

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

 Enriching Lives	REFRIGERATION PACKAGE 117-LZ-480	KIRLOSKAR PNEUMATIC CO.LTD.
TITLE : Mechanical Design Calculations for Lube Oil Cooler (Item No. 117-EE-487)		Doc.No: PRJ/9742/20 Rev.: 0

No of pages : 39 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

REVIEW CODE	1	2	3
Signature & Name	[Signature]		
Date / दिनांक	21/2/10		
V.P. No.	6907/ 212		

0	ISSUED FOR INFORMATION	KK	KK	ECS	28-Feb-10
Rev.	Description	Prepared by	Reviewed by	Approved by	Approved Date

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		KK	KK	RCS	

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8	DESIGN PRESSURE CALCULATIONS (UG-21)	0			
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10	CHANNEL SHELL DESIGN (UG-16,UG-27,UG-28,RCB-3.13)	0			
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13	CHANNEL SHELL FLANGE DESIGN (APPENDIX 2)	0			
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15	TUBE DESIGN (1-1,UG-28,RCB-3.13)	0			
16 - 19	TUBE SHEET DESIGN (UHX-13)	0			
20	MISCELLANEOUS PARTS (RCB-(2.5,4.41,4.42,4.51,4.52,4.71,6.31,6.4,9.131))	0			
21	NOZZLE NECK & REINFORCEMENT-N1,N2,N5,N6 (UG-36, UG-37, UG-45)	0			
22	NOZZLE NECK & REINFORCEMENT-N3,N4,N7,N8 (UG-36, UG-37, UG-45)	0			
23	FLANGE RATING CHECK (UG-44, ASME B16.5)	0			
24	POST FORMING HEAT TREATMENT (UCS-79)	0			
25	IMPACT TEST REQUIREMENTS (UG-20(f))	0			
26	IMPACT TEST REQUIREMENTS (UCS-66)	0			
27	PWHT REQUIREMENTS (UW-2, UCS-56, UCS-68)	0			
28	TEST PRESSURE (UG-99,UG-100)	0			
29	WIND LOAD CALCULATIONS (IS:875)	0			
30	SEISMIC LOAD CALCULATIONS (IS:1893)	0			
31	SUPPORT DESIGN (ZICK ANALYSIS)	0			
32	SUPPORT DESIGN (ZICK ANALYSIS) - Contd..	0			
33	SUPPORT DESIGN (ZICK ANALYSIS) - Contd..	0			
34	CALCULATIONS FOR Ixx & Zxx FOR SADDLES	0			
35	EXTERNAL LOADS ON NOZZLES	0			
36	LOCAL LOAD ANALYSIS FOR NOZZLE N1,N2 (WRC 297)	0			
37	LOCAL LOAD ANALYSIS FOR NOZZLE N1,N2 (WRC 297)	0			
38	LOCAL LOAD ANALYSIS FOR NOZZLE N3,N4 (WRC 297)	0			
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		APPLICABLE STANDARDS / REFERENCES		PRPD.	CHKD.
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SR. NO.	DESCRIPTION			EDITION	
1	ASME SEC II	MATERIAL SPECIFICATIONS PARTS A, C & D		ED-2007 + ADD-2009	
2	ASME SEC V	NONDESTRUCTIVE EXAMINATION		ED-2007 + ADD-2009	
3	ASME SEC VIII DIV 1	RULES FOR CONSTRUCTION OF PRESSURE VESSELS		ED-2007 + ADD-2009	
4	ASME SEC IX	WELDING & BRAZING QUALIFICATIONS		ED-2007 + ADD-2009	
5	TEMA	STANDARDS FOR THE TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION		NINTH EDITION - 2007	
6	ASME B16.5	PIPE FLANGES AND FLANGED FITTINGS (UPTO 24" NPS)		ED-2003	
7	ASME B16.11	FORGED STEEL FITTINGS, SOCKET WELDED & THREADED		ED-2001	
8	ASME B16.20	METALLIC GASKETS FOR PIPE FLANGES - RING JOINT, SPIRAL WOUND & JACKETED		ED-1998 (R-2004)	
9	IS:875 (PART 3)	CODE FOR WIND LOADS		1987	
10	IS:1893 (PART 4)	CODE FOR SEISMIC LOADS		2005	

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DESCRIPTION		UNIT	SHELL SIDE		CHANNEL SIDE		REMARKS	
CONFIGURATION		-	HORIZONTAL - BEM					
DESIGN CODE		-	ASME SEC VIII DIV. 1-ED 2007, ADD 2009, TEMA - NINTH ED TEMA CLASS - R					
CODE STAMP		-	NO					
INTERNAL DESIGN PRESSURE		BAR (g)						
		KG/CM ² (g)	26.700		20.600			
EXTERNAL DESIGN PRESSURE		BAR (g)						
		KG/CM ² (g)	1.055		1.055			
DESIGN TEMPERATURE FOR INTERNAL PRESSURE DESIGN		°C	130		80			
		°F	266		176			
DESIGN TEMPERATURE FOR EXTERNAL PRESSURE DESIGN		°C	130		80			
		°F	266		176			
MDMT		°C	-45		-45			
		°F	-49		-49			
CORROSION ALLOWANCE		MM	3		3			
RADIOGRAPHY (SHELL / D'END)		-	100%		100%			
JOINT EFFICIENCY		FOR SHELL	1.00	1.00	1.00	1.00		LONG/CIRC.JOINT
		FOR HEAD			1.00			
INTERNAL OPERATING PRESSURE		KG/CM ² (a)	25.169		5.000			
EXTERNAL OPERATING PRESSURE		KG/CM ² (g)	-		-			
OPERATING TEMPERATURE (IN/OUT)		°C	100.28	50.00	33.00	43.00		
FLUID		-	LUBE OIL		WATER			
DENSITY		KG/M ³	961.4		995.3			
HYDROTEST PRESSURE (AT TOP)		BAR (g)	N.A.					
		KG/CM ² (g)			26.780			
PNEUMATIC TEST PRESSURE		BAR (g)			N.A.			
		KG/CM ² (g)	29.370					
TEST TEMPERATURE (MIN.)		°C	20					
SEISMIC CODE		-	IS:1893 (PART 4)					
WIND CODE		-	IS:875 (PART 3)					
PWHT		-	NO		NO			
FLANGE RATING		-	300#		300#			
EMPTY WEIGHT	We	KG	1690				FOR DETAILS, REFER DRGS.	
TEST WEIGHT	Ww	KG	1971					
TUBE BUNDLE WEIGHT	Wt	KG	940					
OPERATING WEIGHT	Wo	KG	2340					

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		EVALUATION OF MATERIALS						PRPD.		CHKD.	
						KK		KK		RCS	
MATERIALS OF CONSTRUCTION & ALLOWABLE STRESSES :											
DESCRIPTION		MATERIAL SPEC.	DESIGN TEMP. T °F	ALLOWABLE STRESS (1)				RATIO =Sa/S (2)	REMARKS		
				S		Sa					
				PSI	KG/CM ²	PSI	KG/CM ²				
SHELL SIDE	MAIN SHELL	SA 516 GR 70	266.00	20000	1406.2	20000	1406.2	1.00			
	PIPE	SA 333 GR 6	266.00	17100	1202.3	17100	1202.3	1.00			
	FITTINGS	SA 420 GR WPL6	266.00	17100	1202.3	17100	1202.3	1.00			
	DISHED END										
	NOZZLE FLANGE	SA 350 GR LF2 CL1	266.00	20000	1406.2	20000	1406.2	1.00			
	BOLTING FOR BODY FLANGE	SA 320 GR L7 SA 194 GR 7	266.00	25000	1757.8	25000	1757.8	1.00			
	BOLTING FOR NOZZLE FLANGE	SA 320 GR L7 SA 194 GR 7	266.00	25000	1757.8	25000	1757.8	1.00			
	GASKET FOR	BODY FLANGE	SS316 JACKETED GRAPHITE FILLED				m = 3.75		y (psi)= 9000		632.8
	NOZZLE FLANGE					-		-		KG/CM ²	
CHANNEL SIDE	CHANNEL SHELL	SA 516 GR 70	176.00	20000	1406.2	20000	1406.2	1.00			
	PIPE	SA 333 GR 6	176.00	17100	1202.3	17100	1202.3	1.00			
	FITTINGS	SA 420 GR WPL6	176.00	17100	1202.3	17100	1202.3	1.00			
	DISHED END	SA 516 GR 70	176.00	20000	1406.2	20000	1406.2	1.00			
	GIRTH FLANGE	SA 350 GR LF2 CL1	176.00	20000	1406.2	20000	1406.2	1.00			
	NOZZLE FLANGE	SA 350 GR LF2 CL1	176.00	20000	1406.2	20000	1406.2	1.00			
	BOLTING FOR BODY FLANGE	SA 320 GR L7 SA 194 GR 7	176.00	25000	1757.8	25000	1757.8	1.00			
	BOLTING FOR NOZZLE FLANGE	SA 320 GR L7 SA 194 GR 7	176.00	25000	1757.8	25000	1757.8	1.00			
	GASKET FOR	BODY FLANGE	SS316 JACKETED GRAPHITE FILLED				m = 3.75		y (psi)= 9000		632.8
	NOZZLE FLANGE					-		-		KG/CM ²	
MISC.	TUBES	SA 334 GR 1 (SEAMLESS)	266.00	15700	1103.9	15700	1103.9	1.00			
	TUBE SHEET	SA 350 GR LF2 CL1	266.00	20000	1406.2	20000	1406.2	1.00			
	SUPPORTS(3)	SA 516 GR 70	266.00	20000	1406.2	20000	1406.2	1.00			
	ANCHOR BOLTS(3)	IS 1367	-	-	-	17000	1195.3	-			
REF. NEXT PAGE FOR NOTES.											

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	EVALUATION OF MATERIALS - Contd..	PRPD.	CHKD.	APPD.
		KK	KK	RCS

NOTES :

1. S = ALLOWABLE STRESS AT DESIGN TEMPERATURE
Sa = ALLOWABLE STRESS AT AMBIENT TEMPERATURE
2. RATIO OF ALLOWABLE STRESSES AT AMBIENT TEMPERATURE TO ALLOWABLE STRESS AT DESIGN TEMPERATURE.
- AS PRESSURE TEST IS TO BE CARRIED OUT AT AMBIENT TEMPERATURE, $Sh = Sa$
WHERE, Sh = ALLOWABLE STRESS AT TEST TEMPERATURE.
ACCORDINGLY,

$$(Sh/S)_{MIN} = (Sa/S)_{MIN} = 1.00 \quad \text{FOR SHELL SIDE}$$

$$(Sh/S)_{MIN} = (Sa/S)_{MIN} = 1.00 \quad \text{FOR CHANNEL SIDE}$$
3. SUPPORTS & ANCHOR BOLTS ARE OUTSIDE CODE LIMIT.
ALLOWABLE STRESS = TENSILE STRENGTH/3.5

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	DESIGN PRESSURE CALCULATIONS (UG-21)		PRPD.	CHKD.	APPD.
			KK	KK	RCS

FOR SHELL SIDE

INTERNAL DESIGN PRESSURE	P	KG/CM ² (g)	26.700
EXTERNAL PRESSURE FOR CHANNEL SIDE	Pec	-	1.055
MAXIMUM STATIC HEAD (SAME AS ID)	H	MM	400.00
SPECIFIC GRAVITY OF CONTENT	ρ	-	0.961

FOR MAIN SHELL

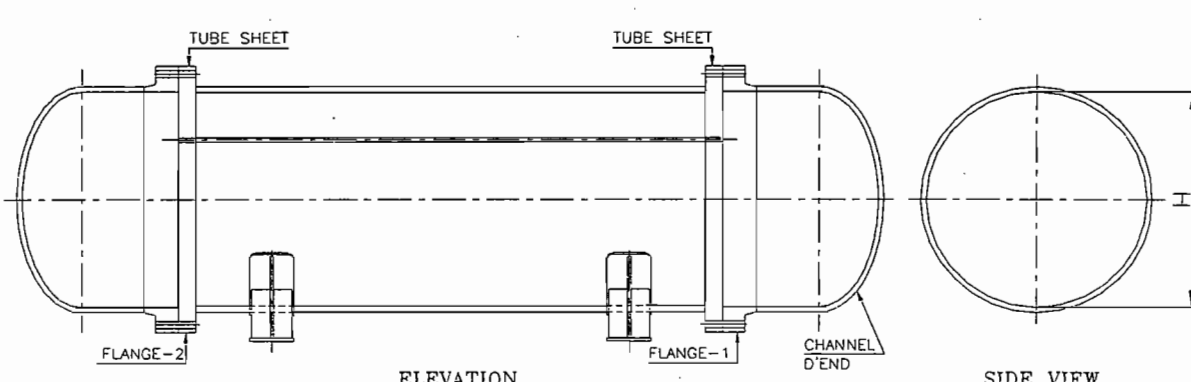
DESIGN PRESSURE INCLUDING STATIC HEAD	Ps	KG/CM ² (g)	26.739
$= P + H * \rho / 10000$			
CORRECTED FOR VACUUM ON CHANNEL SIDE	Ps	KG/CM ² (g)	27.794
$= P + Pec + H * \rho / 10000$			

FOR CHANNEL SIDE

INTERNAL DESIGN PRESSURE	P	KG/CM ² (g)	20.600
EXTERNAL PRESSURE FOR SHELL SIDE	Pes	-	1.055
MAXIMUM STATIC HEAD (SAME AS ID)	H	MM	400.00
SPECIFIC GRAVITY OF CONTENT	ρ	-	0.995
DESIGN PRESSURE INCLUDING STATIC HEAD	Pt	KG/CM ² (g)	20.640
$= Pt + H * \rho / 10000$			
CORRECTED FOR VACUUM ON SHELL SIDE	Pt	KG/CM ² (g)	21.695
$= Pt + Pes + H * \rho / 10000$			

CONCLUSION

PRESSURE VALUES IN BOLD ABOVE ARE USED IN FURTHER CALCULATIONS



ELEVATION

SIDE VIEW

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	MAIN SHELL DESIGN (UG-16,UG-27,UG-28,RCB-3.13)		PRPD.	CHKD.	APPD.
			KK	KK	RCS

DESIGN INPUT				
INTERNAL DESIGN PRESSURE	Ps	KG/CM ² (g)	26.739	
EXTERNAL DESIGN PRESSURE	Pe	KG/CM ² (g)	1.055	
DESIGN TEMPERATURE FOR INTERNAL PRESSURE	T	°C	130	
DESIGN TEMPERATURE FOR EXTERNAL PRESSURE	T'	°C	130	
INSIDE DIAMETER	Di	MM	400.00	
MATERIAL	-	-	SA 516 GR 70	
ALLOWABLE STRESS AT DESIGN TEMPERATURE	S	KG/CM ²	1406.2	
JOINT EFFICIENCY FOR LONGITUDINAL JOINT	E	-	1.00	
JOINT EFFICIENCY FOR CIRCUMFERENTIAL JOINT	Ec	-	1.00	
CORROSION ALLOWANCE	C	MM	3	

DESIGN UNDER INTERNAL PRESSURE				
AS PER UG-27(c)(1) OF ASME SEC. VIII DIV.1, REQUIRED SHELL THICKNESS			FOR REINFORCEMENT CALCN. WITH E = 1.0 trs = 6.90 MM	
$trs_1 = \frac{Ps (Di + 2C)}{2(SE - 0.6Ps)} + C$ $= \frac{26.739 \times (400 + 2 \times 3)}{2 \times (1406.2 \times 1 - 0.6 \times 26.739)} + 3$ $= 6.90 \text{ MM}$			CHECK FOR APPLICABILITY OF UG-27(c)(1) & (2),	
AS PER UG-27(c)(2) OF ASME SEC. VIII DIV.1, REQUIRED SHELL THICKNESS			PARAMETER	VALUE
$trs_2 = \frac{Ps (Di + 2C)}{2(2SEc + 0.4Ps)} + C$ $= \frac{26.739 \times (400 + 2 \times 3)}{2 \times (2 \times 1406.2 \times 1 + 0.4 \times 26.739)} + 3$ $= 4.92 \text{ MM}$			(Di/2 + C)/2	101.50
			0.385 x S x E	541.39
			1.25 x S x Ec	1757.75
AS PER UG-16(b) OF ASME SEC. VIII DIV.1, REQUIRED SHELL THICKNESS			CHECK WHETHER,	
$trs_3 = 1.5 + C$ $= 4.50 \text{ MM}$			ts < (Di/2 + C)/2	YES
			Ps < 0.385 x S x E	YES
			Ps < 1.25 x S x Ec	YES
			UG-27(c)(1)&(2) IS APPLICABLE	

DESIGN UNDER EXTERNAL PRESSURE					
AS PER UG-28(c) OF ASME SEC. VIII DIV. 1, ASSUMED SHELL THICKNESS			trs ₄	MM	6.60
MAXIMUM DESIGN LENGTH (T/S OUTSIDE TO OUTSIDE)			L	MM	4094.00
OD OF VESSEL = Di + 2*ts			Do	MM	420
GEOMETRIC RATIO			L/Do	-	9.748
GEOMETRIC RATIO			Do/(trs ₄ -C)	-	116.67
FROM FIG G OF ASME SEC II D SUBPART 3			A	-	9.902E-05
FROM APPLICABLE CHART- CS-2			B	PSI	1425.42
MAXIMUM ALLOWABLE EXTERNAL PRESSURE			Pa	PSI	16.29
= 4*B / 3*(Do/(trs ₄ -C))				KG/CM ²	1.145
AS Pa > Pe, DESIGN IS SAFE.					

MINIMUM SHELL THICKNESS AS PER TEMA RCB-3.13				
REQUIRED SHELL THICKNESS INCLUDING 'C'	trs ₅	MM	9.50	

CONCLUSION:				
REQUIRED THICKNESS=MAX. OF trs ₁ ,trs ₂ ,trs ₃ ,trs ₄ ,trs ₅	trs	MM	9.50	
PROVIDED SHELL THICKNESS	ts	MM	10.00	

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	CHANNEL SHELL DESIGN (UG-16,UG-27,UG-28,RCB-3.13)		PRPD.	CHKD.	APPD.
			KK	KK	RCS
DESIGN INPUT					
INTERNAL DESIGN PRESSURE	Pt	KG/CM ² (g)	20.640		
EXTERNAL DESIGN PRESSURE	Pe	KG/CM ² (g)	1.055		
DESIGN TEMPERATURE FOR INTERNAL PERSSURE	T	°C	80		
DESIGN TEMPERATURE FOR EXTERNAL PERSSURE	T'	°C	80		
INSIDE DIAMETER	Di	MM	400.00		
MATERIAL	-	-	SA 516 GR 70		
ALLOWABLE STRESS AT DESIGN TEMPERATURE	S	KG/CM ²	1406.2		
JOINT EFFICIENCY FOR LONGITUDINAL JOINT	E	-	1.00		
JOINT EFFICIENCY FOR CIRCUMFERENTIAL JOINT	Ec	-	1.00		
CORROSION ALLOWANCE	C	MM	3		
DESIGN UNDER INTERNAL PRESSURE					
AS PER UG 27(c)(1) OF ASME SEC. VIII DIV.1, REQUIRED CHANNEL SHELL THICKNESS		FOR REINFORCEMENT CALCN. WITH E = 1.0 trcs = 6.01 MM			
$trcs_1 = \frac{Pt (Di + 2C)}{(2(SE - 0.6Pt))} + C$ $= \frac{20.64 \times (400 + 2 \times 3)}{2 \times (1406.2 \times 1 - 0.6 \times 20.64)} + 3$ $= 6.01 \text{ MM}$		CHECK FOR APPLICABILITY OF UG-27(c)(1) & (2),			
AS PER UG-27(c)(2) OF ASME SEC. VIII DIV.1, REQUIRED CHANNEL SHELL THICKNESS		PARAMETER	VALUE		
$trs_2 = \frac{Pt (Di + 2C)}{(2(2SEc + 0.4Pt))} + C$ $= \frac{20.64 \times (400 + 2 \times 3)}{2 \times (2 \times 1406.2 \times 1 + 0.4 \times 20.64)} + 3$ $= 4.49 \text{ MM}$		(Di/2 + C)/2	101.50		
		0.385 x S x E	541.39		
		1.25 x S x Ec	1757.75		
AS PER UG-16(b) OF ASME SEC. VIII DIV.1, REQUIRED CHANNEL SHELL THICKNESS		CHECK WHETHER,			
$trs_3 = 2.5 + C$ $= 5.50 \text{ MM}$		ts<(Di/2 + C)/2	YES		
		Pt<0.385xSxE	YES		
		Pt<1.25xSxEc	YES		
		UG-27(c)(1)&(2) IS APPLICABLE			
DESIGN UNDER EXTERNAL PRESSURE					
AS PER UG-28(c) OF ASME SEC. VIII DIV. 1, ASSUMED CHANNEL SHELL THICKNESS		trcs ₄	MM	4.20	
MAXIMUM DESIGN LENGTH		L	MM	310.00	
OD OF VESSEL = Di + 2*trcs		Do	MM	420	
GEOMETRIC RATIO		L/Do	-	0.738	
GEOMETRIC RATIO		Do/(trcs ₄ -C)	-	350.00	
FROM FIG G OF ASME SEC II D SUBPART 3		A	-	2.926E-04	
FROM APPLICABLE CHART- CS-2		B	PSI	4220.59	
MAXIMUM ALLOWABLE EXTERNAL PRESSURE		Pa	PSI	16.08	
$= 4 \times B / 3 \times (Do / (trcs_4 - C))$			KG/CM ²	1.130	
AS Pa > Pe, DESIGN IS SAFE.					
MINIMUM CHANNEL SHELL THICKNESS AS PER TEMA RCB-3.13					
REQUIRED CHANNEL SHELL THICKNESS INCLUDING 'C'		trcs ₅	MM	9.50	
CONCLUSION:					
REQUIRED THICKNESS=MAX. OF trcs ₁ ,trcs ₂ ,trcs ₃ ,trcs ₄ ,trcs ₅		trcs	MM	9.50	
PROVIDED CHANNEL SHELL THICKNESS		tcs	MM	10.00	

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	CHANNEL D'END DESIGN (1-4,UG-32,UG-33,RCB-3.2)		PRPD.	CHKD.	APPD.
			KK	KK	RCS
DESIGN INPUT					
INTERNAL DESIGN PRESSURE	Pt	KG/CM ² (g)	20.640		
EXTERNAL DESIGN PRESSURE	Pe	KG/CM ² (g)	1.055		
DESIGN TEMPERATURE FOR INTERNAL PRESSURE	T	°C	80		
DESIGN TEMPERATURE FOR EXTERNAL PRESSURE	T'	°C	80		
INSIDE DIAMETER	Di	MM	400.00		
TYPE OF DISHED END	-	-	2:1 ELLIPSOIDAL		
MATERIAL	-	-	SA 516 GR 70		
ALLOWABLE STRESS AT DESIGN TEMPERATURE	S	KG/CM ²	1406.2		
JOINT EFFICIENCY FOR LONGITUDINAL JOINT	E	-	1.00		
JOINT EFFICIENCY FOR SHELL TO DISHED END JOINT	Ec	-	1.00		
CORROSION ALLOWANCE	C	MM	3		
FACTOR FROM TABLE 1-4.1	K	-	1		
INSIDE DEPTH OF D'END = Di / 4	hi _B	MM	100.00		
DESIGN UNDER INTERNAL PRESSURE					
AS PER 1-4(c) OF ASME SEC. VIII DIV.1,		FOR REINFORCEMENT CALCN. AS PER UG-37(a),			
$trh_1 = \frac{Pt (Di + 2C) K}{(2 S E - 0.2 Pt)} + C$ $= \frac{20.64 \times (400 + 2 \times 3) \times 1}{2 \times 1406.2 \times 1 - 0.2 \times 20.64} + 3$ $= 5.98 \text{ MM}$		$K1 = 0.9 \text{ (TABLE UG-37)}$ $trh = K1(Di+2C)Pt/(2S-0.2Pt)+C$ $= 5.69 \text{ MM}$			
AS PER UG-32(b) & (f) OF ASME SEC. VIII DIV.1,					
$trh_2 = \frac{Pt (Di/2 + C)}{(2 S - 0.2 Pt) Ec} + C$ $= \frac{20.64 \times (400 / 2 + 3)}{2 \times 1406.2 - 0.2 \times 20.64} + 3$ $= 4.49 \text{ MM}$					
AS PER UG-16(b) OF ASME SEC. VIII DIV.1, REQUIRED CHANNEL DISHED END THICKNESS					
$trh_3 = 2.5 + C$ $= 5.50 \text{ MM}$					
REQUIREMENT OF TAPER TRANSITION & SF					
AS PER UG-32(l) & UW-13(b)(3) OF ASME SEC. VIII DIV.1,					
PROVIDED MIN. DISHED END THICKNESS	th (MIN)	MM	8.00		
PROVIDED NOM. DISHED END THICKNESS	th (NOM)	MM	10.00		
PROVIDED CHANNEL SHELL THICKNESS	tcs	MM	10.00		
DIFFERENCE IN THICKNESS = th (NOM) - tcs	t _d	MM	0.00		
MIN. OF {(MIN. OF th(NOM) & tcs)/4 , 3}	t _{da}	MM	2.50		
CHECK WHETHER TAPER TRANSITION (1:3 MIN) IS REQUIRED ON D'END			NO		
MIN. REQD. SF ON DISHED END =MIN OF (3*th(NOM),38)	SF _R	MM	30.00		
PROVIDED SF ON DISHED END	SF	MM	40.00		

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	CHANNEL D'END DESIGN - Contd.. (1-4,UG-32,UG-33,RCB-3.2)		PRPD.	CHKD.	APPD.
			KK	KK	RCS

PERCENTAGE THINNING				
% THINNING = {th(NOM) - th(MIN)} / th(NOM) x 100		%	20.00%	

DESIGN UNDER EXTERNAL PRESSURE				
AS PER UG-33(a)(1)(a) OF ASME SEC. VIII DIV. 1,				
EQUIVALENT INTERNAL DESIGN PRESSURE = 1.67 * Pe	P	KG/CM ² (g)	1.7619	
$trh_4 = \frac{P (Di + 2C) K}{(2 S E - 0.2 P)} + C$ $= \frac{1.76185 \times (400 + 2 \times 3) \times 1}{2 \times 1406.2 \times 1 - 0.2 \times 1.76185} + 3$ $= 3.25 \text{ MM}$				
AS PER UG-33(d) OF ASME SEC. VIII DIV. 1,				
ASSUMED MINIMUM THICKNESS	th ₅ (MIN)	MM	4.10	
ASSUMED NOMINAL THICKNESS	th ₅ (NOM)	MM	10.00	
OD OF DISHED END = Di + 2*th ₅ (NOM)	Do	MM	420	
FACTOR FROM TABLE UG-33.1	Ko	-	0.9	
EQUIVALENT OUTSIDE RADIUS = Ko * Do	Ro	MM	378.0	
FACTOR A = 0.125 / {Ro / (th ₅ (MIN) - C)}	A	-	3.638E-04	
FROM APPLICABLE CHART CS-2	B	PSI	5247.43	
MAXIMUM ALLOWABLE EXTERNAL PRESSURE	Pa	PSI	15.27	
= B / {Ro / (th ₅ (MIN) - C)}		KG/CM ²	1.074	
AS Pa > Pe, DESIGN IS SAFE.				

CHANNEL DISHED END NOMINAL THICKNESS AS PER TEMA RCB-3.2				
REQUIRED DISHED END NOM THICKNESS INCLUDING 'C'	trh ₆	MM	9.50	

CONCLUSION:				
REQUIRED MIN. THICKNESS = MAX. OF trh ₁ to trh ₅	trh (MIN)	MM	5.98	
PROVIDED MIN. DISHED END THICKNESS	th (MIN)	MM	8.00	
PROVIDED NOM. DISHED END THICKNESS	th (NOM)	MM	10.00	

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	CHANNEL SHELL FLANGE DESIGN (APPENDIX 2)		PRPD.	CHKD.	APPD.
			KK	KK	RCS

AS PER APPENDIX 2 OF ASME SECTION VIII DIV. 1 - INTEGRAL TYPE FLANGE					
Component Mark/No.		CHANNEL FLANGE - 1,2		Location: CHANNEL SHELL	
DESIGN CONDITIONS					
Int. Design Press, P (kg/cm ²)	20.640	ALLOWABLE STRESSES (kg/cm ²)			
Design Temperature(°C)	80	Flange		Bolting	
Flange material	SA 350 GR LF2 CL1	Design temp., Sfo	1406.2	Design temp., Sb	1757.80
Bolting material	SA 320 GR L7	Atm.Temp., Sfa	1406.2	Atm.temp., Sa	1757.80
Corr.Allowance (mm)	3.0				
GASKET AND FACING DETAILS					
Gasket Material	**	Gasket I.D Gi (mm)	442.00	y (kg/cm ²)	632.8
Facing Sketch	1a OR 1b	Gasket O.D. Go (mm)	462.00	m	3.75
FLANGE DIMENSIONS					
B (Flange I.D) (mm)	400.00	C (Bolt cir.Dia) (mm)	494.00	A(Flange OD)(mm)	542.00
OTHER DIMENSIONS (TABLE 2-5.2)			LOAD AND BOLT CALCULATIONS		
N (mm)	10.00	go = Hub thk (mm)	10.00	Am1=Wm1/Sb (mm ²)	2918.08
bo (mm)	5.00	h = Hub length (mm)	30.00	Am2=Wm2/Sa (mm ²)	4226.56
b (mm)	5.00	Wm1 = Hp + H (kg)	51294.01	Am=Max(Am1,Am2)	4226.56
G (mm)	452.00	Wm2=(bπG+0.5RA)y (kg)	74294.45	n = 'No. of Bolts	24
Nmin = Ab Sa / (2 π y G)	5.10	Hp=(bπG+RA/2)2mP (kg)	18175.07	a = Bolt size	M20
RA = Rib Area (mm ²)	9282.00	H = G ² πP/4 (kg)	33118.94	Root area(mm ²)	217.05
g1 = Hub thk at back (mm)	15.00	W = Ab * Sa (kg)	91567.32	Ab (mm ²)	5209.20
MOMENT CALCULATIONS					
LOAD		LEVER ARM		MOMENT	
OPERATING					
H _D = πB ² P/4 (kg)	26720.93	h _D = (C - B - g1)/2 (mm)	38.00	M _D = H _D *h _D (kg-m)	1015.40
H _G = Wm1 - H (kg)	18175.07	h _G = (C-G)/2 (mm)	21.00	M _G = H _G *h _G (kg-m)	381.68
H _T = H - H _D (kg)	6398.01	h _T = (h _D +h _G +g1/2)/2 (mm)	32.50	M _T = H _T *h _T (kg-m)	207.94
f1=Correction Factor(RCB-11.23)	1.00	Mo = (M _D + M _G + M _T)*f1 (kg-m)			1605.01
GASKET SEATING					
H _G = W (kg)	91567.32	h _G = (C-G)/2 (mm)	21.00	Mo"=H _G *h _G (kg.m)	1922.91
f1=Correction Factor(RCB-11.23)	1.00	Mo' = Mo" * f1 (kg-m)			1922.91
FLANGE THICKNESS (mm)		SHAPE CONSTANTS			
THK.	46.000	K = A/B	1.3350	ho=(B*go) ^{1/2}	53.3104
STEP	5.000	U	7.5546	Z	3.5570
NET THK.	41.000	V	0.2533	e	0.0155
				Y	6.8747
				T	1.7824
				f	1.0000
				F	0.8250
				d	77918.32
				L	1.8015
STRESS CALCULATIONS (kg/cm ²)					
OPERATING		ALLOWABLE	GASKET SEATING		ALLOWABLE
S _H = f*Mo/(L*g1 ² *B)	1523.86	2109.30	S _H = f*Mo'/(L*g1 ² *B)	1825.70	2109.30
S _R = (1.33*t*e + 1)*Mo/(L*t ² *B)	240.69	1406.20	S _R = (1.33*t*e + 1)*Mo'/(L*t ² *B)	288.37	1406.20
S _T = (Y*Mo)/(t ² *B) - Z*S _R	760.59	1406.20	S _T = (Y*Mo')/(t ² *B) - Z*S _R	911.24	1406.20
(S _H + S _R) / 2	882.28	1406.20	(S _H + S _R) / 2	1057.03	1406.20
(S _H + S _T) / 2	1142.22	1406.20	(S _H + S _T) / 2	1368.47	1406.20
RESULT	O.K.		O.K.		
RIGIDITY CHECK (OPERATING)			RIGIDITY CHECK (GASKET SEATING)		
Mod.of Elasticity, E (kg/cm ²)	2033975	Rigidity Index J	Modulus of Elasticity, E (MPa)	2061233	Rigidity Index J
Rigidity Factor, K _i	0.30	0.738 < 1, OK	Rigidity Factor, K _i	0.30	0.873 < 1, OK
** SS316 JACKETED GRAPHITE FILLED					

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	ITEM NO. : 117-EE-487			REV.	0
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	CHANNEL SHELL FLANGE DESIGN - Contd.. (APPENDIX 2)			PRPD.	CHKD.
			KK	KK	RCS
AS PER APPENDIX 2 OF ASME SECTION VIII DIV. 1 - INTEGRAL TYPE FLANGE					
Component Mark/No.	CHANNEL FLANGE - 1,2		Location:		CHANNEL SHELL
DESIGN CONDITIONS					
Ext. Design Press, P (kg/cm ²)	1.055	ALLOWABLE STRESSES (kg/cm ²)			
Design Temperature(^o C)	80	Flange		Bolting	
Flange material	SA 350 GR LF2 CL1	Design temp., Sfo	1406.2	Design temp.,Sb	1757.8
Bolting material	SA 320 GR L7	Atm.Temp.,Sfa	1406.2	Atm.temp.,Sa	1757.8
Corr.Allowance (mm)	3				
GASKET AND FACING DETAILS					
Gasket Material	**	Gasket I.D Gi (mm)	442.00	y (kg/cm ²)	632.8
Facing Sketch	1a OR 1b	Gasket O.D. Go (mm)	462.00	m	3.75
FLANGE DIMENSIONS					
B (Flange I.D) (mm)	400	C (Bolt cir.Dia) (mm)	494.00	A(Flange OD)(mm)	542.00
OTHER DIMENSIONS (TABLE 2-5.2)			LOAD AND BOLT CALCULATIONS		
N (mm)	10.00	go = Hub thk (mm)	10.00	Am1=Wm1/Sb (mm ²)	149.16
bo (mm)	5.00	h = Hub length (mm)	30.00	Am2=Wm2/Sa (mm ²)	4226.56
b (mm)	5.00	Wm1 = Hp + H (kg)	2621.86	Am=Max(Am1,Am2)	4226.56
G (mm)	452.00	Wm2=(bπG+0.5RA)y (kg)	74294.45	n = 'No. of Bolts	24
Nmin = Ab Sa / (2 π y G)	5.10	Hp=(bπG+RA/2)2mP (kg)	929.01	a = size of Bolt (mm)	M20
RA = Rib Area (mm ²)	9282.00	H = G ² πP/4 (kg)	1692.85	Bolt root area(mm ²)	217.05
g1 = Hub thk at back (mm)	15.00	W = Ab * Sa (kg)	91567.32	Ab (mm ²)	5209.20
MOMENT CALCULATIONS					
LOAD		LEVER ARM		MOMENT	
OPERATING					
HD = πB ² P/4 (kg)	1365.82	hd =(C - B - g1)/2 (mm)	38.00	MD=HD*hd(kg-m)	51.90
HG = Wm1 - H (kg)	929.01	hg =(C-G)/2 (mm)	21.00	MG=HG*hg(kg-m)	19.51
HT = H - HD (kg)	327.03	ht =(hd+hg+g1/2)/2 (mm)	32.50	MT=HT*ht(kg-m)	10.63
f1=Correction Factor(RCB-11.23)	1.00	Mo={HD*(hd-hg)+HT*(ht-hg)}*f1 (kg-m)			26.98
GASKET SEATING					
HG = W (kg)	91567.32	hg =(C-G)/2 (mm)	21.00	Mo'=HG*hg(kg.m)	1922.91
f1=Correction Factor(RCB-11.23)	1.00	Mo' * f1 (kg-m)		1922.91	
FLANGE THICKNESS (mm)		SHAPE CONSTANTS			
THK.	46.000	K = A/B	1.3350	ho=(B*go) ^{1/2}	53.3104
STEP	5.000	U	7.5546	Z	3.5570
NET THK.	41.000	V	0.2533	e	0.0155
STRESS CALCULATIONS (kg/cm ²)					
OPERATING		ALLOWABLE	GASKET SEATING		ALLOWABLE
SH = f*Mo/(L*g1 ² *B)	25.62	2109.30	SH = f*Mo'/(L*g1 ² *B)	1825.70	2109.30
SR = (1.33*t*e + 1)*Mo/(L*t ² *B)	4.05	1406.20	SR = (1.33*t*e + 1)*Mo'/(L*t ² *B)	288.37	1406.20
ST = (Y*Mo)/(t ² *B) - Z*SR	12.79	1406.20	ST = (Y*Mo')/(t ² *B) - Z*SR	911.24	1406.20
(SH + SR) / 2	14.83	1406.20	(SH + SR) / 2	1057.03	1406.20
(SH + ST) / 2	19.20	1406.20	(SH + ST) / 2	1368.47	1406.20
RESULT		O.K.		O.K.	
RIGIDITY CHECK (OPERATING)			RIGIDITY CHECK (GASKET SEATING)		
Mod.of Elasticity, E (kg/cm ²)	2033975	Rigidity Index J	Modulus of Elasticity, E (MPa)	2061233	Rigidity Index J
Rigidity Factor, Ki	0.30	0.012 < 1, OK	Rigidity Factor, Ki	0.30	0.873 < 1, OK
** SS316 JACKETED GRAPHITE FILLED					

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	ITEM NO. : 117-EE-487		REV.	0	
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	TUBE DESIGN		PRPD.	CHKD.	APPD.
	(1-1,UG-28,RCB-3.13)		KK	KK	RCS

DESIGN INPUT				
INTERNAL DESIGN PRESSURE	Pt	KG/CM ² (g)	20.640	
EXTERNAL DESIGN PRESSURE = Ps	Pe	KG/CM ² (g)	26.739	
DESIGN TEMPERATURE	T	°C	130	
OUTSIDE DIAMETER	Do	MM	20.00	
MATERIAL	-	SA 334 GR 1 (SEAMLESS)		
ALLOWABLE STRESS AT DESIGN TEMPERATURE	S	KG/CM ²	1103.9	
JOINT EFFICIENCY FOR LONGITUDINAL JOINT	E	-	1.00	
CORROSION ALLOWANCE	C	MM	0	

DESIGN UNDER INTERNAL PRESSURE				
AS PER 1-1(a)(1) OF ASME SEC. VIII DIV.1,				
REQUIRED TUBE THICKNESS				
$trt_1 = \frac{Pt * Do}{(2(SE + 0.4Pt))} + C$ $= \frac{20.64 * 20}{2 * (1103.9 * 1 + 0.4 * 20.64)} + 0$ $= 0.19 \text{ MM}$				

DESIGN UNDER EXTERNAL PRESSURE				
AS PER UG-28(c) OF ASME SEC. VIII DIV. 1,				
ASSUMED TUBE THICKNESS	trt ₂	MM	1.00	
MAXIMUM DESIGN LENGTH	L	MM	4100.00	
OD OF TUBE	Do	MM	20.00	
GEOMETRIC RATIO	L/Do	-	205.000	
GEOMETRIC RATIO	Do/(trt ₂ -C)	-	20.00	
FROM FIG G OF ASME SEC II D SUBPART 3	A	-	2.750E-03	
FROM APPLICABLE CHART- CS-2	B	PSI	15900.00	
MAXIMUM ALLOWABLE EXTERNAL PRESSURE	Pa	PSI	1060.00	
=4*B / 3*(Do/(trt ₂ -C))		KG/CM ²	74.527	
AS Pa > Pe, DESIGN IS SAFE.				

CONCLUSION:				
REQUIRED THICKNESS = MAXIMUM OF trt ₁ & trt ₂	trt	MM	1.00	
PROVIDED TUBE THICKNESS (AVG)	tt	MM	2.00	

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	ITEM NO. : 117-EE-487		REV.		0	
	DOCUMENT NO. : PRJ/9742/20		DATE		28-Feb-10	
	TUBE SHEET DESIGN (UHX-13)		PRPD.		CHKD.	APPD.
			KK		KK	RCS
DESIGN INPUT						
OUTSIDE DIAMETER		A	MM	542.00		
BOLT CIRCLE DIAMETER		C	MM	494.00		
CHANNEL SHELL INSIDE DIAMETER (CORRODED)		D _c	MM	406.00		
MAIN SHELL INSIDE DIAMETER (CORRODED)		D _s	MM	406.00		
TUBESHEET MATERIAL				SA 350 GR LF2 CL1		
DESIGN TEMPERATURE		T	°C	130.00		
MODULUS OF ELASTICITY AT T		E	KG/CM ²	2001687.0		
ALLOWABLE STRESS AT T		S	KG/CM ²	1406.2		
YIELD STRENGTH AT T		S _y	KG/CM ²	2264.6		
POISSON'S RATIO		v	-	0.30		
TUBE MATERIAL		-	-	SA 334 GR 1 (SEAMLESS)		
DESIGN TEMPERATURE		T _t	°C	130.00		
MODULUS OF ELASTICITY AT T _t (E _t at T)		E _t	KG/CM ²	2001687.0		
ALLOWABLE STRESS AT T _t (S _t at T)		S _t	KG/CM ²	1103.9		
YIELD STRENGTH AT T _t		S _{y,t}	KG/CM ²	1887.1		
POISSON'S RATIO		v _t	-	0.30		
CHANNEL SHELL MATERIAL		-	-	SA 516 GR 70		
DESIGN TEMPERATURE		T _c	°C	80.00		
MODULUS OF ELASTICITY AT T _c		E _c	KG/CM ²	2033975.0		
ALLOWABLE STRESS AT T _c		S _c	KG/CM ²	1406.2		
YIELD STRENGTH AT T _c		S _{y,c}	KG/CM ²	2477.2		
POISSON'S RATIO		v _c	-	0.30		
MAIN SHELL MATERIAL		-	-	SA 516 GR 70		
DESIGN TEMPERATURE		T _s	°C	130.00		
MODULUS OF ELASTICITY AT T _s		E _s	KG/CM ²	2001687.0		
ALLOWABLE STRESS AT T _s		S _s	KG/CM ²	1406.2		
YIELD STRENGTH AT T _s		S _{y,s}	KG/CM ²	2391.1		
POISSON'S RATIO		v _s	-	0.30		
CHANNEL GASKET LOAD REACTION DIAMETER		G _c	MM	452.00		
MAIN SHELL GASKET LOAD REACTION DIAMETER		G _s	MM	N.A.		
TUBE SHEET THICKNESS INCLUDING GROOVES		h	MM	41.00		
PASS PARTITION GROOVE DEPTH (FIG UHX-11.1(c))		hg	MM	5.00		
INTERNAL DESIGN PRESSURE INCL. STATIC SHELL SIDE		P _s	KG/CM ² (g)	27.794		
HEAD & CORRECTED FOR VACUUM CHANNEL SIDE		P _t	KG/CM ² (g)	21.695		
CHANNEL SIDE CORROSION ALLOWANCE		C _{ac}	MM	3.00		
SHELL SIDE CORROSION ALLOWANCE		C _{as}	MM	3.00		
TUBESHEET CORROSION ALLOWANCE CHANNEL SIDE		C _{att}	MM	3.00		
SHELL SIDE		C _{ats}	MM	3.00		
CHANNEL SHELL THICKNESS (CORRODED)		t _c	MM	7.00		
MAIN SHELL THICKNESS (CORRODED)		t _s	MM	7.00		
NOMINAL TUBE WALL THICKNESS		t _t	MM	2.00		
CHANNEL FLANGE DESIGN BOLT LOAD FOR GASKET SEAT.		W _c	KG	91567.32		
SHELL FLANGE DESIGN BOLT LOAD FOR GASKET SEAT.		W _s	KG	0.00		
MAXIMUM FLANGE DESIGN BOLT LOAD = MAX OF W _c & W _s		W	KG	91567.32		

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	TUBE SHEET DESIGN - Contd.. (UHX-13)		PRPD.		CHKD.	APPD.
			KK	KK	RCS	
RADIAL CHANNEL DIMENSION = $G_c/2$ a_c MM 226.00						
RADIUS TO OUTERMOST TUBE HOLE CENTRE (FIG UHX-11.1(a)) r_o MM 180.05						
TUBE NOMINAL OUTSIDE DIAMETER d_t MM 20.00						
EQUIVALENT DIA OF OTL CIRCLE = $2r_o + d_t$ D_o MM 380.10						
EQUIVALENT RADIUS OF OTL CIRCLE = $D_o/2$ a_o MM 190.05						
RADIAL SHELL DIMENSION = $D_s/2$ a_s MM 203.00						
TUBE LENGTH BETWEEN OUTER TUBESHEET FACE L_t MM 4094.00						
TUBE LENGTH BETWEEN INNER TUBESHEET FACE = L_t-2h L MM 4012.00						
NUMBER OF TUBES N_t NOS 154						
TUBE PITCH p MM 25.00						
TUBE PATTERN (S = SQUARE, T = TRIANGULAR) - T						
EXPANDED LENGTH OF TUBE IN TUBESHEET l_{tx} MM 26.00						
TUBE EXPANSION DEPTH RATIO = l_{tx} / h ρ - 0.6341						
MEAN SHELL METAL TEMPERATURE $T_{s.m}$ °C 68.57						
MEAN TUBE METAL TEMPERATURE $T_{t.m}$ °C 43.52						
AMBIENT TEMPERATURE T_a °C 20.00						
MEAN COEFFICIENT OF THERMAL EXPANSION FOR SHELL AT $T_{s.m}$ $\alpha_{s.m}$ MM/MM°C 0.00001190						
MEAN COEFFICIENT OF THERMAL EXPANSION FOR TUBE AT $T_{t.m}$ $\alpha_{t.m}$ MM/MM°C 0.00001174						
UNTUBED AREA CALCULATIONS						
CENTER TO CENTER DISTANCE BETWEEN ADJACENT TUBE ROWS OF UNTUBED LANES (MM), NOT TO EXCEED $4p$ U_{L1} 36.00 U_{L2} 36.00 U_{L3} 36.00 U_{L4} 0.00 U_{L5} 0.00						
LENGTH OF UNTUBED LANE L_{L1} 380.10 L_{L2} 322.10 L_{L3} 322.10 L_{L4} 0.00 L_{L5} 0.00						
TOTAL AREA OF UNTUBED LANES = $U_{L1} * L_{L1} + U_{L2} * L_{L2} + \dots$ A_L MM² 36874.80						
STEP-1 (UHX-13.5.1)						
μ = 0.2000 μ^* = 0.4082 ρ_s = 1.0681						
d^* = 18.01 MM hg' = 2.00 (CASE 1,2,3) ρ_c = 1.1892						
p^* = 30.43 MM hg' = 0.00 (CASE 4,5,6,7) x_s = 0.5736						
x_t = 0.7271						
STEP-2 (UHX-13.5.2)						
K_s = 45314.08 KG/MM β_s = 0.0338 β_c = 0.0000						
K_t = 564.27 KG/MM k_s = 42513.73 k_c = 0.0000						
$K_{s,t}$ = 0.52 λ_s = 6964.85 λ_c = 0.0000						
BELLOW USED? NO (YES/NO) δ_s = 0.2500 δ_c = 0.0000						
J = 1.00E+00 (NO BELLOW) D_J = MM						
K_J = KG/MM						
STEP-3 (UHX-13.5.3)						
h/p = 1.4000						
E^*/E = 0.4487 (FIG UHX-11.3) FROM FIG UHX-13.2, FOR X_a						
E^* = 898075.5 KG/CM ² Z_d = 0.0710						
v^* = 0.2962 (FIG UHX-11.3) $Z_v = Z_w$ = 0.1241						
X_a = 2.7454 Z_m = 0.5628						
STEP-4 (UHX-13.5.4)						
K = 1.4259 Q_1 = -0.0605						
F = 1.1024 Q_{Z1} = 1.8043						
ϕ = 1.4289 Q_{Z2} = 2.5575 U = 5.1151						

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	ITEM NO. : 117-EE-487						REV.		0	
	DOCUMENT NO. : PRJ/9742/20						DATE		28-Feb-10	
	TUBE SHEET DESIGN - Contd.. (UHX-13)						PRPD.		CHKD.	APPD.
						KK		KK	RCS	
STEP-5 (UHX-13.5.5)										
γ = 0.0000 (CASE 1,2,3) ω_s = 837.96 MM ² ω_c = 0.00 MM ²										
γ = -1.2111 (CASE 4,5,6,7) ω_s^* = -751.25 MM ² ω_c^* = 2892.89 MM ²										
γ_b = -0.1105										
STEP-6,7,8,9 (UHX-13.5.6,7,8,9)										
LOADING CASE										
			1.	2	3	4	5	6	7	
SHELL SIDE PRESSURE	Ps	KG/CM ² (g)	0.000	27.794	27.794	0.000	0.000	27.794	27.794	
TUBE SIDE PRESSURE	Pt	KG/CM ² (g)	21.695	0.000	21.695	0.000	21.695	0.000	21.695	
Ps'	Ps'	KG/CM ² (g)	0.000	52.029	52.029	0.000	0.000	52.029	52.029	
Pt'	Pt'	KG/CM ² (g)	60.931	0.000	60.931	0.000	60.931	0.000	60.931	
Pw	Pw	KG/CM ² (g)	22.805	22.805	22.805	22.805	22.805	22.805	22.805	
Py	Py	KG/CM ² (g)	0.000	0.000	0.000	-92.744	-92.744	-92.744	-92.744	
Prim	Prim	KG/CM ² (g)	8.888	2.957	11.845	0.000	8.888	2.957	11.845	
EFFECTIVE PRESSURE	Pe	KG/CM ² (g)	-7.504	19.965	6.608	-17.950	-31.307	-3.838	-17.195	
	Q ₂	KG	-1240.43	-1008.29	-1356.16	-892.56	-1240.43	-1008.29	-1356.16	
	Q ₃	-	0.8548	-0.3402	-1.1969	0.2148	0.1589	1.3943	0.3762	
FROM FIG. UHX-13.3-1 & 2	Fm	-	0.4700	0.1700	0.6000	0.1800	0.1600	0.7500	0.2400	
BENDING STRESS IN T/S	σ	KG/CM ²	-1719.6	1654.8	1933.2	-1400.4	-2171.1	-1247.6	-1788.7	
CHECK WHETHER $ \sigma \leq 1.5S$	-	YES	YES	YES	-	-	-	-	-	
CHECK WHETHER $ \sigma \leq 3S$	-	-	-	-	YES	YES	YES	YES	YES	
RESULT	-	OK	OK	OK	OK	OK	OK	OK	OK	
AVG.SHEAR STRESS IN T/S	τ	KG/CM ²	-101.9	271.0	89.7	-243.7	-425.0	-52.1	-233.4	
CHECK WHETHER $ \tau \leq 0.8S$	-	YES	YES	YES	YES	YES	YES	YES	YES	
RESULT	-	OK	OK	OK	OK	OK	OK	OK	OK	
COEFFICIENT	Ft,min	-	-2.5891	0.8186	-2.2013	-0.7250	-0.5620	-4.1605	-1.1951	
	Ft,max	-	5.0308	1.0733	3.3869	2.7749	2.5777	6.9325	3.3438	
AXIAL TUBE STRESS	$\sigma_{t,1}$	KG/CM ²	-229.4	-2.6	95.9	-84.8	-217.4	-0.2	-132.8	
	$\sigma_{t,2}$	KG/CM ²	143.2	-35.7	-144.7	324.5	423.0	277.2	375.7	
MAX OF $ \sigma_{t,1} $ & $ \sigma_{t,2} $	$\sigma_{t,max}$	KG/CM ²	229.4	35.7	144.7	324.5	423.0	277.2	375.7	
CHECK WHETHER $\sigma_{t,max} \leq St$	-	YES	YES	YES	-	-	-	-	-	
CHECK WHETHER $\sigma_{t,max} \leq 2*St$	-	-	-	-	YES	YES	YES	YES	YES	
RESULT	-	OK	OK	OK	OK	OK	OK	OK	OK	
AS AXIAL TUBE STRESS IS NOT NEGATIVE, TUBE DESIGN IS ACCEPTABLE.										
UNSUPPORTED TUBE SPAN	l	MM								
FACTOR	k	-								
DESIGN LENGTH = l x k	lt	MM								
	rt	MM								
RATIO = lt / rt	Ft	-								
	Ct	-								
FACTOR OF SAFETY	Fs	-								
MAX. ALL. BUCK. STRESS	Stb	KG/CM ²								
MIN OF $\sigma_{t,1}$ & $\sigma_{t,2}$	$\sigma_{t,min}$	KG/CM ²								
CHECK WHETHER $ \sigma_{t,min} \leq Stb$	-	-								
RESULT	-	-								

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER			PAGE	20	
	ITEM NO. : 117-EE-487			REV.	0	
	DOCUMENT NO. : PRJ/9742/20			DATE	28-Feb-10	
	MISCELLANEOUS PARTS (RCB-(2.5,4.41,4.42,4.51,4.52, 4.71,6.31,6.4,9.131))			PRPD.	CHKD.	APPD.
				KK	KK	RCS
TRANSVERSE BAFFLES & SPACING (RCB-4.41,RCB-4.51,RCB-4.52)						
DESCRIPTION		UNIT	VALUE	REQUIRED	PROVIDED	
NOMINAL SHELL ID		MM	400.00	-	-	
TUBE OD		MM	20.00	-	-	
BAFFLE SPACING (MIN)		MM	-	80.00	200.00	
UNSUPPORTED TUBE LENGTH (MAX)		MM	-	1524.00		
BAFFLE THICKNESS (TEMA)		MM	-	4.80	6.00	
BAFFLE THICKNESS (7.6.3.1 OF API 660)		MM	-	N.A.		
LONGITUDINAL BAFFLES (RCB-4.42)						
REQUIRED BAFFLE THICKNESS						
AS PER TEMA		MM	-	6.00	N.A.	
TIE RODS (RCB-4.71)						
DIAMETER OF TIE RODS		MM	-	9.50	10.00	
NUMBER OF TIE RODS		NOS	-	6	6	
TUBE PITCH (RCB-2.5)						
TUBE PITCH		MM	-	25.00	25.00	
GASKET (RCB-6.31,RCB-6.4)						
WIDTH OF PERIPHERAL RING GASKET		MM	-	9.50	10.00	
WIDTH OF PASS PARTITION		MM	-	6.40	7.00	
PASS PARTITION PLATE (RCB-9.131,RCB-9.132)						
AS PER RCB-9.132						
PRESSURE DROP ACROSS PLATE			q	KG/CM ² (g)	0.700	
DESIGN TEMPERATURE			T	°C	80	
MATERIAL			-	-	SA 516 GR 70	
ALLOWABLE STRESS AT DESIGN TEMPERATURE			S	KG/CM ²	1406.2	
CORROSION ALLOWANCE			C	MM	3	
ATTACHMENT			Three Sides fixed, One Side simply supported			
DIMENASION `a`			a	MM	400.00	
DIMENASION `b`			b	MM	371.00	
RATIO = a/b			-	-	1.08	
A VALUE FROM TABLE RCB-9.132 FOR RATIO `a/b`			B	-	0.3441	
REQUIRED THICKNESS = $b*\{(q*B) / (1.5*S)\}^{1/2}$			trpp ₁	MM	3.96	
REQUIRED THICKNESS AS PER TABLE RCB-9.131			trpp ₂	MM	9.50	
REQUIRED THICKNESS = MAX OF trpp ₁ & trpp ₂			trpp	MM	9.50	
PROVIDED THICKNESS			tpp	MM	10.00	

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER				PAGE		21	
	ITEM NO. : 117-EE-487				REV.		0	
	DOCUMENT NO. : PRJ/9742/20				DATE		28-Feb-10	
	NOZZLE NECK & REINFORCEMENT-N1,N2,N5,N6 (UG-36, UG-37, UG-45)				PRPD.		CHKD.	APPD.
					KK	KK	RCS	

DESIGN INPUT					NOZZLE NECK CALCULATIONS (mm)		
-	Nozzle Mark	N1,N2		AS PER UG-45 OF ASME SEC. VIII DIV.1,			
-	Nozzle Size	50 NB		trn	P*(do/2)/(S*E+0.4P)+C (As per 1-1(a)(1))	3.66	
-	Nozzle Location	MAIN SHELL					
P	Design Pressure (Kg/cm ² (g))	26.739		t ₁	Smls. Shell Thickness	6.90	
T	Design Temperature (°C)	130		Sw	Std Wall Thickness	3.91	
do	Nozzle Outside Dia. (mm)	60.3		t ₂	0.875*Sw + C	6.42	
C	Corrosion Allowance (mm)	3		t ₃	Minimum of t ₁ & t ₂	6.42	
-	Nozzle Material	SA 333 GR 6		t ₄	1.5 + C (As per UG-16(b))	4.50	
S	Allowable Stress (Kg/cm ²)	1202.3		Min.Reqd thk = Max of (trn,t ₃ ,t ₄)		6.42	
E	Joint Efficiency	1.00		tn	Provided thk(Min)=tn ₁ -Neg.Tol.(mm)	7.65	
t	Shell Thickness (mm)	10.00		Provided pipe Sch.		SCH 160	
				tn ₁	Provided thk (Nom) (mm)	8.74	
FILLET SIZE CALCULATIONS (UW-16) (mm)					d	Finished Opening Size (mm) do - 2*tn + 2*C	51.01
Applicable Fig.		UW-16.1(c)		Fillet Size			
tmin	Min of tn ₁ , t & 19	8.74	Reqd.	Provided			
tc	Min of 0.7*tmin, 6	6.00	8.49	9.00			
As per clause UG-36(c)(3)(a), finished openings upto the size 89 mm are exempted from reinforcement calculations. Accordingly this nozzle is exemted from reinforcement calculations.							

DESIGN INPUT					NOZZLE NECK CALCULATIONS (mm)		
-	Nozzle Mark	N5,N6		AS PER UG-45 OF ASME SEC. VIII DIV.1,			
-	Nozzle Size	40 NB		trn	P*(do/2)/(S*E+0.4P)+C (As per 1-1(a)(1))	3.53	
-	Nozzle Location	MAIN SHELL					
P	Design Pressure (Kg/cm ² (g))	26.739		t ₁	Smls. Shell Thickness	6.90	
T	Design Temperature (°C)	130		Sw	Std Wall Thickness	3.68	
do	Nozzle Outside Dia. (mm)	48.3		t ₂	0.875*Sw + C	6.22	
C	Corrosion Allowance (mm)	3		t ₃	Minimum of t ₁ & t ₂	6.22	
-	Nozzle Material	SA 333 GR 6		t ₄	1.5 + C (As per UG-16(b))	4.50	
S	Allowable Stress (Kg/cm ²)	1202.3		Min.Reqd thk = Max of (trn,t ₃ ,t ₄)		6.22	
E	Joint Efficiency	1.00		tn	Provided thk(Min)=tn ₁ -Neg.Tol.(mm)	6.25	
t	Shell Thickness (mm)	10.00		Provided pipe Sch.		SCH 160	
				tn ₁	Provided thk (Nom) (mm)	7.14	
FILLET SIZE CALCULATIONS (UW-16) (mm)					d	Finished Opening Size (mm) do - 2*tn + 2*C	41.81
Applicable Fig.		UW-16.1(c)		Fillet Size			
tmin	Min of tn ₁ , t & 19	7.14	Reqd.	Provided			
tc	Min of 0.7*tmin, 6	5.00	7.07	8.00			
As per clause UG-36(c)(3)(a), finished openings upto the size 89 mm are exempted from reinforcement calculations. Accordingly this nozzle is exemted from reinforcement calculations.							

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER				PAGE		22	
	ITEM NO. : 117-EE-487				REV.		0	
	DOCUMENT NO. : PRJ/9742/20				DATE		28-Feb-10	
	NOZZLE NECK & REINFORCEMENT-N3,N4,N7,N8 (UG-36, UG-37, UG-45)				PRPD.		CHKD.	APPD.
				KK		KK	RCS	

DESIGN INPUT					NOZZLE NECK CALCULATIONS (mm)			
-	Nozzle Mark	N3,N4			AS PER UG-45 OF ASME SEC. VIII DIV.1,			
-	Nozzle Size	50 NB		trn	P*(do/2)/(S*E+0.4P)+C		3.51	
-	Nozzle Location	CHANNEL SHELL			(As per 1-1(a)(1))			
P	Design Pressure (Kg/cm ² (g))	20.640		t ₁	Smls. Channel Thickness		6.01	
T	Design Temperature (°C)	80		Sw	Std Wall Thickness		3.91	
do	Nozzle Outside Dia. (mm)	60.3		t ₂	0.875*Sw + C		6.42	
C	Corrosion Allowance (mm)	3		t ₃	Minimum of t ₁ & t ₂		6.01	
-	Nozzle Material	SA 333 GR 6		t ₄	2.5 + C (As per UG-16(b))		5.50	
S	Allowable Stress (Kg/cm ²)	1202.3			Min.Reqd thk = Max of (trn,t ₃ ,t ₄)		6.01	
E	Joint Efficiency	1.00		tn	Provided thk(Min)=tn ₁ -Neg.Tol.(mm)		7.65	
t	Channel Thickness (mm)	10.00			Provided pipe Sch.		SCH 160	
				tn ₁	Provided thk (Nom) (mm)		8.74	
FILLET SIZE CALCULATIONS (UW-16) (mm)					d	Finished Opening Size (mm)		
Applicable Fig.		UW-16.1(c)		do - 2*tn + 2*C		51.01		
tmin	Min of tn ₁ , t & 19	8.74	Reqd.	Provided				
tc	Min of 0.7*tmin, 6	6.00	8.49	9.00				
As per clause UG-36(c)(3)(a), finished openings upto the size 89 mm are exempted from reinforcement calculations. Accordingly this nozzle is exmpted from reinforcement calculations.								

DESIGN INPUT					NOZZLE NECK CALCULATIONS (mm)			
-	Nozzle Mark	N7,N8			AS PER UG-45 OF ASME SEC. VIII DIV.1,			
-	Nozzle Size	40 NB		trn	P*(do/2)/(S*E+0.4P)+C		3.41	
-	Nozzle Location	CHANNEL SHELL			(As per 1-1(a)(1))			
P	Design Pressure (Kg/cm ² (g))	20.640		t ₁	Smls. Channel Thickness		6.01	
T	Design Temperature (°C)	80		Sw	Std Wall Thickness		3.68	
do	Nozzle Outside Dia. (mm)	48.3		t ₂	0.875*Sw + C		6.22	
C	Corrosion Allowance (mm)	3		t ₃	Minimum of t ₁ & t ₂		6.01	
-	Nozzle Material	SA 333 GR 6		t ₄	2.5 + C (As per UG-16(b))		5.50	
S	Allowable Stress (Kg/cm ²)	1202.3			Min.Reqd thk = Max of (trn,t ₃ ,t ₄)		6.01	
E	Joint Efficiency	1.00		tn	Provided thk(Min)=tn ₁ -Neg.Tol.(mm)		6.25	
t	Channel Thickness (mm)	10.00			Provided pipe Sch.		SCH 160	
				tn ₁	Provided thk (Nom) (mm)		7.14	
FILLET SIZE CALCULATIONS (UW-16) (mm)					d	Finished Opening Size (mm)		
Applicable Fig.		UW-16.1(c)		do - 2*tn + 2*C		41.81		
tmin	Min of tn ₁ , t & 19	7.14	Reqd.	Provided				
tc	Min of 0.7*tmin, 6	5.00	7.07	8.00				
As per clause UG-36(c)(3)(a), finished openings upto the size 89 mm are exempted from reinforcement calculations. Accordingly this nozzle is exmpted from reinforcement calculations.								

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER	PAGE	23		
	ITEM NO. : 117-EE-487	REV.	0		
	DOCUMENT NO. : PRJ/9742/20	DATE	28-Feb-10		
	FLANGE RATING CHECK (UG-44, ASME B16.5)	PRPD.	CHKD.	APPD.	
		KK	KK	RCS	

FLANGE RATING CHECK :

AS PER UG-44, FLANGES AS PER ASME B16.5 ARE ACCEPTABLE

DESCRIPTION	UNIT	VALUE FOR	
		SHELL SIDE	CHANNEL SIDE
STANDARD FOR FLANGES	-	ASME B16.5	ASME B16.5
SELECTED RATING	-	300#	300#
MATERIAL	-	SA 350 GR LF2 CL1	SA 350 GR LF2 CL1
MATERIAL GROUP	-	1.1	1.1
DESIGN TEMPERATURE	°F	266	176
ALLOWABLE PRESSURE FOR SELECTED RATING	KG/CM ² (g)	46.650	48.822
DESIGN PRESSURE INCL. STATIC HEAD (MAX.)	KG/CM ² (g)	26.739	20.640
CONCLUSION		SAFE	SAFE

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER		PAGE	24		
	ITEM NO. : 117-EE-487		REV.	0		
	DOCUMENT NO. : PRJ/9742/20		DATE	28-Feb-10		
	POST FORMING HEAT TREATMENT (UCS-79)		PRPD.	CHKD.	APPD.	
			KK	KK	RCS	

AS PER UCS-79(d), AFTER COLD FORMING, HEAT TREATMENT IS REQUIRED WHEN THE RESULTING EXTREME FIBER ELONGATION IS MORE THAN 5% AND ANY OF FOLLOWING CONDITION EXIST :

SR. NO	CONDITION	APPLICABLE
1	LETHAL SERVICE	NO
2	WHETHER MATERIAL REQUIRES IMPACT TESTING	YES
3	PART THICKNESS EXCEEDS 5/8" (16 MM) BEFORE COLD FORMING	NO
4	REDUCTION IN THK BY FORMING IS MORE THAN 10% (REF. PAGE 12)	YES
5	THE FORMING TEMPERATURE IS BETWEEN 250 - 950 °F (121 - 482 °C)	NO

PERCENTAGE EXTREME FIBER ELONGATION :

CYLINDRICAL SHELLS :

PART	MATERIAL	THICKNESS t MM	ID AFTER FORMING MM	FINAL C/L RADIUS (Rf) MM	ORIGINAL RADIUS (Ro) MM	EXT.FIB. ELONG. %	SR REQD. (Yes/No)
MAIN SHELL	SA 516 GR 70	10.00	400.00	205	INFINITY	2.44	NO
CHANNEL SHELL	SA 516 GR 70	10.00	400.00	205	INFINITY	2.44	NO

- SINCE EXTREME FIBER ELONGATION IS LESS THAN 5%, STRESS RELIEVING AFTER FORMING IS NOT REQUIRED FOR ABOVE PARTS.
- % EXTREME FIBER ELONGATION FOR CYLINDRICAL SHELL = $50 \cdot t / R_f \cdot (1 - R_f / R_o)$

DISHED ENDS :

PART	MATERIAL	THICKNESS t (NOM) MM	INSIDE KNUCKLE RADIUS MM	FINAL C/L RADIUS (Rf) MM	ORIGINAL RADIUS (Ro) MM	EXT.FIB. ELONG. %	SR REQD. (Yes/No)
CHANNEL D'END	SA 516 GR 70	10.00	68.00	73.00	INFINITY	10.27	YES

- SINCE EXTREME FIBER ELONGATION IS MORE THAN 5%, STRESS RELIEVING AFTER FORMING IS REQUIRED FOR ABOVE PARTS.
- % EXTREME FIBER ELONGATION FOR DISHED END = $75 \cdot t / R_f \cdot (1 - R_f / R_o)$
- FOR 2:1 ELLIPSOIDAL DISHED END, INSIDE KNUCKLE RADIUS = 0.17 * DISHED END ID

D'ENDS SHALL BE STRESS RELIEVED.

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER		PAGE	25	
	ITEM NO. : 117-EE-487		REV.	0	
	DOCUMENT NO. : PRJ/9742/20		DATE	28-Feb-10	
	IMPACT TEST REQUIREMENTS (UG-20(f))		PRPD.	CHKD.	APPD.
			KK	KK	RCS

AS PER UG-20(f), IMPACT TESING AS PER UG-84 IS NOT REQUIRED FOR PRESSURE VESSEL MATERIAL WHICH SATISFY ALL OF THE FOLLOWING:

SR. NO	CONDITION	CONDITION SATISFIED?
1	MATERIAL IS LIMITED TO P NO. 1, GR. NO. 1 & 2 THK IS LESS THAN 13 MM FOR MATERIAL LISTED IN CURVE-A THK IS LESS THAN 25 MM FOR MATERIAL LISTED IN CURVE-B,C,D	YES
2	THE VESSEL IS HYDRAULICALLY TESTED AS PER UG-99(b) OR (c) OR 27-4	YES **
3	DESIGN TEMPERATURE IS NO WARMER THAN 345 °C NOR COLDER THAN -29 °C	NO
4	THE THERMAL OR MECHANICAL SHOCK LOADINGS ARE NOT CONTROLLING DESIGN REQUIREMENTS (UG-22)	YES
5	CYCLICAL LOADING IS NOT A CONTROLLING DESIGN REQUIREMENT (UG-22)	YES

AS ALL ABOVE CONDITIONS ARE NOT SATISFIED, REQUIREMENTS OF UCS-66
NEED TO BE CHECKED.

** FOR SHELL SIDE, PNEUMATIC TEST WILL BE CARRIED OUT IN LIEU OF
HYDROSTATIC TEST AS PERMITTED BY UG-100(a).

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER				PAGE	26
	ITEM NO. : 117-EE-487				REV.	0
	DOCUMENT NO. : PRJ/9742/20				DATE	28-Feb-10
	IMPACT TEST REQUIREMENTS (UCS-66)				PRPD.	CHKD.
				KK	KK	RCS

SHELL SIDE					
DESCRIPTION		APPLICABLE CURVE	MAX. THK EXEMPTED MM	MAXIMUM THK IN JOB MM	APPLICABLE CLAUSE
MDMT (°C / °F)	-45 / -49	-	-	-	-
PLATES	SA 516 GR 70	D	15.10	10.00	UCS-66(a)
PIPES	SA 333 GR 6	B	NOT EXEMPTED	8.74	UCS-66(a)
FORGINGS (STD FLANGES)	SA 350 GR LF2 CL1	AS PER CLAUSE UCS-66(c) OF ASME SEC VIII DIV 1, IMPACT TESTING IS NOT REQUIRED FOR ASME B16.5 FLANGES OF FERRITIC STEEL FOR MDMT WARMER THAN -20 °F. HENCE, NOT EXEMPTED.			
BOLTS	SA 320 GR L7	AS PER NOTE (c) OF FIG UCS-66 OF ASME SEC VIII DIV 1, BOLT SIZES UPTO 64 MM ARE EXEMPTED FROM IMPACT TESTING FOR MDMT WARMER THAN -48 °C.			
NUTS	SA 194 GR 7	AS PER NOTE (c) OF FIG UCS-66 OF ASME SEC VIII DIV 1, NUTS ARE EXEMPTED FROM IMPACT TESTING FOR MDMT WARMER THAN -48 °C.			
HENCE, IMPACT TESTING IS REQUIRED FOR PIPES AND FORGINGS ONLY. HOWEVER, IMPACT TESTING SHALL BE CARRIED OUT FOR ALL MATERIAL IN LINE WITH DATA SHEET.					
CHANNEL SIDE					
DESCRIPTION		APPLICABLE CURVE	MAX. THK EXEMPTED MM	MAXIMUM THK IN JOB MM	APPLICABLE CLAUSE
MDMT (°C / °F)	-45 / -49	-	-	-	-
PLATES	SA 516 GR 70	D	15.10	10.00	UCS-66(a)
PIPES	SA 333 GR 6	B	NOT EXEMPTED	8.74	UCS-66(a)
FORGINGS (STD FLANGES, TUBESHEET, BODY FLANGES)	SA 350 GR LF2 CL1	AS PER CLAUSE UCS-66(c) OF ASME SEC VIII DIV 1, IMPACT TESTING IS NOT REQUIRED FOR ASME B16.5 FLANGES OF FERRITIC STEEL FOR MDMT WARMER THAN -20 °F. HENCE, NOT EXEMPTED.			
BOLTS	SA 320 GR L7	AS PER NOTE (c) OF FIG UCS-66 OF ASME SEC VIII DIV 1, BOLT SIZES UPTO 64 MM ARE EXEMPTED FROM IMPACT TESTING FOR MDMT WARMER THAN -48 °C.			
NUTS	SA 194 GR 7	AS PER NOTE (c) OF FIG UCS-66 OF ASME SEC VIII DIV 1, NUTS ARE EXEMPTED FROM IMPACT TESTING FOR MDMT WARMER THAN -48 °C.			
HENCE, IMPACT TESTING IS REQUIRED FOR PIPES AND FORGINGS ONLY. HOWEVER, IMPACT TESTING SHALL BE CARRIED OUT FOR ALL MATERIAL IN LINE WITH DATA SHEET.					

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER		PAGE	27	
	ITEM NO. : 117-EE-487		REV.	0	
	DOCUMENT NO. : PRJ/9742/20		DATE	28-Feb-10	
	PWHT REQUIREMENTS (UW-2, UCS-56, UCS-68)		PRPD.	CHKD.	APPD.
			KK	KK	RCS

POST WELD HEAT TREATMENT IS REQUIRED WHEN ANY OF FOLLOWING CONDITION EXIST:

SR. NO	APPLICABLE CLAUSE	DESCRIPTION	APPLICABLE	REMARKS
1	UW-2(a)	LETHAL SERVICE	NO	
2	UW-2(c)	UNFIRED STEAM BOILER WITH DESIGN PRESSURE EXCEEDING 50 PSI	NO	
3	UCS-68(b)	IF MDMT IS COLDER THAN -55°F (-48°C) AND THE COINCIDENT RATIO DEFINED IN FIG UCS-66.1 IS 0.35 OR GREATER	NO	
4	UCS-56	MATERIAL OVER 1-1/4" (32 MM) NOMINAL THICKNESS AS DEFINED IN UW-40(f)	NO	

HENCE, PWHT IS NOT REQUIRED.

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER		PAGE		28	
	ITEM NO. : 117-EE-487		REV.		0	
	DOCUMENT NO. : PRJ/9742/20		DATE		28-Feb-10	
	TEST PRESSURE (UG-99,UG-100)		PRPD.	CHKD.	APPD.	
			KK	KK	RCS	
FOR SHELL SIDE						
DESIGN PRESSURE		P	KG/CM ² (g)	26.700		
MINIMUM STRESS RATIO (REF. PAGE NO. 7)		(Sh/S) _{MIN}	-	1.000		
AS PER UG-100(b) OF ASME SEC. VIII DIV.1,						
PNEUMATIC TEST PRESSURE AT THE TOP		P _{ht}	KG/CM ² (g)	29.370		
=1.1 * P * (Sh/S) _{MIN}			BAR (g)			
FOR CHANNEL SIDE						
DESIGN PRESSURE		P	KG/CM ² (g)	20.600		
MINIMUM STRESS RATIO (REF. PAGE NO. 7)		(Sh/S) _{MIN}	-	1.000		
AS PER UG-99(b) OF ASME SEC. VIII DIV.1,						
HYDROSTATIC TEST PRESSURE AT THE TOP		P _{ht}	KG/CM ² (g)	26.780		
=1.3 * P * (Sh/S) _{MIN}			BAR (g)			

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER	PAGE	29				
	ITEM NO. : 117-EE-487	REV.	0				
	DOCUMENT NO. : PRJ/9742/20	DATE	28-Feb-10				
	WIND LOAD CALCULATIONS (IS:875)	PRPD.	CHKD.	APPD.			
		KK	KK	RCS			
AS PER IS:875 PART 3							
DESCRIPTION		SYMBOL	UNIT	VALUE			
BASIC WIND SPEED		Vb	M/SEC	50			
PROBABILITY FACTOR (RISK CO-EFFICIENT)		K1	-	1.00			
TERRAIN, HT. & STRCT. SIZE FACTOR		K2	-	1.00			
TOPOGRAPHY FACTOR		K3	-	1.00			
INSULATION THICKNESS		Ti	MM	25			
OUTSIDE DIAMETER INCLUDING INSULATION THK.		D	M	0.470			
WIND RESISTING DIAMETER = 1.2 * D **		Do	M	0.564			
WIND RESISTING HEIGHT		H	M	0.735			
DISTANCE FROM EQUIPMENT C.L. TO SUPPORT BOTTOM		B	M	0.500			
OVERALL LENGTH		L	M	4.840			
FORCE COEFFICIENT		Cf	-	0.7			
DESIGN WIND SPEED = K1 * K2 * K3 * Vb		Vz	M/SEC	50.00			
WIND PRESSURE = 0.6 * Vz ²		Pz ₁	N/M ²	1500.00			
			KG/M ²	153.00			
MINIMUM WIND PRESSURE TO BE CONSIDERED (as per client)		Pz ₂	KG/M ²	-			
DESIGN WIND PRESSURE = MAX OF Pz ₁ & Pz ₂		Pz	KG/M ²	153.00			
WIND RESISTING AREA FOR TRANSVERSE FORCE=L*H		Af _T	M ²	3.557			
WIND RESISTING AREA FOR LONGITUDINAL FORCE=H*Do		Af _L	M ²	0.415			
WIND TRANSVERSE FORCE AT BASE = Cf * Pz * Af _T		F _{TW}	KG	381.00			
WIND TRANSVERSE MOMENT AT BASE = F _{TW} * B		M _{TW}	KG.M	190.50			
WIND LONGITUDINAL FORCE AT BASE = Cf * Pz * Af _L		F _{LW}	KG	44.40			
WIND LONGITUDINAL MOMENT AT BASE = F _{LW} * B		M _{LW}	KG.M	22.20			
** TO TAKE CARE OF EXTERNALS.							
WIND LOAD FOR VARIOUS CONDITIONS:							
	UNIT	OPERATING		TEST		EMPTY	
		TRANS.	LONG.	TRANS.	LONG.	TRANS.	LONG.
WIND LOAD	KG	381.00	44.40	125.73	14.65	381.00	44.40
WIND MOMENT	KG-M	190.50	22.20	62.86	7.33	190.50	22.20
NOTES :							
1. DURING TEST CONDITION, WIND LOADS SHALL BE CONSIDERED AS 33% OF THE VALUES DURING OPERATING CONDITION. ACCORDINGLY, ABOVE VALUES DURING TEST ARE REDUCED.							

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER		PAGE		30	
	ITEM NO. : 117-EE-487		REV.		0	
	DOCUMENT NO. : PRJ/9742/20		DATE		28-Feb-10	
	SEISMIC LOAD CALCULATIONS (IS:1893)		PRPD.	CHKD.	APPD.	
			KK	KK	RCS	

AS PER IS:1893			
DESCRIPTION	SYMBOL	UNIT	VALUE
OPERATING WEIGHT	Wo	KG	2340
EMPTY WEIGHT	We	KG	1690
TEST WEIGHT	Wh	KG	1971
SEISMIC ZONE	-	-	V
SEISMIC ZONE FACTOR	Z	-	0.36
SPECTRAL ACCELERATION	Sa/g (NOTE-3)	-	2.50
DAMPING	-	%	2.00
MULTIPLYING FACTOR FROM TABLE-3, PART-1	M _F	-	1.40
RESPONSE REDUCTION FACTOR FROM TABLE-9	R	-	3.00
IMPORTANCE FACTOR FROM TABLE-2	I	-	1.75
HORIZONTAL SEISMIC CO-EFF. = (Z/2) * (Sa/g) * M _F / (R/I)	Ah1	-	0.3675
HORIZONTAL SEISMIC CO-EFF. AS PER CLIENT SPEC.	Ah2	-	-
HORIZONTAL SEISMIC CO-EFF. = MAX OF Ah1 & Ah2	Ah	-	0.3675
DISTANCE FROM EQUIPMENT C.L. TO SUPPORT BOTTOM	B	M	0.500

SEISMIC LOAD FOR VARIOUS CONDITIONS:				
DESCRIPTION	UNIT	OPERATING	TEST	EMPTY
W = WEIGHT	KG	2340	1971	1690
Fe = SEIS. FORCE AT BASE = Ah * W	KG	859.95	0.00	621.08
Me = SEIS. MOMENT AT BASE = Fe*B	KG-M	429.98	0.00	310.54

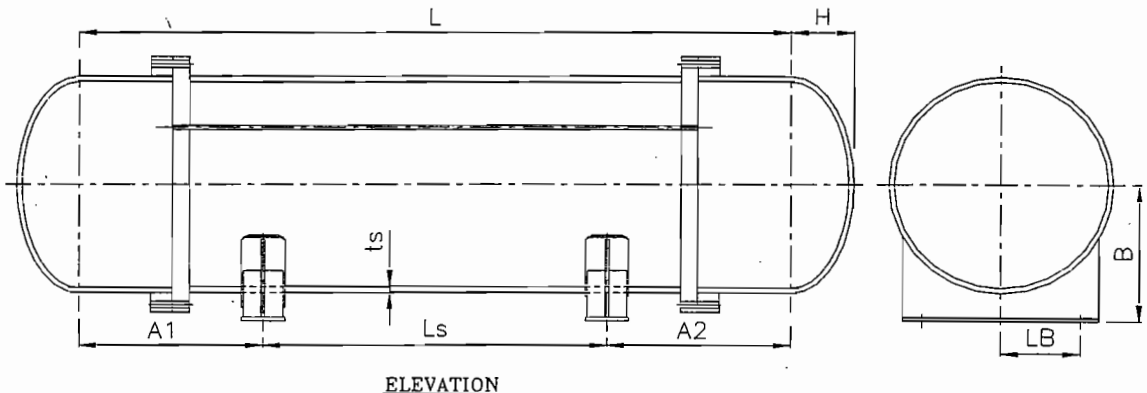
NOTES :

1. DURING TEST CONDITION, SEISMIC LOADS SHALL BE CONSIDERED AS 0% OF THE FULL VALUES DURING THAT CONDITION. ACCORDINGLY, ABOVE VALUES DURING TEST ARE REDUCED.
2. SEISMIC FORCES WILL BE SAME IN BOTH TRANSEVERSE & LONGITUDINAL DIRECTIONS.
3. AS FUNDAMENTAL TIME PERIOD IS NOT CALCULATED, MAXIMUM POSSIBLE VALUE OF Sa/g IS CONSIDERED RESULTING IN CONSERVATIVE DESIGN.

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER	PAGE	31
	ITEM NO. : 117-EE-487	REV.	0
	DOCUMENT NO. : PRJ/9742/20	DATE	28-Feb-10
	SUPPORT DESIGN (ZICK ANALYSIS)	PRPD.	CHKD.
		KK	RCS

DESIGN INPUT

T.L. TO T.L. LENGTH	L	MM	4620.00
T.L. TO SUPPORT DISTANCE (MAX OF A1 & A2)	A	MM	816.00
DISTANCE BETWEEN TWO SUPPORTS	Ls	MM	3000.00
DISHED END OUTSIDE HEIGHT	H	MM	110.00
INSIDE DIAMETER (CORRODED)	Di	MM	406.00
INSIDE RADIUS (CORRODED)	R	MM	203.00
CORROSION ALLOWANCE	C	MM	3.00
SHELL THICKNESS (CORRODED)	ts	MM	7.00
D'END THICKNESS (CORRODED)	th	MM	5.00
JOINT EFFICIENCY FOR LONGITUDINAL JOINT	E	-	1.00
YIELD STRENGTH	Sy	KG/MM ²	23.91
NO OF SUPPORTS	N	NOS	2
CONTACT ANGLE	θ	Deg	120.00
SUPPORT HEIGHT	B	MM	500.00
SADDLE WIDTH	b	MM	134.00



SUPPORT DESIGN

	SYMBOL	UNIT	OPERATING	TEST	EMPTY
INTERNAL PRESSURE	P	KG/CM ² (g)	26.739	29.370	0.000
EXTERNAL PRESSURE	Pe	KG/CM ² (g)	1.055	0.000	1.055
ALLOWABLE STRESS	S	KG/MM ²	14.062	24.046	14.062
WEIGHT	W	KG	2340.00	1971.00	1690.00
TRANSEVERSE LOAD (MAX OF WIND/SEIS.)	F _T	KG	859.95	125.73	621.08
LONGITUDINAL LOAD (MAX OF WIND/SEIS.)	F _L	KG	859.95	14.65	621.08
CG LOCATION FROM FIXED SUPPORT	l ₁	MM	1500.00	1500.00	1500.00
Ls - l ₁	l ₂	MM	1500.00	1500.00	1500.00
Q ₁ = W * (MAX OF l ₁ & l ₂) / Ls + F _L *B / Ls	Q ₁	KG	1313.33	987.94	948.51
Q ₂ = W * (MAX OF l ₁ & l ₂) / Ls + 3 * F _T *B / 2a	Q ₂	KG	2845.23	1230.43	2054.89
Q = MAX OF Q ₁ & Q ₂	Q	KG	2845.23	1230.43	2054.89

LONGITUDINAL BENDING MOMENT

AT SUPPORTS	M ₁	KG-MM	460199.49	199014.64	332366.30
= Q/2*(8*A*H+6*A ² -3*R ² +3H ²)/(3*L+4*H)					
AT MID-SPAN	M ₂	KG-MM	872104.64	377144.24	629853.35
= Q/4*(3*L ² + 6*R ² -6H ² -12*A*L-16*A*H)/(3*L+4*H)					

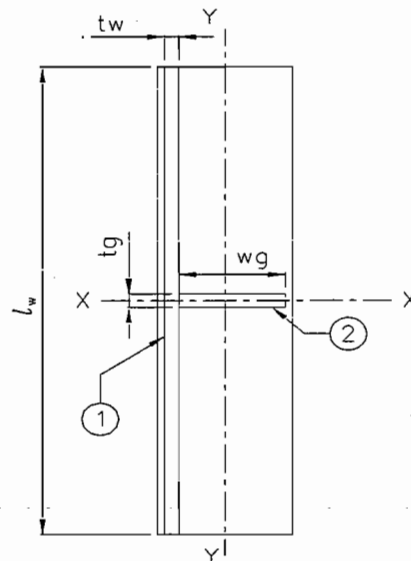
KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER				PAGE	32	
	ITEM NO. : 117-EE-487				REV.	0	
	DOCUMENT NO. : PRJ/9742/20				DATE	28-Feb-10	
	SUPPORT DESIGN (ZICK ANALYSIS) - Contd..				PRPD.	CHKD.	APPD.
					KK	KK	RCS
CALCULATIONS FOR STRESSES :							
WHETHER STIFFENERS PROVIDED				NO			
LONG. BENDING STRESS AT SADDLE = $M_1/(K_1 \cdot R^2 \cdot t_s)$ $K_1 = 0.335$	S_1	KG/MM ²	4.762	2.059	3.439		
LONG. BENDING STRESS AT SADDLE = $-M_1/(K_7 \cdot R^2 \cdot t_s)$ $K_7 = 0.603$	S_2	KG/MM ²	-2.646	-1.144	-1.911		
LONG. BENDING STRESS AT SADDLE = $M_1/(\pi \cdot R^2 \cdot t_s)$	S_3	KG/MM ²	N.A.	N.A.	N.A.		
LONG. BENDING STRESS AT MID SPAN = $M_2/(\pi \cdot R^2 \cdot t_s)$	S_4	KG/MM ²	0.962	0.416	0.695		
TANGENTIAL SHEAR(Shell stiff.in saddle plane) = $Q \cdot ((L-2 \cdot A)/(L+4/3 \cdot H))/(\pi \cdot R \cdot t_s)$	S_5	KG/MM ²	N.A.	N.A.	N.A.		
TANGENTIAL SHEAR = $K_2 \cdot Q \cdot ((L-2 \cdot A)/(L+4/3 \cdot H))/(R \cdot t_s)$ $K_2 = 1.171$	S_6	KG/MM ²	1.470	0.636	1.061		
TANGENTIAL SHEAR IN SHELL = $K_3 \cdot Q/(R \cdot t_s)$ $K_3 = 0.880$	S_7	KG/MM ²	N.A.	N.A.	N.A.		
TANGENTIAL SHEAR IN HEAD = $K_3 \cdot Q/(R \cdot t_h)$ $K_3 = 0.880$	S_8	KG/MM ²	N.A.	N.A.	N.A.		
CIRC. BENDING AT HORN OF SADDLE $K_6 = 0.053$	S_9	KG/MM ²	4.089	1.768	2.953		
CIRC. BENDING AT HORN OF SADDLE $K_6 = 0.053$	S_{10}	KG/MM ²	N.A.	N.A.	N.A.		
ADDITIONAL STRESS IN HEAD = $K_4 \cdot Q/(R \cdot t_h)$ $K_4 = 0.401$	S_{11}	KG/MM ²	N.A.	N.A.	N.A.		
CIRCUMFERENTIAL COMPRESSION = $-K_5 \cdot Q/(t_s \cdot (b+1.56 \cdot \text{SQRT}(R \cdot t_s)))$ $K_5 = 0.760$	S_{12}	KG/MM ²	-1.602	-0.693	-1.157		
CIRCUMFERENTIAL STRESS $K_8 = 0.340$ $K_9 = 0.053$	S_{13}	KG/MM ²	N.A.	N.A.	N.A.		
CIRCUMFERENTIAL COMPRESSION IN STIFF. $K_8 = 0.340$ $K_9 = 0.053$	S_{14}	KG/MM ²	N.A.	N.A.	N.A.		
PRESSURE STRESSES							
= $P \cdot (R + t_s) / (2 \cdot t_s)$	σ_x	KG/MM ²	4.011	4.406	0.000		
= $P \cdot (R + t_s) / t_s$	σ_b	KG/MM ²	8.022	8.811	0.000		
= $P \cdot (R + t_s) / t_s$	σ_h	KG/MM ²	8.022	8.811	0.000		
= $P_e \cdot (R + t_s) / (2 \cdot t_s)$	σ_e	KG/MM ²	0.158	0.000	0.158		
ALLOWABLE LIMITS FOR STRESSES :							
STRESS	SYMBOL	ALLOW. LIMIT	UNIT	OPERATING	TEST	EMPTY	
TENSION	$S_1, S_3, S_4 + \sigma_x$	SE	KG/MM ²	14.062	24.046	14.062	
COMPRESSION	$S_2, S_3, S_4 - \sigma_c$	SE	KG/MM ²	14.062	24.046	14.062	
TANG. SHEAR	S_5, S_6, S_7, S_8	0.8*S	KG/MM ²	11.250	19.236	11.250	
CIRC. BENDING	S_9, S_{10}	MIN OF 1.5S & 0.9*Sy	KG/MM ²	21.093	24.046	21.093	
ADD. STRESS IN D'EN	$S_{11} + \sigma_h$	1.25*S*E	KG/MM ²	17.578	30.057	17.578	
CIRC.COMP.STRESS	S_{12}	1.5*S	KG/MM ²	21.093	36.068	21.093	
	S_{13}, S_{14}	NOT APPLICABLE					
AS ALL THE STRESSES ARE WITHIN THE ALLOWABLE LIMITS, DESIGN IS SAFE.							

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER			PAGE	33	
	ITEM NO. : 117-EE-487			REV.	0	
	DOCUMENT NO. : PRJ/9742/20			DATE	28-Feb-10	
	SUPPORT DESIGN (ZICK ANALYSIS) - Contd..			PRPD.	CHKD.	APPD.
				KK	KK	RCS
DESIGN OF SADDLE						
	SYMBOL	UNIT	OPERATING	TEST	EMPTY	
TRANSVERSE WIND FORCE AT BASE	F _{TW}	KG	381.00	125.73	381.00	
TRANSEVERS WIND MOMENT AT BASE	M _{TW}	KG-M	190.50	62.86	190.50	
TRANSVERSE SEISMIC FORCE AT BASE	F _{TS}	KG	859.95	0.00	621.08	
TRANSVERSE SEISMIC MOMENT AT BASE	M _{TS}	KG-M	429.98	0.00	310.54	
DISTANCE BETWEEN BOLT & VESSEL C.L.	L _B	MM	110.00	110.00	110.00	
SIZE OF ANCHOR BOLT	-	-	M24	M24	M24	
ROOT AREA OF ONE BOLT	A _b	MM ²	312.75	312.75	312.75	
NO OF BOLTS PER SUPPORT	N _B	NOS	2	2	2	
BOLT ALLOWABLE STRESS FOR TENSION	S _T	KG/CM ²	1195.3	1195.3	1195.3	
BOLT ALLOWABLE STRESS FOR SHEAR	S _S	KG/CM ²	796.9	796.9	796.9	
SADDLE ALLOWABLE STRESS	S	KG/CM ²	1406.2	1406.2	1406.2	
MI OF ONE SADDLE SUPPORT @ LONG.AXIS	I _{xx}	MM ⁴	5.708E+07	5.708E+07	5.708E+07	
SECTION MODULUS OF ONE SADDLE SUPP.	Z _{xx}	MM ³	2.965E+05	2.965E+05	2.965E+05	
(REFER NEXT PAGE FOR CALCULATIONS OF I _{xx} & Z _{xx})						
MAXIMUM SHEAR FORCE AT BASE	F _T	KG	859.95	125.73	621.08	
MAXIMUM BENDING MOMENT AT BASE	M _T	KG-M	429.98	62.86	310.54	
BENDING STRESS IN SADD.AT BASE=M/Z _{xx}	S _b	KG/CM ²	144.997	21.199	104.720	
AS S _b <S, DESIGN IS SAFE						
DESIGN OF ANCHOR BOLTS						
TENSILE LOAD DUE TO WIND LOADING M _T / L _B - W/2	T _{b1}	KG	561.81	-414.00	886.81	
TENSILE LOAD DUE TO SEISMIC LOADING M _T / L _B - W/2	T _{b2}	KG	2738.86	-985.50	1978.07	
MAXIMUM TENSILE LOAD=MAX OF T _{b1} & T _{b2}	T _b	KG	2738.86	-414.00	1978.07	
REQUIRED ROOT AREA OF ONE BOLT						
FOR TENSION = T _b /(N*N _B /2)/S _T	A _r	MM ²	1.15	N.A.	0.83	
FOR SHEAR = F / (N * N _B) / (S _S)			26.98	3.94	19.48	
AS A _b > A _r , DESIGN IS SAFE						
(-) SIGN INDICATES INDICATES THAT THERE IS NO TENSILE LOAD IN THE ANCHOR BOLTS.						
CALCULATIOS FOR BEARING STRESS						
LENGTH OF BASE PLATE	a	MM	385.00	385.00	385.00	
WIDTH OF BASE PLATE	b	MM	150.00	150.00	150.00	
BEARING STRESS = Q / (a*b)	P _B	KG/CM ²	4.93	2.13	3.56	
ALLOWABLE BEARING STRESS	P _{BA}	KG/CM ²	52.73	52.73	52.73	
AS ALLOWABLE BEARING STRESS > ACTUAL BEARING STRESS, DESIGN IS SAFE						
CALCULATIOS FOR BASE PLATE						
REQUIRED BASE PLATE THICKNESS = [(6*Q*b) / (8*a*S)] ^{1/2}	t _{br}	MM	7.69	5.06	6.53	
PROVIDED BASE PLATE THICKNESS	t _b	MM	16.00	16.00	16.00	
AS PROVIDED THICKNESS > REQUIRED THICKNESS, DESIGN IS SAFE						

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER	PAGE	34	
	ITEM NO. : 117-EE-487	REV.	0	
	DOCUMENT NO. : PRJ/9742/20	DATE	28-Feb-10	
	CALCULATIONS FOR Ixx & Zxx FOR SADDLES	PRPD.	CHKD.	APPD.
		KK	KK	RCS

CALCULATIONS FOR I_{xx} & Z_{xx}

WEB PLATE THICKNESS	tw	MM	12.00
WEB PLATE LENGTH	lw	MM	385.00
GUSSET PLATE THICKNESS	tg	MM	12.00
GUSSET PLATE WIDTH (MARKED AS 2)	wg	MM	122.00
MOMENT OF INERTIA @ X-X AXIS FOR			
WEB PLATE (MARKED AS 1) = $tw \cdot lw^3 / 12$	I_{xx1}	MM ⁴	5.707E+07
GUSSET PLATE (MARKED AS 2) = $wg \cdot tg^3 / 12$	I_{xx2}	MM ⁴	1.757E+04
TOTAL FOR CROSS SECTION = $I_{xx1} + I_{xx2}$	I_{xx}	MM ⁴	5.708E+07
SECTION MODULUS = $I_{xx} / (lw/2)$	Z_{xx}	MM ³	2.965E+05
CROSS SECTIONAL AREA = $tw \cdot lw + wg \cdot tg$	A	MM ²	6084.00



PLAN FOR SADDLE

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER	PAGE	35	
	ITEM NO. : 117-EE-487	REV.	0	
	DOCUMENT NO. : PRJ/9742/20	DATE	28-Feb-10	
	EXTERNAL LOADS ON NOZZLES	PRPD.	CHKD.	APPD.
		KK	KK	RCS

EXTERNAL LOADS ON NOZZLES SHALL BE AS FOLLOWS:

DESCRIPTION	SYMBOL	UNIT	VALUE FOR NOZZLE			
NOZZLE MARK	-	-	N1,N2	N3,N4		
NOZZLE SIZE	-	-	50 NB	50 NB		
FLANGE RATING	-	-	300#	300#		
RADIAL LOAD (AXIAL LOAD)	F_A	KG	135.0	135.0		
CIRCUMFERENTIAL SHEAR LOAD	F_C	KG	200.0	200.0		
LONGITUDINAL SHEAR LOAD	F_L	KG	200.0	200.0		
CIRCUMFERENTIAL MOMENT	M_C	KG-M	30.0	30.0		
LONGITUDINAL MOMENT	M_L	KG-M	40.0	40.0		
TORSIONAL MOMENT	M_T	KG-M	50.0	50.0		

NOTES :

1. ABOVE LOADS ARE AS PER EIL STD.
2. TWO CASES ARE ANALYSED FOR EXTERNAL LOADS AS EXPLAINED BELOW:
 - (A) CONSIDERING 100% OF ABOVE LOADS WITH COMBINED STRESS ALLOWABLE LIMIT AS $3 \times S$.
 - (B) WITH NO INTERNAL / EXTERNAL PRESSURE & CONSIDERING 50% OF ABOVE LOADS WITH COMBINED STRESS ALLOWABLE LIMIT AS $1.5 \times S$

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER		PAGE	36
	ITEM NO. : 117-EE-487		REV.	0
	DOCUMENT NO. : PRJ/9742/20		DATE	28-Feb-10
	LOCAL LOAD ANALYSIS FOR NOZZLE N1,N2		PRPD.	CHKD.
	(WRC 297)		KK	RCS

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N1,N2 NOZZLE SIZE : 50 NB LOADING CASE (A)

STRESSES AT THE EDGE OF ATTACHMENT :

RADIAL LOAD	KG	F_A	135.0	PAD THICKNESS	MM	T_p	0.00
CIRC. SHEAR LOAD	KG	F_C	200.0	$T_e = \text{SQRT}(T^2 + T_p^2)$	MM	T_e	7.00
LONG. SHEAR LOAD	KG	F_L	200.0	NOZZLE OUTSIDE DIA.	MM	d	60.30
CIRC. MOMENT	KG-M	M_C	30.0	NOZZLE THICKNESS	MM	t	4.65
LONG. MOMENT	KG-M	M_L	40.0	FACTOR = $(d/D)(D/T_e)^{1/2}$	-	λ	1.121
TORSIONAL MOMENT	KG-M	M_T	50.0	RATIO	-	d/t	12.97
INTERNAL DESIGN PRESS.	KG/CM ² (g)	P_r	26.739	RATIO	-	T_e/t	1.51
SHELL MEAN DIA (CORR.)	MM	D	413.00	SHELL ALLOWABLE STRESS	KG/CM ²	S	1406.2
SHELL THK (CORRODED)	MM	T	7.00	NOZZLE ALLOWABLE STRESS	KG/CM ²	S_n	1202.3

VALUES FOR FACTORS m_r , n_r , m_θ & n_θ :

LOAD	m_r			n_r			m_θ			n_θ		
	d/t	FIG	VALUE	d/t	FIG	VALUE	d/t	FIG	VALUE	d/t	FIG	VALUE
F_A	10.00	3	0.1200	10.00	8	0.1400	10.00	13	0.0660	10.00	18	0.1550
	20.00	4	0.1200	20.00	9	0.0970	20.00	14	0.0740	20.00	19	0.1600
	12.97	-	0.1200	12.97	-	0.1272	12.97	-	0.0684	12.97	-	0.1565
M_C	10.00	23	0.2100	10.00	27	0.1900	10.00	32	0.1500	10.00	36	0.1400
	30.00	24	0.2100	20.00	28	0.1500	30.00	33	0.1500	20.00	37	0.1100
	12.97	-	0.2100	12.97	-	0.1781	12.97	-	0.1500	12.97	-	0.1311
M_L	10.00	41	0.1600	10.00	45	0.1500	10.00	50	0.1150	10.00	54	0.1600
	30.00	42	0.1600	20.00	46	0.1150	30.00	51	0.1000	20.00	55	0.2200
	12.97	-	0.1600	12.97	-	0.1396	12.97	-	0.1128	12.97	-	0.1778

STRESS CALCULATIONS:

LOAD	PART	EQ. NO.	σ_r (KG/CM ²)			EQ. NO.	σ_θ (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL		MEMBRANE	BENDING	TOTAL
F_A	VESSEL	1	35.0	198.4	233.4	2	43.1	113.0	156.1
	NOZZLE	5	15.3	211.5	226.8	7	43.1	0.0	43.1
M_C	VESSEL	3	180.8	1279.3	1460.1	4	133.1	913.8	1046.9
	NOZZLE	6	226.0	1671.6	1897.6	8	133.1	0.0	133.1
M_L	VESSEL	3	189.0	1299.6	1488.6	4	240.8	916.0	1156.7
	NOZZLE	6	301.4	1662.2	1963.6	8	240.8	0.0	240.8

SHEAR STRESS DUE TO M_T	188.4	SHEAR STRESS DUE TO F_L	45.4
SHEAR STRESS DUE TO F_C	45.4	TOTAL SHEAR STRESS τ (KG/CM ²)	279.2

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	534.8	1498.0	1863.6
		INNER	534.8	1498.0	1863.6
	TRANSVERSE	OUTER	476.0	1477.7	1819.9
		INNER	476.0	1477.7	1819.9
NOZZLE	LONGITUDINAL	OUTER	580.0	1873.7	2230.5
		INNER	580.0	1873.7	2230.5
	TRANSVERSE	OUTER	489.9	1883.0	2163.6
		INNER	489.9	1883.0	2163.6

MAXIMUM COMBINED STRESS IN SHELL 1863.6 < 3*S, SAFE (Absolute values)

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER	PAGE	37		
	ITEM NO. : 117-EE-487	REV.	0		
	DOCUMENT NO. : PRJ/9742/20	DATE	28-Feb-10		
	LOCAL LOAD ANALYSIS FOR NOZZLE N1,N2 (WRC 297)	PRPD.	CHKD.	APPD.	
		KK	KK	RCS	

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N1,N2 NOZZLE SIZE : 50 NB LOADING CASE (B)

STRESSES AT THE EDGE OF ATTACHMENT :

RADIAL LOAD	KG	F_A	67.5	PAD THICKNESS	MM	T_p	0.00
CIRC. SHEAR LOAD	KG	F_C	100.0	$T_e = \text{SQRT}(T^2 + T_p^2)$	MM	T_e	7.00
LONG. SHEAR LOAD	KG	F_L	100.0	NOZZLE OUTSIDE DIA.	MM	d	60.30
CIRC. MOMENT	KG-M	M_C	15.0	NOZZLE THICKNESS	MM	t	4.65
LONG. MOMENT	KG-M	M_L	20.0	FACTOR = $(d/D)(D/T_e)^{1/2}$	-	λ	1.121
TORSIONAL MOMENT	KG-M	M_T	25.0	RATIO	-	d/t	12.97
INTERNAL DESIGN PRESS.	KG/CM ² (g)	P_r	0.000	RATIO	-	T_e/t	1.51
SHELL MEAN DIA (CORR.)	MM	D	413.00	SHELL ALLOWABLE STRESS	KG/CM ²	S	1406.2
SHELL THK (CORRODED)	MM	T	7.00	NOZZLE ALLOWABLE STRESS	KG/CM ²	S_n	1202.3

VALUES FOR FACTORS m_r , n_r , m_θ & n_θ :

LOAD	m_r			n_r			m_θ			n_θ		
	d/t	FIG	VALUE	d/t	FIG	VALUE	d/t	FIG	VALUE	d/t	FIG	VALUE
F_A	10.00	3	0.1200	10.00	8	0.1400	10.00	13	0.0660	10.00	18	0.1550
	20.00	4	0.1200	20.00	9	0.0970	20.00	14	0.0740	20.00	19	0.1600
	12.97	-	0.1200	12.97	-	0.1272	12.97	-	0.0684	12.97	-	0.1565
M_C	10.00	23	0.2100	10.00	27	0.1900	10.00	32	0.1500	10.00	36	0.1400
	30.00	24	0.2100	20.00	28	0.1500	30.00	33	0.1500	20.00	37	0.1100
	12.97	-	0.2100	12.97	-	0.1781	12.97	-	0.1500	12.97	-	0.1311
M_L	10.00	41	0.1600	10.00	45	0.1500	10.00	50	0.1150	10.00	54	0.1600
	30.00	42	0.1600	20.00	46	0.1150	30.00	51	0.1000	20.00	55	0.2200
	12.97	-	0.1600	12.97	-	0.1396	12.97	-	0.1128	12.97	-	0.1778

STRESS CALCULATIONS:

LOAD	PART	EQ. NO.	σ_r (KG/CM ²)			EQ. NO.	σ_θ (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL		MEMBRANE	BENDING	TOTAL
F_A	VESSEL	1	17.5	99.2	116.7	2	21.6	56.5	78.1
	NOZZLE	5	7.7	105.7	113.4	7	21.6	0.0	21.6
M_C	VESSEL	3	90.4	639.7	730.1	4	66.5	456.9	523.4
	NOZZLE	6	113.0	835.8	948.8	8	66.5	0.0	66.5
M_L	VESSEL	3	94.5	649.8	744.3	4	120.4	458.0	578.4
	NOZZLE	6	150.7	831.1	981.8	8	120.4	0.0	120.4

SHEAR STRESS DUE TO M_T	94.2	SHEAR STRESS DUE TO F_L	22.7
SHEAR STRESS DUE TO F_C	22.7	TOTAL SHEAR STRESS τ (KG/CM ²)	139.6

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	267.4	749.0	931.8
		INNER	267.4	749.0	931.8
	TRANSVERSE	OUTER	238.0	738.8	910.0
		INNER	238.0	738.8	910.0
NOZZLE	LONGITUDINAL	OUTER	290.0	936.9	1115.2
		INNER	290.0	936.9	1115.2
	TRANSVERSE	OUTER	245.0	941.5	1081.8
		INNER	245.0	941.5	1081.8

MAXIMUM COMBINED STRESS IN SHELL 931.8 < 1.5*S, SAFE (Absolute values)

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER	PAGE	38	
	ITEM NO. : 117-EE-487	REV.	0	
	DOCUMENT NO. : PRJ/9742/20	DATE	28-Feb-10	
	LOCAL LOAD ANALYSIS FOR NOZZLE N3,N4 (WRC 297)	PRPD.	CHKD.	APPD.
		KK	KK	RCS

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N3,N4 **NOZZLE SIZE : 50 NB** **LOADING CASE (A)**

STRESSES AT THE EDGE OF ATTACHMENT :

RADIAL LOAD	KG	F_A	135.0	PAD THICKNESS	MM	T_p	0.00
CIRC. SHEAR LOAD	KG	F_C	200.0	$T_e = \text{SQRT}(T^2 + T_p^2)$	MM	T_e	7.00
LONG. SHEAR LOAD	KG	F_L	200.0	NOZZLE OUTSIDE DIA.	MM	d	60.30
CIRC. MOMENT	KG-M	M_C	30.0	NOZZLE THICKNESS	MM	t	4.65
LONG. MOMENT	KG-M	M_L	40.0	FACTOR = $(d/D)(D/T_e)^{1/2}$	-	λ	1.121
TORSIONAL MOMENT	KG-M	M_T	50.0	RATIO	-	d/t	12.97
INTERNAL DESIGN PRESS.	KG/CM ² (g)	P_r	20.640	RATIO	-	T_e/t	1.51
SHELL MEAN DIA (CORR.)	MM	D	413.00	SHELL ALLOWABLE STRESS	KG/CM ²	S	1406.2
SHELL THK (CORRODED)	MM	T	7.00	NOZZLE ALLOWABLE STRESS	KG/CM ²	S_n	1202.3

VALUES FOR FACTORS m_r , n_r , m_θ & n_θ :

LOAD	m_r			n_r			m_θ			n_θ		
	d/t	FIG	VALUE	d/t	FIG	VALUE	d/t	FIG	VALUE	d/t	FIG	VALUE
F_A	10.00	3	0.1200	10.00	8	0.1400	10.00	13	0.0660	10.00	18	0.1550
	20.00	4	0.1200	20.00	9	0.0970	20.00	14	0.0740	20.00	19	0.1600
	12.97	-	0.1200	12.97	-	0.1272	12.97	-	0.0684	12.97	-	0.1565
M_C	10.00	23	0.2100	10.00	27	0.1900	10.00	32	0.1500	10.00	36	0.1400
	30.00	24	0.2100	20.00	28	0.1500	30.00	33	0.1500	20.00	37	0.1100
	12.97	-	0.2100	12.97	-	0.1781	12.97	-	0.1500	12.97	-	0.1311
M_L	10.00	41	0.1600	10.00	45	0.1500	10.00	50	0.1150	10.00	54	0.1600
	30.00	42	0.1600	20.00	46	0.1150	30.00	51	0.1000	20.00	55	0.2200
	12.97	-	0.1600	12.97	-	0.1396	12.97	-	0.1128	12.97	-	0.1778

STRESS CALCULATIONS:

LOAD	PART	EQ. NO.	σ_r (KG/CM ²)			EQ. NO.	σ_θ (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL		MEMBRANE	BENDING	TOTAL
F_A	VESSEL	1	35.0	198.4	233.4	2	43.1	113.0	156.1
	NOZZLE	5	15.3	211.5	226.8	7	43.1	0.0	43.1
M_C	VESSEL	3	180.8	1279.3	1460.1	4	133.1	913.8	1046.9
	NOZZLE	6	226.0	1671.6	1897.6	8	133.1	0.0	133.1
M_L	VESSEL	3	189.0	1299.6	1488.6	4	240.8	916.0	1156.7
	NOZZLE	6	301.4	1662.2	1963.6	8	240.8	0.0	240.8

SHEAR STRESS DUE TO M_T	188.4	SHEAR STRESS DUE TO F_L	45.4
SHEAR STRESS DUE TO F_C	45.4	TOTAL SHEAR STRESS τ (KG/CM ²)	279.2

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	534.8	1498.0	1863.6
		INNER	534.8	1498.0	1863.6
	TRANSVERSE	OUTER	476.0	1477.7	1819.9
		INNER	476.0	1477.7	1819.9
NOZZLE	LONGITUDINAL	OUTER	580.0	1873.7	2230.5
		INNER	580.0	1873.7	2230.5
	TRANSVERSE	OUTER	489.9	1883.0	2163.6
		INNER	489.9	1883.0	2163.6

MAXIMUM COMBINED STRESS IN SHELL 1863.6 < 3*S, SAFE (Absolute values)

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: LUBE OIL COOLER	PAGE	39		
	ITEM NO. : 117-EE-487	REV.	0		
	DOCUMENT NO. : PRJ/9742/20	DATE	28-Feb-10		
	LOCAL LOAD ANALYSIS FOR NOZZLE N3,N4 (WRC 297)	PRPD.	CHKD.	APPD.	
		KK	KK	RCS	

**LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N3,N4 NOZZLE SIZE : 50 NB LOADING CASE (B)**

STRESSES AT THE EDGE OF ATTACHMENT :

RADIAL LOAD	KG	F _A	67.5	PAD THICKNESS	MM	T _p	0.00
CIRC. SHEAR LOAD	KG	F _C	100.0	Te = SQRT (T ² + T _p ²)	MM	Te	7.00
LONG. SHEAR LOAD	KG	F _L	100.0	NOZZLE OUTSIDE DIA.	MM	d	60.30
CIRC. MOMENT	KG-M	M _C	15.0	NOZZLE THICKNESS	MM	t	4.65
LONG. MOMENT	KG-M	M _L	20.0	FACTOR = (d/D)(D/Te) ^{1/2}	-	λ	1.121
TORSIONAL MOMENT	KG-M	M _T	25.0	RATIO	-	d/t	12.97
INTERNAL DESIGN PRESS.	KG/CM ² (g)	Pr	0.000	RATIO	-	Te/t	1.51
SHELL MEAN DIA (CORR.)	MM	D	413.00	SHELL ALLOWABLE STRESS	KG/CM ²	S	1406.2
SHELL THK (CORRODED)	MM	T	7.00	NOZZLE ALLOWABLE STRESS	KG/CM ²	Sn	1202.3

VALUES FOR FACTORS m_r, n_r, m_θ & n_θ:

LOAD	m _r			n _r			m _θ			n _θ		
	d/t	FIG	VALUE	d/t	FIG	VALUE	d/t	FIG	VALUE	d/t	FIG	VALUE
F _A	10.00	3	0.1200	10.00	8	0.1400	10.00	13	0.0660	10.00	18	0.1550
	20.00	4	0.1200	20.00	9	0.0970	20.00	14	0.0740	20.00	19	0.1600
	12.97	-	0.1200	12.97	-	0.1272	12.97	-	0.0684	12.97	-	0.1565
M _C	10.00	23	0.2100	10.00	27	0.1900	10.00	32	0.1500	10.00	36	0.1400
	30.00	24	0.2100	20.00	28	0.1500	30.00	33	0.1500	20.00	37	0.1100
	12.97	-	0.2100	12.97	-	0.1781	12.97	-	0.1500	12.97	-	0.1311
M _L	10.00	41	0.1600	10.00	45	0.1500	10.00	50	0.1150	10.00	54	0.1600
	30.00	42	0.1600	20.00	46	0.1150	30.00	51	0.1000	20.00	55	0.2200
	12.97	-	0.1600	12.97	-	0.1396	12.97	-	0.1128	12.97	-	0.1778

STRESS CALCULATIONS:

LOAD	PART	EQ. NO.	σ _r (KG/CM ²)			EQ. NO.	σ _θ (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL		MEMBRANE	BENDING	TOTAL
F _A	VESSEL	1	17.5	99.2	116.7	2	21.6	56.5	78.1
	NOZZLE	5	7.7	105.7	113.4	7	21.6	0.0	21.6
M _C	VESSEL	3	90.4	639.7	730.1	4	66.5	456.9	523.4
	NOZZLE	6	113.0	835.8	948.8	8	66.5	0.0	66.5
M _L	VESSEL	3	94.5	649.8	744.3	4	120.4	458.0	578.4
	NOZZLE	6	150.7	831.1	981.8	8	120.4	0.0	120.4

SHEAR STRESS DUE TO M _T	94.2	SHEAR STRESS DUE TO F _L	22.7
SHEAR STRESS DUE TO F _C	22.7	TOTAL SHEAR STRESS τ(KG/CM ²)	139.6

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	267.4	749.0	931.8
		INNER	267.4	749.0	931.8
	TRANSVERSE	OUTER	238.0	738.8	910.0
		INNER	238.0	738.8	910.0
NOZZLE	LONGITUDINAL	OUTER	290.0	936.9	1115.2
		INNER	290.0	936.9	1115.2
	TRANSVERSE	OUTER	245.0	941.5	1081.8
		INNER	245.0	941.5	1081.8

MAXIMUM COMBINED STRESS IN SHELL	931.8	< 1.5*S, SAFE (Absolute values)
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