	(m/s)	0.50		1.49	
Mole fraction inert	(-)		0.0000		
Average film coef.	(kcal/m2-hr-C)		1496.14		6146.71
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)	558.03 /	1091.56 /	618.59
Heat duty, Calculated/Specified	(MM kcal/hr)	0.7045 /	0.6400	
Effective overall temperature difference	(Deg C)	9.2		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg C)	9.27 *	0.9958 *	1.0000

Exchanger Fluid Volumes			
Approximate shellside (L)	874.3		
Approximate tubeside (L)	756.7		

Shell Construction Information

TEMA shell type	BEM	Shell ID	(mm)	600.000
Shells Series	1 Parallel 1	Total area	(m2)	138.630
Passes Shell	1 Tube 6	Eff. area	(m2/shell)	136.600
Shell orientation angle (deg)	0.00			
Impingement present	Circular plate	Impingement diameter/nozzle		1.1
Pairs seal strips	3	Passlane seal rods (mm)	20.000	No. 10
Shell expansion joint	No	Rear head support plate	No	
Weight estimation Wet/Dry/Bundle		5538.0 /	3908.1 /	2150.6 (kg/shell)

Baffle Information

Type	Parallel Single-Seg.	Baffle cut (% dia)	30.00
Crosspasses/shellpass	17	No. (Pct Area)	(mm) to C.L
Central spacing	(mm) 300.000	1	25.64 120.000
Inlet spacing	(mm) 555.942	2	0.00 0.000
Outlet spacing	(mm) 461.988		
Baffle thickness	(mm) 4.763		

Tube Information

Tube type	Plain	Tubecount per shell	394
Overall length	(mm) 5600.	Pct tubes removed (both)	6.6
Effective length	(mm) 5518.	Outside diameter	(mm) 20.000
Total tubesheet	(mm) 82.013	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)	60

Final Results

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MKH Units

Condenser

Condenser

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

Shellside Performance

Nom vel, X-flow/window 0.72 / 0.78

Flow fractions for vapor phase

A=0.1981 B=0.4686 C=0.0440 E=0.1342 F=0.1551

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.986	0.920	1.071	0.974	1.000

Pressure Drops (Percent of Total)

Cross	Window	Ends	Nozzle	Shell	Tube
49.66	19.94	7.62	Inlet	20.25	3.79
MOMENTUM		-5.15	Outlet	7.69	2.42

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F
RPM	Sens Gas	Gravity	Gravity	1.0041

H. T. Parameters

Shell

Tube

Overall wall correction		1.001
Midpoint	Prandtl no.	4.50
Midpoint	Reynolds no.	11816
Bundle inlet	Reynolds no.	43398
Bundle outlet	Reynolds no.	7397
Fouling layer	(mm)	39465

Thermal Resistance

Shell	Tube	Fouling	Metal	Over Des
41.35	12.58	43.33	2.74	10.85
Total fouling resistance				7.000e-4
Differential resistance				1.754e-4

Shell Nozzles

Inlet at channel end-No	Inlet	Outlet	Liquid Outlet
Number at each position	1	1	0
Diameter	(mm) 154.051	102.261	
Velocity	(m/s) 3.62	0.60	
Pressure drop	(kgf/cm2) 3.732e-3	1.417e-3	
Height under nozzle	(mm) 56.187	28.001	
Nozzle R-V-SQ	(kg/m-s2) 444.95	167.32	
Shell ent.	(kg/m-s2) 252.42	114.49	

Tube Nozzle

	Inlet	Outlet	Liquid Outlet
	RADIAL	RADIAL	
Diameter	(mm) 102.261	102.261	
Velocity	(m/s) 2.33	2.34	
Pressure drop	(kgf/cm2) 0.030	0.019	
Nozzle R-V-SQ	(kg/m-s2) 5385.92	5405.67	

Annular Distributor

Inlet

Outlet

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

Diametral Clearances (mm)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
4.7625	13.9261	0.7938

Supplementary Results

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MKH Units

Condenser

Condenser

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)		

Mean Metal Temperatures

Mean shell temperature 49.89 (C)

Mean tube metal temperature in each tubepass, (C)

<u>Tube Pass</u>	<u>Inside</u>	<u>Outside</u>	<u>Radial</u>
1	40.63	41.01	40.83
2	41.87	42.17	42.03
3	42.78	43.04	42.92
4	43.72	43.94	43.84
5	44.38	44.57	44.48
6	44.83	44.98	44.91

Vibration Analysis

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MKH Units

Condenser

Condenser

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

Shellside condition		Cond. Vapor	(Level 2.3)	
Axial stress loading	(kg/mm2)	0.000	Added mass factor	1.761
Beta		3.250		
Position In The Bundle		Inlet	Center	Outlet
Length for natural frequency	(mm)	856.	600.	762.
Length/TEMA maximum span	(--)	0.543	0.380	0.483
Number of spans	(--)	9	9	9
Tube natural frequency	(Hz)	108.9 +	130.2	119.1
Shell acoustic frequency	(Hz)	187.3 +		
Flow Velocities		Inlet	Center	Outlet
Window parallel velocity	(m/s)	1.33	0.65	9.702e-2
Bundle crossflow velocity	(m/s)	0.24	0.22	2.094e-2
Bundle/shell velocity	(m/s)	0.38	0.35	3.373e-2
Fluidelastic Instability Check		Inlet	Center	Outlet
Log decrement	HTRI	0.025	0.055	0.038
Critical velocity	(m/s)	10.10	21.45	4.68
Baffle tip cross velocity ratio	(--)	0.0550	0.0237	0.0104
Average crossflow velocity ratio	(--)	0.0550	0.0237	0.0104
Acoustic Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.119		
Chen number	(--)	793		
Turbulent buffeting ratio	(--)	0.127		
Tube Vibration Check		Inlet	Center	Outlet
Vortex shedding ratio	(--)	0.088	0.080	0.008
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)	10.44	18.01	1.10
Bundle Entrance/Exit			Entrance	Exit
(analysis at first tube row)				
Fluidelastic instability ratio	(--)		0.121	0.032
Vortex shedding ratio	(--)		0.553	0.068
Crossflow amplitude	(mm)		0.00835	0.00076
Crossflow velocity	(m/s)		1.51	0.19
Tubesheet to inlet/outlet support	(mm)		None	None
Shell Entrance/Exit Parameters			Entrance	Exit
Impingement plate			Yes	
Flow area	(m2)		0.025	9.929e-3
Velocity	(m/s)		2.73	0.50
RHO-V-SQ	(kg/m-s2)		252.42	114.49
Shell type	BEM	Baffle type	Single-Seg.	
Tube type	Plain	Baffle layout	Parallel	
Pitch ratio	1.2500	Tube diameter, (mm)	20.000	
Layout angle	60	Tube material	Carbon steel	
		Supports/baffle space		

Program Messages

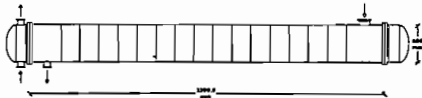
+ Frequency ratios are based upon lowest natural or acoustic frequency

* 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				Item No.			
Type	BEM			Orientation Horizontal		Connected In 1 Parallel 1 Series	
Surf/Unit (Gross/Eff)		138.63 / 136.60 m2		Shell/Unit 1		Surf/Shell (Gross/Eff) 138.63 / 136.60 m2	
PERFORMANCE OF ONE UNIT							
Fluid Allocation		Shell Side			Tube Side		
Fluid Name		Propylene vapour			Cooling water		
Fluid Quantity, Total		1000-kg/hr		8.2390		68.4465	
Vapor (In/Out)		wt%		100.0 0.0		0.0 0.0	
Liquid		wt%		0.0 100.0		100.0 100.0	
Temperature (In/Out)		C		80.02 47.06		33.00 43.00	
Density		kg/m3		33.883 464.05		994.98 991.35	
Viscosity		cP		0.0110 0.0773		0.7488 0.6178	
Specific Heat		kcal/kg-C		0.4999 0.7196		1.0369 1.0222	
Thermal Conductivity		kcal/hr-m-C		0.0226 0.0867		0.5336 0.5461	
Critical Pressure		kgf/cm2A					
Inlet Pressure		kgf/cm2A		19.680		5.000	
Velocity		m/s				0.50 1.49	
Pressure Drop, Allow/Calc		kgf/cm2		0.100 0.018		0.800 0.797	
Average Film Coefficient		kcal/m2-hr-C		1496.14		6146.71	
Fouling Resistance (min)		m2-hr-C/kcal		0.000200		0.000400	
Heat Exchanged		0.7045 MM kcal/hr		MTD (Corrected) 9.2 C		Overdesign 10.85 %	
Transfer Rate, Service		558.03 kcal/m2-hr-C		Calculated 618.59 kcal/m2-hr-C		Clean 1091.56 kcal/m2-hr-C	
CONSTRUCTION OF ONE SHELL							
		Shell Side		Tube Side			
Design Pressure		kgf/cm2G		21.199 16.400			
Design Temperature		C		120.00 80.00			
No Passes per Shell		1		6			
Flow Direction		Downward		Upward			
Connections		In mm		1 @ 154.051 1 @ 102.261			
Size &		Out mm		1 @ 102.261 1 @ 102.261			
Rating		Liq. Out mm		@ @			
Tube No.		394 OD 20.000 mm		Thk(Avg) 2.000 mm		Length 5600. mm	
Tube Type Plain		Material CARBON STEEL(LTCS)		Pairs seal strips		3	
Shell ID 600.000 mm		Kettle ID mm		Passlane Seal Rod No.		10	
Cross Baffle Type PARALLEL SINGLE-SEG.		%Cut (Diam) 30.00		Impingement Plate		Circular plate	
Spacing(c/c) 300.000 mm		Inlet 555.942 mm		No. of Crosspasses		17	
Rho-V2-Inlet Nozzle 444.95 kg/m-s2		Shell Entrance 252.42		Shell Exit 114.49		kg/m-s2	
		Bundle Entrance 76.82		Bundle Exit 15.96		kg/m-s2	
Weight/Shell 3908.10		Filled with Water 5538.03		Bundle 2150.63		kg	
Notes:				Thermal Resistance, %		Velocities, m/s	
				Shell 41.35		Shellside 0.50	
				Tube 12.58		Tubeside 1.49	
				Fouling 43.33		Crossflow 0.72	
Reported duty and flow rates include a user-				Metal 2.74		Window 0.78	
specified multiplier of 1.10.						F 0.155	

Stream Properties

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MKH Units

Condenser

Condenser

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

Hot Shellside Fluid	Inlet			Outlet		
Fluid name	Propylene vapour					
Temperature (C)	80.02			47.06		
Pressure (kgf/cm2A)	19.680			19.661		
Weight fraction vapor (-)	1.0000			0.0000		
Vapor Properties						
Density (kg/m3)	33.8835			42.5442		
Viscosity (cP)	0.0110			0.0103		
Conductivity (kcal/hr-m-C)	0.0226			0.0206		
Heat capacity (kcal/kg-C)	0.4999			0.5799		
Molecular weight (-)	42.0797			42.0797		
Liquid Properties						
Density (kg/m3)	463.962			464.054		
Viscosity (cP)	0.0773			0.0773		
Conductivity (kcal/hr-m-C)	0.0867			0.0867		
Heat capacity (kcal/kg-C)	0.7199			0.7196		
Molecular weight (-)	42.0797			42.0797		
Latent heat (kcal/kg)	68.3781			68.4043		
Surface tension (dyne/cm)	3.9136			3.9185		
Molar Composition				Vapor	Liquid	K-Value
1 propylene				--	--	--

Stream Properties

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MKH Units

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

Cold Tubeside Fluid	Inlet			Outlet		
Fluid name	Cooling water					
Temperature (C)	33.00			43.00		
Pressure (kgf/cm2A)	5.000			4.203		
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)	994.985			991.350		
Viscosity (cP)	0.7488			0.6178		
Conductivity (kcal/hr-m-C)	0.5336			0.5461		
Heat capacity (kcal/kg-C)	1.0369			1.0222		
Molecular weight (-)	18.0153			18.0153		
Latent heat (kcal/kg)	--			--		
Surface tension (dyne/cm)	70.7188			69.1044		
Molar Composition						
1 water	Vapor	Liquid	K-Value	Vapor	Liquid	K-Value
	--	--	--	--	--	--

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MKH Units

Condenser

Condenser

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	600.000 mm
Flow in 1st tubepass	Countercurrent
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	60 degrees
Tube count method	Rigorous
Tube length	5600. mm
Tube material	Carbon steel

Tubepass Arrangement Data

Force symmetric layout	No
Force cleaning lanes	No
Tubes to remove for tie rods	Calculated

Baffle Data

Baffle type	Single segmental
Baffle orientation	Program sets
Baffle cut percent	30 % shell ID
Central baffle spacing	300.000 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	154.051 mm
Number of shellside inlet nozzles	1
Number of shellside outlet nozzles	1
Number of tubeside inlet nozzles	1
Number of tubeside outlet nozzles	1
Radial position on shell inlet nozzle	Program decides
Longitudinal position on shell of inlet nozzle	At rear head
Radial position on shell outlet nozzle	Program decides
Tubeside entry type	Radial
Tubeside inlet position	Front head
Tubeside exit type	Same as inlet
Front head location	Left

Impingement Data

Impingement device present	Yes
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	16.400 kgf/cm2G
Shellside design temperature	120.00 C
Shellside design pressure	21.200 kgf/cm2G

Process Conditions Data

	Hot Fluid	Cold Fluid
Phase condition	Two phase	Sensible liquid
Flow rate	7.4900	-- 1000-kg/hr
Inlet vapor fraction	1	0
Outlet vapor fraction	0	0
Inlet temperature	80.02	33.00 C
Outlet temperature	--	43.00 C
Inlet pressure	19.680	5.000 kgf/cm2A
Allowable pressure drop	0.100	0.800 kgf/cm2
Exchanger duty		0.6400 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	Propylene vapour
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	REFPROP
Use full GERG-2004 natural gas mixture model	

Hot Fluid Component Data

Component number	1
Component name	propylene
Comp. bank name	propylene
Component bank	REFPROP
Component code	115071
Component phase	Mixed
Component quantity	1

Cold Fluid Property Data

Fluid name	Cooling 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	REFPROP
Use full GERG-2004 natural gas mixture model	

Cold Fluid Component Data

Component number	1
Component name	water
Comp. bank name	water
Component bank	REFPROP
Component code	7732185
Component phase	Mixed
Component quantity	100

Control Name Data

Case name	Condenser
Problem name	Condenser
Revision	0
Customer	BCPL
Plant	Assam

Input Reprint

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Released to the following HTRI Member Company:

KPCL

Kannan

Xist Ver. 6.00 SP1 20/01/2010 18:51 SN: 1500214140

MKH Units

Condenser

Condenser

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

Control Methods Data

Shellside friction factor method	Commercial
Tubeside friction factor method	Commercial
Pure longitudinal flow	No
Pure component condensation	Yes
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
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Control Vibration Data

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