

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

 Enriching Lives	REFRIGERATION PACKAGE 117-LZ-480	KIRLOSKAR PNEUMATIC CO.LTD.
TITLE : Mechanical Design Calculations for Condenser (Item No. 117-EE-485)		Doc.No: PRJ/9742/17 Rev.: 0

No of pages : 44 including this sheet

OWNER : BCPL-LEPETKATA, DIBRUGARH ASSAM

PROJECT : BRAHMAPUTRA PETROCHEMICAL COMPLEX PROJECT

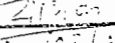
UNIT : 220 KTA-LLDPE/HDPE

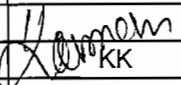
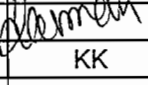
PMC : ENGINEERS INDIA LIMITED, NEW DELHI

EIL JOB NO. : 6907

VENDOR : KIRLOSKAR PNEUMATIC CO. LTD, PUNE

KPCL JOB NO. : 9742

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Signature & Name 		
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Date / दिनांक 		
V.P. No. 		
वी.पी.न. 6907/218		

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

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8	DESIGN PRESSURE CALCULATIONS (UG-21)	0			
9	MAIN SHELL DESIGN (UG-16,UG-27,UG-28,RCB-3.13)	0			
10	CHANNEL SHELL DESIGN (UG-16,UG-27,UG-28,RCB-3.13)	0			
11	CHANNEL D'END DESIGN (1-4,UG-32,UG-33,RCB-3.2)	0			
12	CHANNEL D'END DESIGN - Contd.. (1-4,UG-32,UG-33,RCB-3.2)	0			
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15	TUBE DESIGN (1-1,UG-28,RCB-3.13)	0			
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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 (UG-36, UG-37, UG-45)	0			
22	NOZZLE NECK & REINFORCEMENT-N2 (UG-36, UG-37, UG-45)	0			
23	NOZZLE NECK & REINFORCEMENT - N3,N4 (UG-36, UG-37, UG-45)	0			
24	NOZZLE NECK & REINFORCEMENT-N5,N6,N7 (UG-36, UG-37, UG-45)	0			
25	NOZZLE NECK & REINFORCEMENT-N8,N9 (UG-36, UG-37, UG-45)	0			
26	FLANGE RATING CHECK (UG-44, ASME B16.5)	0			
27	POST FORMING HEAT TREATMENT (UCS-79)	0			
28	IMPACT TEST REQUIREMENTS (UG-20(f))	0			
29	IMPACT TEST REQUIREMENTS (UCS-66)	0			
30	PWHT REQUIREMENTS (UW-2, UCS-56, UCS-68)	0			
31	TEST PRESSURE (UG-99,UG-100)	0			
32	WIND LOAD CALCULATIONS (IS:875)	0			
33	SEISMIC LOAD CALCULATIONS (IS:1893)	0			
34	SUPPORT DESIGN (ZICK ANALYSIS)	0			
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37	CALCULATIONS FOR Ixx & Zxx FOR SADDLES	0			
38	EXTERNAL LOADS ON NOZZLES	0			
39	LOCAL LOAD ANALYSIS FOR NOZZLE N1 (WRC 297)	0			
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41	LOCAL LOAD ANALYSIS FOR NOZZLE N2 (WRC 297)	0			
42	LOCAL LOAD ANALYSIS FOR NOZZLE N2 (WRC 297)	0			
43	LOCAL LOAD ANALYSIS FOR NOZZLE N3,N4 (WRC 297)	0			
44	LOCAL LOAD ANALYSIS FOR NOZZLE N3,N4 (WRC 297)	0			

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		APPLICABLE STANDARDS / REFERENCES		PRPD. KK	CHKD. KK
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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KK						KK	RCS	

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)					16.400	
		KG/CM ² (g)	21.200					
EXTERNAL DESIGN PRESSURE		BAR (g)					1.055	
		KG/CM ² (g)	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		FOR DETAILS, REFER DRGS.	
INTERNAL OPERATING PRESSURE		KG/CM ² (a)	19.680			5.000		
EXTERNAL OPERATING PRESSURE		KG/CM ² (g)	-			-		
OPERATING TEMPERATURE (IN/OUT)		°C	80.02	47.06	33.00	43.00		
FLUID		-	PROPYLENE VAPOR		COOLING WATER			
DENSITY		KG/M ³	464.3			995.4		
HYDROTEST PRESSURE (AT TOP)		BAR (g)	N.A.					
		KG/CM ² (g)			21.320			
PNEUMATIC TEST PRESSURE		BAR (g)	23.320		N.A.			
		KG/CM ² (g)						
TEST TEMPERATURE (MIN.)		°C	20					
SEISMIC CODE		-	IS:1893 (PART 4)					
WIND CODE		-	IS:875 (PART 3)					
PWHT		-	NO		NO			
FLANGE RATING		-	300#		150#			
EMPTY WEIGHT	We	KG	4250					
TEST WEIGHT	Ww	KG	4922					
TUBE BUNDLE WEIGHT	Wt	KG	2640					
OPERATING WEIGHT	Wo	KG	5325					

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		EVALUATION OF MATERIALS						PRPD.	CHKD.	APPD.
						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)	21.200
EXTERNAL PRESSURE FOR CHANNEL SIDE	Pec	-	1.055
MAXIMUM STATIC HEAD (SAME AS ID)	H	MM	600.00
SPECIFIC GRAVITY OF CONTENT	ρ	-	0.464

FOR MAIN SHELL

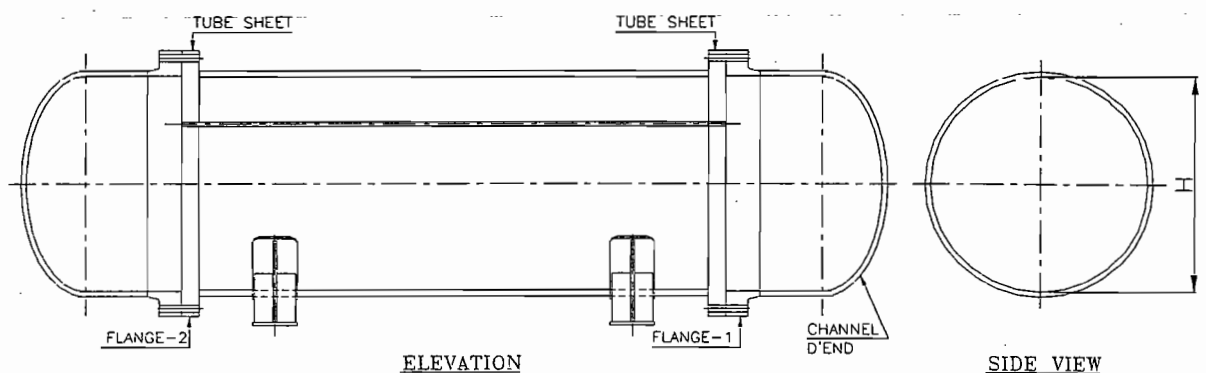
DESIGN PRESSURE INCLUDING STATIC HEAD	Ps	KG/CM ² (g)	21.228
$= P + H * \rho / 10000$			
CORRECTED FOR VACUUM ON CHANNEL SIDE	Ps	KG/CM ² (g)	22.283
$= P + Pec + H * \rho / 10000$			

FOR CHANNEL SIDE

INTERNAL DESIGN PRESSURE	P	KG/CM ² (g)	16.400
EXTERNAL PRESSURE FOR SHELL SIDE	Pes	-	1.055
MAXIMUM STATIC HEAD (SAME AS ID)	H	MM	600.00
SPECIFIC GRAVITY OF CONTENT	ρ	-	0.995
DESIGN PRESSURE INCLUDING STATIC HEAD	Pt	KG/CM ² (g)	16.460
$= Pt + H * \rho / 10000$			
CORRECTED FOR VACUUM ON SHELL SIDE	Pt	KG/CM ² (g)	17.515
$= Pt + Pes + H * \rho / 10000$			

CONCLUSION

PRESSURE VALUES IN BOLD ABOVE ARE USED IN FURTHER CALCULATIONS



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	MAIN SHELL DESIGN		PRPD.	CHKD.	APPD.
	(UG-16,UG-27,UG-28,RCB-3.13)		KK	KK	RCS
DESIGN INPUT					
INTERNAL DESIGN PRESSURE	Ps	KG/CM ² (g)	21.228		
EXTERNAL DESIGN PRESSURE	Pe	KG/CM ² (g)	1.055		
DESIGN TEMPERATURE FOR INTERNAL PERSSURE	T	°C	130		
DESIGN TEMPERATURE FOR EXTERNAL PERSSURE	T'	°C	130		
INSIDE DIAMETER	Di	MM	600.00		
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 = 7.62 MM			
$trs_1 = \frac{Ps (Di + 2C)}{(2(SE - 0.6Ps))} + C$ $= \frac{21.228 \times (600 + 2 \times 3)}{2 \times (1406.2 \times 1 - 0.6 \times 21.228)} + 3$ $= 7.62 \text{ MM}$		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	
$trs_2 = \frac{Ps (Di + 2C)}{(2(2SEc + 0.4Ps))} + C$ $= \frac{21.228 \times (600 + 2 \times 3)}{2 \times (2 \times 1406.2 \times 1 + 0.4 \times 21.228)} + 3$ $= 5.28 \text{ MM}$		(Di/2 + C)/2		151.50	
		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<0.385xSxE		YES	
		Ps<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 SHELL THICKNESS		trs ₄	MM	8.20	
MAXIMUM DESIGN LENGTH (T/S OUTSIDE TO OUTSIDE)		L	MM	5594.00	
OD OF VESSEL = Di + 2*ts		Do	MM	624	
GEOMETRIC RATIO		L/Do	-	8.965	
GEOMETRIC RATIO		Do/(trs ₄ -C)	-	120.00	
FROM FIG G OF ASME SEC II D SUBPART 3		A	-	9.946E-05	
FROM APPLICABLE CHART- CS-2		B	PSI	1431.79	
MAXIMUM ALLOWABLE EXTERNAL PRESSURE		Pa	PSI	15.91	
$= 4*B / 3*(Do/(trs_4-C))$			KG/CM ²	1.119	
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	12.00	

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	CHANNEL SHELL DESIGN		PRPD.	CHKD.	APPD.
	(UG-16,UG-27,UG-28,RCB-3.13)		KK	KK	RCS
DESIGN INPUT					
INTERNAL DESIGN PRESSURE	Pt	KG/CM ² (g)	16.460		
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	600.00		
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 = 6.57 MM			
$trcs_1 = \frac{Pt (Di + 2C)}{(2(SE - 0.6Pt))} + C$ $= \frac{16.46 \times (600 + 2 \times 3)}{2 \times (1406.2 \times 1 - 0.6 \times 16.46)} + 3$ $= 6.57 \text{ MM}$		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	
$trs_2 = \frac{Pt (Di + 2C)}{(2(2SEc + 0.4Pt))} + C$ $= \frac{16.46 \times (600 + 2 \times 3)}{2 \times (2 \times 1406.2 \times 1 + 0.4 \times 16.46)} + 3$ $= 4.77 \text{ MM}$		(Di/2 + C)/2		151.50	
		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	4.70	
MAXIMUM DESIGN LENGTH		L	MM	394.00	
OD OF VESSEL = Di + 2*trcs		Do	MM	620	
GEOMETRIC RATIO		L/Do	-	0.635	
GEOMETRIC RATIO		Do/(trcs ₄ -C)	-	364.71	
FROM FIG G OF ASME SEC II D SUBPART 3		A	-	3.186E-04	
FROM APPLICABLE CHART- CS-2		B	PSI	4595.60	
MAXIMUM ALLOWABLE EXTERNAL PRESSURE		Pa	PSI	16.80	
$= 4 \times B / 3 \times (Do / (trcs_4 - C))$			KG/CM ²	1.181	
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)	16.460		
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	600.00		
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	150.00		
DESIGN UNDER INTERNAL PRESSURE					
AS PER 1-4(c) OF ASME SEC. VIII DIV.1, $trh_1 = \frac{Pt (Di + 2C) K}{(2 S E - 0.2 Pt)} + C$ $= \frac{16.46 \times (600 + 2 \times 3) \times 1}{2 \times 1406.2 \times 1 - 0.2 \times 16.46} + 3$ $= 6.55 \text{ MM}$			FOR REINFORCEMENT CALCN. AS PER UG-37(a), K1 = 0.9 (TABLE UG-37) $trh = K1(Di+2C)Pt/(2S-0.2Pt)+C$ $= 6.20 \text{ MM}$		
AS PER UG-32(b) & (f) OF ASME SEC. VIII DIV.1, $trh_2 = \frac{Pt (Di/2 + C)}{(2 S - 0.2 Pt) Ec} + C$ $= \frac{16.46 \times (600 / 2 + 3)}{2 \times 1406.2 - 0.2 \times 16.46} + 3$ $= 4.78 \text{ MM}$					
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		

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	12
	ITEM NO. : 117-EE-485		REV.	0
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10
	CHANNEL D'END DESIGN - Contd.. (1-4,UG-32,UG-33,RCB-3.2)		PRPD.	CHKD.
			APPD.	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
$trh_4 = \frac{P (Di + 2C) K}{(2 S E - 0.2 P)} + C$ $= \frac{1.76185 \times (600 + 2 \times 3) \times 1}{2 \times 1406.2 \times 1 - 0.2 \times 1.76185} + 3$ $= 3.38 \text{ MM}$				
AS PER UG-33(d) OF ASME SEC. VIII DIV. 1,				
ASSUMED MINIMUM THICKNESS	th ₅ (MIN)	MM	4.70	
ASSUMED NOMINAL THICKNESS	th ₅ (NOM)	MM	10.00	
OD OF DISHED END = Di + 2*th ₅ (NOM)	Do	MM	620	
FACTOR FROM TABLE UG-33.1	Ko	-	0.9	
EQUIVALENT OUTSIDE RADIUS = Ko * Do	Ro	MM	558.0	
FACTOR A = 0.125 / {Ro / (th ₅ (MIN) - C)}	A	-	3.808E-04	
FROM APPLICABLE CHART CS-2	B	PSI	5493.83	
MAXIMUM ALLOWABLE EXTERNAL PRESSURE	Pa	PSI	16.74	
= B / {Ro / (th ₅ (MIN) - C)}		KG/CM ²	1.177	
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	6.55	
PROVIDED MIN. DISHED END THICKNESS	th (MIN)	MM	8.00	
PROVIDED NOM. DISHED END THICKNESS	th (NOM)	MM	10.00	

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	13	
	ITEM NO. : 117-EE-485		REV.	0	
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10	
	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)	16.460	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)	636.00	y (kg/cm ²)	632.8
Facing Sketch	1a OR 1b	Gasket O.D. Go (mm)	662.00	m	3.75
FLANGE DIMENSIONS					
B (Flange I.D) (mm)	600.00	C (Bolt cir. Dia) (mm)	694.00	A (Flange OD) (mm)	742.00
OTHER DIMENSIONS (TABLE 2-5.2)			LOAD AND BOLT CALCULATIONS		
N (mm)	13.00	go = Hub thk (mm)	10.00	Am1=Wm1/Sb (mm ²)	4689.29
bo (mm)	6.50	h = Hub length (mm)	30.00	Am2=Wm2/Sa (mm ²)	8150.75
b (mm)	6.42	Wm1 = Hp + H (kg)	82428.33	Am=Max(Am1,Am2)	8150.75
G (mm)	649.15	Wm2=($b\pi G + 0.5R_A$)y (kg)	143273.85	n = 'No. of Bolts	40
Nmin = Ab Sa / (2 π y G)	5.91	Hp=($b\pi G + R_A/2$)2mP (kg)	27951.60	a = Bolt size	M20
R _A = Rib Area (mm ²)	19080.00	H = G ² π P/4 (kg)	54476.73	Root area (mm ²)	217.05
g1 = Hub thk at back (mm)	15.00	W = Ab * Sa (kg)	152612.20	Ab (mm ²)	8682.00
MOMENT CALCULATIONS					
LOAD		LEVER ARM		MOMENT	
OPERATING					
H _D = $\pi B^2 P/4$ (kg)	47475.00	h _D = (C - B - g1)/2 (mm)	38.00	M _D = H _D * h _D (kg-m)	1804.05
H _G = Wm1 - H (kg)	27951.60	h _G = (C-G)/2 (mm)	22.42	M _G = H _G * h _G (kg-m)	626.80
H _T = H - H _D (kg)	7001.73	h _T = (h _D + h _G + g1/2)/2 (mm)	33.21	M _T = H _T * h _T (kg-m)	232.54
f1=Correction Factor(RCB-11.23)	1.00	Mo = (M _D + M _G + M _T)*f1 (kg-m)			2663.40
GASKET SEATING					
H _G = W (kg)	152612.20	h _G = (C-G)/2 (mm)	22.42	Mo' = H _G * h _G (kg-m)	3422.26
f1=Correction Factor(RCB-11.23)	1.00	Mo' = Mo' * f1 (kg-m)			3422.26
FLANGE THICKNESS (mm)		SHAPE CONSTANTS			
THK.	60.000	K = A/B	1.2244	ho=(B*go) ^{1/2}	65.1306
STEP	5.000	U	10.6653	Z	5.0063
NET THK.	55.000	V	0.2778	e	0.0129
				Y	9.7055
				T	1.8290
				f	1.0000
				F	0.8434
				d	122516.45
				L	2.2941
STRESS CALCULATIONS (kg/cm ²)					
OPERATING		ALLOWABLE	GASKET SEATING		ALLOWABLE
S _H = f*Mo/(L*g1 ² *B)	1330.41	2109.30	S _H = f*Mo'/(L*g1 ² *B)	1709.48	2109.30
S _R = (1.33*t*e + 1)*Mo/(L*t ² *B)	123.32	1406.20	S _R = (1.33*t*e + 1)*Mo'/(L*t ² *B)	158.46	1406.20
S _T = (Y*Mo)/(t ² *B) - Z*S _R	792.72	1406.20	S _T = (Y*Mo')/(t ² *B) - Z*S _R	1018.58	1406.20
(S _H + S _R) / 2	726.87	1406.20	(S _H + S _R) / 2	933.97	1406.20
(S _H + S _T) / 2	1061.56	1406.20	(S _H + S _T) / 2	1364.03	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	0.864 < 1, OK	Rigidity Factor, K _i	0.30	1.095 > 1, NOT OK
** SS316 JACKETED GRAPHITE FILLED					

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	14	
	ITEM NO. : 117-EE-485		REV.	0	
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10	
	CHANNEL SHELL FLANGE DESIGN - Contd.. (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					
Ext. Design Press, P (kg/cm ²)	1.055	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	1757.8
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)	636.00	y (kg/cm ²)	632.8
Facing Sketch	1a OR 1b	Gasket O.D. Go (mm)	662.00	m	3.75
FLANGE DIMENSIONS					
B (Flange I.D) (mm)	600	C (Bolt cir.Dia) (mm)	694.00	A(Flange OD)(mm)	742.00
OTHER DIMENSIONS (TABLE 2-5.2)		LOAD AND BOLT CALCULATIONS			
N (mm)	13.00	go = Hub thk (mm)	10.00	Am1=Wm1/Sb (mm ²)	300.56
bo (mm)	6.50	h = Hub length (mm)	30.00	Am2=Wm2/Sa (mm ²)	8150.75
b (mm)	6.42	Wm1 = Hp + H (kg)	5283.23	Am=Max(Am1,Am2)	8150.75
G (mm)	649.15	Wm2=(bπG+0.5RA)y (kg)	143273.85	n = 'No. of Bolts	40
Nmin = Ab Sa / (2 π y G)	5.91	Hp=(bπG+RA/2)2mP (kg)	1791.55	a = size of Bolt (mm)	M20
RA = Rib Area (mm ²)	19080.00	H = G ² πP/4 (kg)	3491.67	Bolt root area(mm ²)	217.05
g1 = Hub thk at back (mm)	15.00	W = Ab * Sa (kg)	152612.20	Ab (mm ²)	8682.00
MOMENT CALCULATIONS					
LOAD		LEVER ARM		MOMENT	
OPERATING					
H _D = πB ² P/4 (kg)	3042.90	h _D =(C - B - g1)/2 (mm)	38.00	M _D =H _D *h _D (kg-m)	115.63
H _G = Wm1 - H (kg)	1791.55	h _G =(C-G)/2 (mm)	22.42	M _G =H _G *h _G (kg-m)	40.17
H _T = H - H _D (kg)	448.77	h _T =(h _D +h _G +g1/2)/2 (mm)	33.21	M _T =H _T *h _T (kg-m)	14.90
f1=Correction Factor(RCB-11.23)	1.00	Mo=(H _D *(h _D -h _G)+H _T *(h _T -h _G))*f1 (kg-m)			52.24
GASKET SEATING					
H _G = W (kg)	152612.20	h _G =(C-G)/2 (mm)	22.42	Mo'=H _G *h _G (kg.m)	3422.26
f1=Correction Factor(RCB-11.23)	1.00			Mo' * f1 (kg-m)	3422.26
FLANGE THICKNESS (mm)		SHAPE CONSTANTS			
THK.	60.000	K = A/B	1.2244	ho=(B*go) ^{1/2}	65.1306
STEP	5.000	U	10.6653	Z	5.0063
NET THK.	55.000	V	0.2778	e	0.0129
				d	122516.45
				T	1.8290
				F	0.8434
				L	2.2941
STRESS CALCULATIONS (kg/cm ²)					
OPERATING		ALLOWABLE	GASKET SEATING		ALLOWABLE
S _H = f*Mo/(L*g1 ² *B)	26.09	2109.30	S _H = f*Mo'/(L*g1 ² *B)	1709.48	2109.30
S _R = (1.33*t*e + 1)*Mo/(L*t ² *B)	2.42	1406.20	S _R = (1.33*t*e + 1)*Mo'/(L*t ² *B)	158.46	1406.20
S _T = (Y*Mo)/(t ² *B) - Z*S _R	15.55	1406.20	S _T = (Y*Mo')/(t ² *B) - Z*S _R	1018.58	1406.20
(S _H + S _R) / 2	14.26	1406.20	(S _H + S _R) / 2	933.97	1406.20
(S _H + S _T) / 2	20.82	1406.20	(S _H + S _T) / 2	1364.03	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	0.017 < 1, OK	Rigidity Factor, K _i	0.30	1.095 > 1, NOT OK
** SS316 JACKETED GRAPHITE FILLED					

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	15	
	ITEM NO. : 117-EE-485		REV.	0	
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10	
	TUBE DESIGN (1-1,UG-28,RCB-3.13)		PRPD.	CHKD.	APPD.
			KK	KK	RCS

DESIGN INPUT				
INTERNAL DESIGN PRESSURE	Pt	KG/CM ² (g)	16.460	
EXTERNAL DESIGN PRESSURE = Ps	Pe	KG/CM ² (g)	21.228	
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				
$trt_1 = \frac{Pt * Do}{(2(SE + 0.4Pt))} + C$ $= \frac{16.46 \times 20}{2 \times (1103.9 \times 1 + 0.4 \times 16.46)} + 0$ $= 0.15 \text{ MM}$				

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	5600.00	
OD OF TUBE	Do	MM	20.00	
GEOMETRIC RATIO	L/Do	-	280.000	
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	

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	16		
	ITEM NO. : 117-EE-485		REV.	0		
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10		
	TUBE SHEET DESIGN (UHX-13)		PRPD.	CHKD.	APPD.	
			KK	KK	RCS	
DESIGN INPUT						
OUTSIDE DIAMETER	A	MM	742.00			
BOLT CIRCLE DIAMETER	C	MM	694.00			
CHANNEL SHELL INSIDE DIAMETER (CORRODED)	D _c	MM	606.00			
MAIN SHELL INSIDE DIAMETER (CORRODED)	D _s	MM	606.00			
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	Sy	KG/CM ²	2264.6			
POISSON'S RATIO	v	-	0.30			
TUBE MATERIAL	-	-	SA 334 GR 1 (SEAMLESS)			
DESIGN TEMPERATURE	Tt	°C	130.00			
MODULUS OF ELASTICITY AT Tt (Et _T at T)	Et	KG/CM ²	2001687.0			
ALLOWABLE STRESS AT Tt (St _T at T)	St	KG/CM ²	1103.9			
YIELD STRENGTH AT Tt	Sy,t	KG/CM ²	1887.1			
POISSON'S RATIO	vt	-	0.30			
CHANNEL SHELL MATERIAL	-	-	SA 516 GR 70			
DESIGN TEMPERATURE	Tc	°C	80.00			
MODULUS OF ELASTICITY AT Tc	Ec	KG/CM ²	2033975.0			
ALLOWABLE STRESS AT Tc	Sc	KG/CM ²	1406.2			
YIELD STRENGTH AT Tc	Sy,c	KG/CM ²	2477.2			
POISSON'S RATIO	vc	-	0.30			
MAIN SHELL MATERIAL	-	-	SA 516 GR 70			
DESIGN TEMPERATURE	Ts	°C	130.00			
MODULUS OF ELASTICITY AT Ts	Es	KG/CM ²	2001687.0			
ALLOWABLE STRESS AT Ts	Ss	KG/CM ²	1406.2			
YIELD STRENGTH AT Ts	Sy,s	KG/CM ²	2391.1			
POISSON'S RATIO	vs	-	0.30			
CHANNEL GASKET LOAD REACTION DIAMETER	Gc	MM	649.15			
MAIN SHELL GASKET LOAD REACTION DIAMETER	Gs	MM	N.A.			
TUBE SHEET THICKNESS INCLUDING GROOVES	h	MM	46.00			
PASS PARTITION GROOVE DEPTH (FIG UHX-11.1(c))	hg	MM	5.00			
INTERNAL DESIGN PRESSURE INCL. STATIC SHELL SIDE	Ps	KG/CM ² (g)	22.283			
HEAD & CORRECTED FOR VACUUM CHANNEL SIDE	Pt	KG/CM ² (g)	17.515			
CHANNEL SIDE CORROSION ALLOWANCE	Cac	MM	3.00			
SHELL SIDE CORROSION ALLOWANCE	Cas	MM	3.00			
TUBESHEET CORROSION ALLOWANCE CHANNEL SIDE	Catt	MM	3.00			
SHELL SIDE	Cats	MM	3.00			
CHANNEL SHELL THICKNESS (CORRODED)	tc	MM	7.00			
MAIN SHELL THICKNESS (CORRODED)	ts	MM	9.00			
NOMINAL TUBE WALL THICKNESS	tt	MM	2.00			
CHANNEL FLANGE DESIGN BOLT LOAD FOR GASKET SEAT.	Wc	KG	152612.20			
SHELL FLANGE DESIGN BOLT LOAD FOR GASKET SEAT.	Ws	KG	0.00			
MAXIMUM FLANGE DESIGN BOLT LOAD = MAX OF Wc & Ws	W	KG	152612.20			

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	17	
	ITEM NO. : 117-EE-485		REV.	0	
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10	
	TUBE SHEET DESIGN - Contd..		PRPD.	CHKD.	APPD.
	(UHX-13)		KK	KK	RCS

RADIAL CHANNEL DIMENSION = $G_c/2$	a_c	MM	324.58
RADIUS TO OUTERMOST TUBE HOLE CENTRE (FIG UHX-11.1(a))	r_o	MM	285.40
TUBE NOMINAL OUTSIDE DIAMETER	d_t	MM	20.00
EQUIVALENT DIA OF OTL CIRCLE = $2r_o + d_t$	D_o	MM	590.80
EQUIVALENT RADIUS OF OTL CIRCLE = $D_o/2$	a_o	MM	295.40
RADIAL SHELL DIMENSION = $D_s/2$	a_s	MM	303.00
TUBE LENGTH BETWEEN OUTER TUBESHEET FACE	L_t	MM	5594.00
TUBE LENGTH BETWEEN INNER TUBESHEET FACE = $L_t - 2h$	L	MM	5502.00
NUMBER OF TUBES	N_t	NOS	394
TUBE PITCH	p	MM	25.00
TUBE PATTERN (S = SQUARE, T = TRIANGULAR)	-	-	T
EXPANDED LENGTH OF TUBE IN TUBESHEET	l_{tx}	MM	31.00
TUBE EXPANSION DEPTH RATIO = l_{tx} / h	ρ	-	0.6739
MEAN SHELL METAL TEMPERATURE	$T_{s.m}$	°C	43.16
MEAN TUBE METAL TEMPERATURE	$T_{t.m}$	°C	49.89
AMBIENT TEMPERATURE	T_a	°C	20.00
MEAN COEFFICIENT OF THERMAL EXPANSION FOR SHELL AT $T_{s.m}$	$\alpha_{s.m}$	MM/MM/°C	0.00001173
MEAN COEFFICIENT OF THERMAL EXPANSION FOR TUBE AT $T_{t.m}$	$\alpha_{t.m}$	MM/MM/°C	0.00001178

UNTUBED AREA CALCULATIONS					
CENTER TO CENTER DISTANCE BETWEEN ADJACENT TUBE	U_{L1}	U_{L2}	U_{L3}	U_{L4}	U_{L5}
ROWS OF UNTUBED LANES (MM), NOT TO EXCEED 4p	39.00	39.00	36.00	0.00	0.00
LENGTH OF UNTUBED LANE	L_{L1}	L_{L2}	L_{L3}	L_{L4}	L_{L5}
	590.80	571.74	571.74	0.00	0.00
TOTAL AREA OF UNTUBED LANES = $U_{L1} * L_{L1} + U_{L2} * L_{L2} + \dots$	A_L	MM ²		59080.00	

STEP-1 (UHX-13.5.1)					
μ = 0.2000	μ^* = 0.3664	ρ_s = 1.0257			
d^* = 17.88 MM	hg' = 2.00 (CASE 1,2,3)	ρ_c = 1.0988			
p^* = 28.23 MM	hg' = 0.00 (CASE 4,5,6,7)	x_s = 0.5485			
		x_t = 0.7110			

STEP-2 (UHX-13.5.2)					
K_s = 63262.02 KG/MM	β_s = 0.0244	β_c = 0.0000			
K_t = 411.46 KG/MM	k_s = 65302.21	k_c = 0.0000			
$K_{s,t}$ = 0.39	λ_s = 9107.96	λ_c = 0.0000			
BELLOW USED? NO (YES/NO)	δ_s = 0.4332	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 = 1.6000					
E^*/E = 0.3847 (FIG UHX-11.3)	FROM FIG UHX-13.2; FOR X_a				
E^* = 770021.8 KG/CM ²	z_d = 0.0292				
v^* = 0.3096 (FIG UHX-11.3)	$z_v = z_w$ = 0.0731				
X_a = 3.7525	z_m = 0.4032				

STEP-4 (UHX-13.5.4)					
K = 1.2559	Q_1 = -0.0556				
F = 1.2256	Q_{z1} = 2.4953				
ϕ = 1.6050	Q_{z2} = 5.0214	U = 10.0428			

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	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	=	1401.87	MM ²	ω_c	=	0.00	MM ²
γ	=	0.4426	(CASE 4,5,6,7)	ω_s^*	=	-1372.62	MM ²	ω_c^*	=	3633.31	MM ²
γ_b	=	-0.0759									

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	22.283	22.283	0.000	0.000	22.283	22.283		
TUBE SIDE PRESSURE	Pt	KG/CM ² (g)	17.515	0.000	17.515	0.000	17.515	0.000	17.515		
Ps'	Ps'	KG/CM ² (g)	0.000	51.330	51.330	0.000	0.000	51.330	51.330		
Pt'	Pt'	KG/CM ² (g)	60.374	0.000	60.374	0.000	60.374	0.000	60.374		
Pw	Pw	KG/CM ² (g)	21.221	21.221	21.221	21.221	21.221	21.221	21.221		
Py	Py	KG/CM ² (g)	0.000	0.000	0.000	26.172	26.172	26.172	26.172		
Prim	Prim	KG/CM ² (g)	7.324	3.520	10.844	0.000	7.324	3.520	10.844		
EFFECTIVE PRESSURE	Pe	KG/CM ² (g)	-6.136	14.665	4.438	9.137	-1.091	19.711	9.483		
	Q ₂	KG	-1505.83	-1305.16	-1691.53	-1119.46	-1505.83	-1305.16	-1691.53		
	Q ₃	-	0.5069	-0.2595	-0.9292	-0.3364	3.1084	-0.2073	-0.4644		
FROM FIG. UHX-13.3-1 & 2	Fm	-	0.2800	0.1300	0.4600	0.1700	1.6700	0.1000	0.2300		
BENDING STRESS IN T/S	σ	KG/CM ²	-1700.3	1886.6	2020.1	1387.2	-1626.9	1760.4	1948.0		
CHECK WHETHER $ \sigma \leq 1.5S$	-	-	YES	YES	YES	-	-	-	-		
CHECK WHETHER $ \sigma \leq 3S$	-	-	-	-	-	YES	YES	YES	YES		
RESULT	-	-	OK	OK	OK	OK	OK	OK	OK		
AVG.SHEAR STRESS IN T/S	τ	KG/CM ²	-113.3	270.8	81.9	168.7	-20.1	363.9	175.1		
CHECK WHETHER $ \tau \leq 0.8S$	-	-	YES	YES	YES	YES	YES	YES	YES		
RESULT	-	-	OK	OK	OK	OK	OK	OK	OK		
COEFFICIENT	Ft,min	-	-2.6593	0.3132	-3.8316	0.4615	-12.7493	0.1107	-0.4654		
	Ft,max	-	6.5687	1.2465	3.0406	1.2346	25.4099	1.4122	1.4770		
AXIAL TUBE STRESS	$\sigma_{t,1}$	KG/CM ²	-177.0	46.9	103.2	-25.9	-162.2	61.8	25.7		
	$\sigma_{t,2}$	KG/CM ²	171.4	-37.3	-84.4	-69.4	93.9	-96.1	-87.6		
MAX OF $ \sigma_{t,1} $ & $ \sigma_{t,2} $	$\sigma_{t,max}$	KG/CM ²	177.0	46.9	103.2	69.4	162.2	96.1	87.6		
CHECK WHETHER $\sigma_{t,max} \leq St$	-	-	YES	YES	YES	-	-	-	-		
CHECK WHETHER $\sigma_{t,max} \leq 2*St$	-	-	-	-	-	YES	YES	YES	YES		
RESULT	-	-	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 = $l \times k$	l_t	MM									
	r_t	MM									
RATIO = l_t / r_t	F_t	-									
	C_t	-									
FACTOR OF SAFETY	F_s	-									
MAX. ALL. BUCK. STRESS	St_b	KG/CM ²									
MIN OF $\sigma_{t,1}$ & $\sigma_{t,2}$	$\sigma_{t,min}$	KG/CM ²									
CHECK WHETHER $ \sigma_{t,min} \leq St_b$	-	-									
RESULT	-	-									

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	TUBE SHEET DESIGN - Contd.. (UHX-13)						PRPD.	CHKD.	APPD.
							KK	KK	RCS
STEP-10,11 (UHX-13.5.10,11)									
AXIAL SHELL MEMBRANE STRESS	$\sigma_{s,m}$	KG/CM ²	176.8	245.9	359.1	142.0	255.2	324.3	437.5
AXIAL SHELL BENDING STRESS	$\sigma_{s,b}$	KG/CM ²	-7.6	1154.5	1143.2	8.5	-2.8	1159.3	1148.0
JOINT EFF. FOR MAIN SHELL C/S	$E_{s,w}$	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00
TOTAL AXIAL STRESS = $ \sigma_{s,m} + \sigma_{s,b} $	σ_s	KG/CM ²	184.4	1400.4	1502.3	150.4	258.0	1483.6	1585.5
ALLOW. LONG. COMP. STRESS	$S_{s,b}$	KG/CM ²	1164.6	1164.6	1164.6	1164.6	1164.6	1164.6	1164.6
CHECK WHETHER $ \sigma_{s,m} \leq S_{s,b}$		-	YES	YES	YES	-	-	-	-
CHECK WHETHER $ \sigma_{s,m} \leq 2S_s$		-	-	-	-	YES	YES	YES	YES
CHECK WHETHER $\sigma_s \leq 1.5S_s$		-	YES	YES	YES	-	-	-	-
CHECK WHETHER $\sigma_s \leq 3S_s$		-	-	-	-	YES	YES	YES	YES
CHECK WHETHER $ \sigma_{s,m} \leq S_{s,b}$ (IF $\sigma_{s,m} < 0$)		-	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
RESULT		-	OK	OK	OK	OK	OK	OK	OK
AS STRESSES ARE WITHIN THE LIMIT, SHELL DESIGN IS ACCEPTABLE									
MINIMUM LENGTH OF SHELL WHICH SHALL HAVE UNIFORM THICKNESS = $1.8 * (D_s * t_s)^{1/2}$						-	MM	132.93	
TUBESHEET FLANGED EXTENSION (UHX-9)									
GASKET LOAD REACTION DIAMETER = G_c					G	MM	649.15		
GASKET MOMENT ARM (REFER PAGE - 13)					H_g	MM	22.42		
TOTAL DEPTH OF STEPS IN TUBESHEET					S_d	MM	13.00		
THICKNESS REQUIRED FOR OPERATING CONDITION									
BOLT LOAD (REFER PAGE - 13)					W_{m1}	KG	82428.33		
ALLOWABLE STRESS AT DESIGN TEMPERATURE					S	KG/MM ²	14.062		
REQUIRED THICKNESS = $(1.9 * W_{m1} * H_g / S_g)^{1/2}$					$hr1$	MM	19.61		
THICKNESS REQUIRED FOR GASKET SEATING									
BOLT LOAD (REFER PAGE - 13)					W	KG	152612.20		
ALLOWABLE STRESS AT AMBIENT TEMPERATURE					S_a	KG/MM ²	14.062		
REQUIRED THICKNESS = $(1.9 * W * H_g / S_a g)^{1/2}$					$hr1$	MM	26.69		
REQUIRED THICKNESS FOR FLANGED EXT. = MAX OF $hr1$ & $hr2$						hr	MM	26.69	
PROVIDED THICKNESS = $h - S_d$						hf	MM	33.00	
ALLOWABLE LONGITUDINAL COMPRESSIVE STRESS FOR MAIN SHELL AS PER UG-28(b),									
A FACTOR = $0.125 / [(D_s + 2 * t_s) / 2 t_s]$					A	-	3.61E-03		
FROM APPLICABLE CHART- CS-2					B	PSI	16563.46		
						KG/CM ²	1164.6		
ALLOWABLE LONGITUDINAL COMPRESSIVE STRESS					$S_{s,b}$	KG/CM ²	1164.6		
= MIN OF S_s & B									

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	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	600.00	-	-
TUBE OD		MM	20.00	-	-
BAFFLE SPACING (MIN)		MM	-	120.00	600.00
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	-	12.70	13.00
WIDTH OF PASS PARTITION		MM	-	9.50	10.00
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	600.00
DIMENASION `b`			b	MM	489.00
RATIO = a/b			-	-	1.23
A VALUE FROM TABLE RCB-9.132 FOR RATIO `a/b`			B	-	0.4137
REQUIRED THICKNESS = $b*\{(q*B) / (1.5*S)\}^{1/2}$			trpp ₁	MM	5.73
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

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	ITEM NO. : 117-EE-485				REV.	0
	DOCUMENT NO. : PRJ/9742/17				DATE	28-Feb-10
	NOZZLE NECK & REINFORCEMENT-N1 (UG-36, UG-37, UG-45)				PRPD.	CHKD.
				KK	KK	RCS
DESIGN INPUT					NOZZLE NECK CALCULATIONS (mm)	
- Nozzle Mark			N1	AS PER UG-45 OF ASME SEC. VIII DIV.1,		
- Nozzle Size			150 NB	trn	$P*(do/2)/(S*E+0.4P)+C$ (As per 1-1(a)(1))	4.48
- Nozzle Location			MAIN SHELL	t ₁	Smls. Shell Thickness	7.62
P	Design Pressure (Kg/cm ² (g))	21.228	Sw	Std Wall Thickness		7.11
T	Design Temperature (°C)	130	t ₂	$0.875*Sw + C$		9.22
do	Nozzle Outside Dia. (mm)	168.3	t ₃	Minimum of t ₁ & t ₂		7.62
C	Corrosion Allowance (mm)	3	t ₄	$1.5 + C$ (As per UG-16(b))		4.50
-	Nozzle Material	SA 333 GR 6		Min.Reqd thk = Max of (trn,t ₃ ,t ₄)		7.62
S	Allowable Stress (Kg/cm ²)	1202.3	tn	Provided thk(Min)=tn ₁ -Neg.Tol.(mm)		9.60
E	Joint Efficiency	1.00		Provided pipe Sch.		SCH 80
t	Shell Thickness (mm)	12.00	tn ₁	Provided thk (Nom) (mm)		10.97
			d	Finished Opening Size (mm) do - 2*tn + 2*C		155.10
As per clause UG-36(c)(3)(a), finished openings upto the size 60 mm are exempted from reinforcement calculations. Accordingly this nozzle is not exmpted from reinforcement calculations.						
DESIGN INPUT					REINFORCEMENT CALCULATIONS	
tn	Nozzle Wall Thickness (mm)	6.60	AS PER UG-37 OF ASME SEC VIII DIV 1,			
tr	Required Shell Thk (mm) (As per UG-37(a))	4.62	Required Area (mm ²)			
t	Specified Shell thk. (mm)	9.00	A	$d*tr*F+2*tn*tr*F*(1-fr1)$		724.8
trn	Reqd. thk. of Nozzle (mm)	1.48	Area Available in Shell (mm ²)			
h	Inside Proj. of Nozzle (mm)	0	A1a	$d*(E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)$		671.6
ti	Thk.of Inside Proj. of Nozzle (mm)	0.00	A1b	$2*(t+tn)*(E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)$		128.4
E1	For Opening in Solid Plate	1.00	A1	Maximum of (A1a,A1b)		671.6
F	Correction Factor	1.00	Area Available in Nozzle Outward Projection (mm ²)			
fr1	Strength Red.Factor = Sn / Sv	0.85	A2a	$5*(tn-trn)*fr2*t$		197.1
fr2	Strength Red.Factor = Sn / Sv	0.85	A2b	$2*(tn-tm)*(2.5*tn+te)*fr2$		144.5
fr3	Strenght Red.Factor=Min(Sn/Sv or Sp/Sv)	0.85	A2	Minimum of (A2a,A2b)		144.5
fr4	Strength Red.Factor = Sp / Sv	1.00	Area Available in Nozzle Inward Projection (mm ²)			
			A3a	$5*t*ti*fr2$		0.0
			A3b	$5*ti*ti*fr2$		0.0
			A3c	$2*h*ti*fr2$		0.0
FILLET SIZE CALCULATIONS (UW-16) (mm)			A3	Minimum of (A3a,A3b,A3c)		0.0
Applicable Fig. UW-16.1(c)		Fillet Size(Nozzle)	Area Available in Nozzle Welds (mm ²)			
tmin	Min of tn, t & 19	10.97	leg ₁	Nozzle Outward Weld Leg Size (mm)		9.0
tc	Min of 0.7*tmin, 6	6.00	leg ₂	Nozzle Inward Weld Leg Size (mm)		0.0
tmin	Min of te, t & 19	0.00	leg ₃	RF Pad Outer Weld Leg Size (mm)		0.0
tf	tmin/2	0.00	A41	For Outward Weld = (leg ₁) ² *fr3 (mm ²)		69.3
All dimensions for reinforcement calculations are in corroded condition.			A43	For Inward Weld=(leg ₂) ² *fr2 (mm ²)		0.0
			A42	For RF Pad Weld=(leg ₂) ² *fr4 (mm ²)		0.0
			Area Available in RF Pad (mm ²)			
			Dpm	Max.of (d+2*tn+2*t-2*leg ₃ ,2*d-2*leg ₃) (mm)		310.2
CONCLUSION :			Dp	Diameter of RF Pad (mm)		0
			te	Thickness of RF Pad (mm)		0
			A5	(Min of Dp & Dpm-d-2*tn)*te*fr4 (mm ²)		0.0
			Provided Area (mm ²)			
Check whether Atp > A			Atp	A1+A2+A3+A41+A42+A43+A5		885.4
Whether Nozzle is properly reinforced?						

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	ITEM NO. : 117-EE-485				REV.	0
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	NOZZLE NECK & REINFORCEMENT-N2 (UG-36, UG-37, UG-45)				PRPD.	CHKD.
					APPD.	RCS
				KK	KK	RCS

DESIGN INPUT				NOZZLE NECK CALCULATIONS (mm)			
-	Nozzle Mark	N2		AS PER UG-45 OF ASME SEC. VIII DIV.1,			
-	Nozzle Size	100 NB		trn	$P*(do/2)/(S*E+0.4P)+C$ (As per 1-1(a)(1))	4.00	
-	Nozzle Location	MAIN SHELL		t ₁	Smls. Shell Thickness	7.62	
P	Design Pressure (Kg/cm ² (g))	21.228		Sw	Std Wall Thickness	6.02	
T	Design Temperature (°C)	130		t ₂	$0.875*Sw + C$	8.27	
do	Nozzle Outside Dia. (mm)	114.3		t ₃	Minimum of t ₁ & t ₂	7.62	
C	Corrosion Allowance (mm)	3		t ₄	$1.5 + C$ (As per UG-16(b))	4.50	
-	Nozzle Material	SA 333 GR 6		tn	Min.Reqd thk = Max of (trn,t ₃ ,t ₄)	7.62	
S	Allowable Stress (Kg/cm ²)	1202.3		tn	Provided thk(Min)=tn ₁ -Neg.Tol.(mm)	9.74	
E	Joint Efficiency	1.00			Provided pipe Sch.	SCH 120	
t	Shell Thickness (mm)	12.00		tn ₁	Provided thk (Nom) (mm)	11.13	
				d	Finished Opening Size (mm) $do - 2*tn + 2*C$	100.82	
As per clause UG-36(c)(3)(a), finished openings upto the size 60 mm are exempted from reinforcement calculations. Accordingly this nozzle is not exempted from reinforcement calculations.							

DESIGN INPUT				REINFORCEMENT CALCULATIONS			
tn	Nozzle Wall Thickness (mm)	6.74		AS PER UG-37 OF ASME SEC VIII DIV 1,			
tr	Required Shell Thk (mm) (As per UG-37(a))	4.62		Required Area (mm ²)			
				A	$d*tr*F+2*tn*tr*F*(1-fr1)$	474.4	
t	Specified Shell thk. (mm)	9.00		Area Available in Shell (mm ²)			
trn	Reqd. thk. of Nozzle (mm)	1.00		A1a	$d*(E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)$	433.4	
h	Inside Proj. of Nozzle (mm)	0		A1b	$2*(t+tn)*(E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)$	129.4	
ti	Thk.of Inside Proj. of Nozzle (mm)	0.00		A1	Maximum of (A1a,A1b)	433.4	
E1	For Opening in Solid Plate	1.00		Area Available in Nozzle Outward Projection (mm ²)			
F	Correction Factor	1.00		A2a	$5*(tn-trn)*fr2*t$	220.7	
fr1	Strength Red.Factor = Sn / Sv	0.85		A2b	$2*(tn-trn)*(2.5*tn+te)*fr2$	165.3	
fr2	Strength Red.Factor = Sn / Sv	0.85		A2	Minimum of (A2a,A2b)	165.3	
fr3	Strenght Red.Factor=Min(Sn/Sv or Sp/Sv)	0.85		Area Available in Nozzle Inward Projection (mm ²)			
fr4	Strength Red.Factor = Sp / Sv	1.00		A3a	$5*t*ti*fr2$	0.0	
				A3b	$5*ti*ti*fr2$	0.0	
				A3c	$2*h*ti*fr2$	0.0	
FILLET SIZE CALCULATIONS (UW-16) (mm)				A3	Minimum of (A3a,A3b,A3c)	0.0	
tmin	Min of tn ₁ , t & 19	11.13	Reqd.	Provided	Area Available in Nozzle Welds (mm ²)		
tc	Min of 0.7*tmin, 6	6.00	8.49	9.00	leg ₁	Nozzle Outward Weld Leg Size (mm)	9.0
tmin	Min of te, t & 19	0.00	Fillet Size(RF Pad)		leg ₂	Nozzle Inward Weld Leg Size (mm)	0.0
tf	tmin/2	0.00	0.00	0.00	leg ₃	RF Pad Outer Weld Leg Size (mm)	0.0
All dimensions for reinforcement calculations are in corroded condition.					A41	For Outward Weld = (leg ₁) ² *fr3 (mm ²)	69.3
					A43	For Inward Weld=(leg ₂) ² *fr2 (mm ²)	0.0
					A42	For RF Pad Weld=(leg ₂) ² *fr4 (mm ²)	0.0
					Area Available in RF Pad (mm ²)		
					Dpm	Max.of (d+2*tn+2*t-2*leg ₃ ,2*d-2*leg ₃) (mm)	201.6
CONCLUSION :					Dp	Diameter of RF Pad (mm)	0
					te	Thickness of RF Pad (mm)	0
					A5	(Min of Dp & Dpm-d-2*tn)*te*fr4 (mm ²)	0.0
					Provided Area (mm ²)		
					Atp	A1+A2+A3+A41+A42+A43+A5	668.0

Check whether Atp > A	YES
Whether Nozzle is properly reinforced?	YES

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	ITEM NO. : 117-EE-485				REV.	0	
	DOCUMENT NO. : PRJ/9742/17				DATE	28-Feb-10	
	NOZZLE NECK & REINFORCEMENT - N3,N4 (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	100 NB		trn	$P*(do/2)/(S*E+0.4P)+C$ (As per 1-1(a)(1))	3.78	
-	Nozzle Location	CHANNEL SHELL		t ₁	Smls. Channel Thickness	6.57	
P	Design Pressure (Kg/cm ² (g))	16.460		Sw	Std Wall Thickness	6.02	
T	Design Temperature (°C)	80		t ₂	$0.875*Sw + C$	8.27	
do	Nozzle Outside Dia. (mm)	114.3		t ₃	Minimum of t ₁ & t ₂	6.57	
C	Corrosion Allowance (mm)	3		t ₄	$2.5 + C$ (As per UG-16(b))	5.50	
-	Nozzle Material	SA 333 GR 6			Min.Reqd thk = Max of (trn,t ₃ ,t ₄)	6.57	
S	Allowable Stress (Kg/cm ²)	1202.3		tn	Provided thk(Min)=tn ₁ -Neg.Tol.(mm)	7.49	
E	Joint Efficiency	1.00			Provided pipe Sch.	SCH 80	
t	Channel Thickness (mm)	10.00		tn ₁	Provided thk (Nom) (mm)	8.56	
				d	Finished Opening Size (mm) do - 2*tn + 2*C	105.32	
As per clause UG-36(c)(3)(a), finished openings upto the size 89 mm are exempted from reinforcement calculations. Accordingly this nozzle is not exempted from reinforcement calculations.							

DESIGN INPUT				REINFORCEMENT CALCULATIONS			
tn	Nozzle Wall Thickness (mm)	4.49		AS PER UG-37 OF ASME SEC VIII DIV 1,			
tr	Required Channel Thk. (mm) (As per UG-37(a))	3.57		Required Area (mm ²)			
				A	$d*tr*F+2*tn*tr*F*(1-fr1)$	380.8	
t	Specified Channel thk. (mm)	7.00		Area Available in Channel (mm ²)			
trn	Reqd. thk. of Nozzle (mm)	0.78		A1a	$d*(E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)$	356.6	
h	Inside Proj. of Nozzle (mm)	0		A1b	$2*(t+tn)*(E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)$	74.3	
ti	Thk.of Inside Proj. of Nozzle (mm)	0.00		A1	Maximum of (A1a,A1b)	356.6	
E1	For Opening in Solid Plate	1.00		Area Available in Nozzle Outward Projection (mm ²)			
F	Correction Factor	1.00		A2a	$5*(tn-trn)*fr2*t$	111.1	
fr1	Strength Red.Factor = Sn / Sv	0.85		A2b	$2*(tn-trn)*(2.5*tn+te)*fr2$	71.2	
fr2	Strength Red.Factor = Sn / Sv	0.85		A2	Minimum of (A2a,A2b)	71.2	
fr3	Strenght Red.Factor=Min(Sn/Sv or Sp/Sv)	0.85		Area Available in Nozzle Inward Projection (mm ²)			
fr4	Strength Red.Factor = Sp / Sv	1.00		A3a	$5*t*ti*fr2$	0.0	
				A3b	$5*ti*ti*fr2$	0.0	
				A3c	$2*h*ti*fr2$	0.0	
Fillet Size CALCULATIONS (UW-16) (mm)				A3	Minimum of (A3a,A3b,A3c)	0.0	
Applicable Fig. UW-16.1(c)		Fillet Size(Nozzle)		Area Available in Nozzle Welds (mm ²)			
tmin	Min of tn ₁ , t & 19	8.56	Reqd.	leg ₁	Nozzle Outward Weld Leg Size (mm)	9.0	
tc	Min of 0.7*tmin, 6	5.99	8.47	9.00	leg ₂	Nozzle Inward Weld Leg Size (mm)	0.0
tmin	Min of te, t & 19	0.00	Fillet Size(RF Pad)		leg ₃	RF Pad Outer Weld Leg Size (mm)	0.0
tf	tmin/2	0.00	0.00	0.00	A41	For Outward Weld = (leg ₁) ² *fr3 (mm ²)	69.3
				A43	For Inward Weld=(leg ₂) ² *fr2 (mm ²)	0.0	
				A42	For RF Pad Weld=(leg ₂) ² *fr4 (mm ²)	0.0	
				Area Available in RF Pad (mm ²)			
				Dpm	Max.of (d+2*tn+2*t-2*leg ₃ ,2*d-2*leg ₃) (mm)	210.6	
				Dp	Diameter of RF Pad (mm)	0	
				te	Thickness of RF Pad (mm)	0	
				A5	(Min of Dp & Dpm-d-2*tn)*te*fr4 (mm ²)	0.0	
				Provided Area (mm ²)			
				Atp	A1+A2+A3+A41+A42+A43+A5	497.1	

All dimensions for reinforcement calculations are in corroded condition.	
CONCLUSION :	
Check whether Atp > A	YES
Whether Nozzle is properly reinforced?	YES

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER				PAGE	24	
	ITEM NO. : 117-EE-485				REV.	0	
	DOCUMENT NO. : PRJ/9742/17				DATE	28-Feb-10	
	NOZZLE NECK & REINFORCEMENT-N5,N6,N7 (UG-36, UG-37, UG-45)				PRPD.	CHKD.	APPD.
					KK	KK	RCS

DESIGN INPUT				NOZZLE NECK CALCULATIONS (mm)			
-	Nozzle Mark	N5,N6,N7		AS PER UG-45 OF ASME SEC. VIII DIV.1,			
-	Nozzle Size	40 NB		trn	P*(do/2)/(S*E+0.4P)+C		3.42
-	Nozzle Location	MAIN SHELL			(As per 1-1(a)(1))		
P	Design Pressure (Kg/cm ² (g))	21.228		t ₁	Smls. Shell Thickness		7.62
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)	12.00		Provided pipe Sch.			SCH 160
				tn ₁	Provided thk (Nom) (mm)		7.14
FILLET SIZE CALCULATIONS (UW-16) (mm)				d	Finished Opening Size (mm)		41.81
Applicable Fig. UW-16.1(c)		Fillet Size			do - 2*tn + 2*C		
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 60 mm are exempted from reinforcement calculations. Accordingly this nozzle is exmpted from reinforcement calculations.							

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER				PAGE	25
	ITEM NO. : 117-EE-485				REV.	0
	DOCUMENT NO. : PRJ/9742/17				DATE	28-Feb-10
	NOZZLE NECK & REINFORCEMENT-N8,N9 (UG-36, UG-37, UG-45)				PRPD.	CHKD.
				KK	KK	RCS

DESIGN INPUT				NOZZLE NECK CALCULATIONS (mm)		
-	Nozzle Mark	N8,N9		AS PER UG-45 OF ASME SEC. VIII DIV.1,		
-	Nozzle Size	40 NB		trn	$P \cdot (do/2) / (S \cdot E + 0.4P) + C$ (As per 1-1(a)(1))	3.33
-	Nozzle Location	CHANNEL SHELL				
P	Design Pressure (Kg/cm ² (g))	16.460		t ₁	Smls. Channel Thickness	6.57
T	Design Temperature (°C)	80		Sw	Std Wall Thickness	3.68
do	Nozzle Outside Dia. (mm)	48.3		t ₂	$0.875 \cdot Sw + C$	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	$2.5 + C$ (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)	6.22
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) $do - 2 \cdot tn + 2 \cdot C$	41.81
Applicable Fig.		UW-16.1(c)				
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: CONDENSER	PAGE	26	
	ITEM NO. : 117-EE-485	REV.	0	
	DOCUMENT NO. : PRJ/9742/17	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#	150#
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	18.702
DESIGN PRESSURE INCL. STATIC HEAD (MAX.)	KG/CM ² (g)	21.228	16.460
CONCLUSION		SAFE	SAFE

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	27	
	ITEM NO. : 117-EE-485		REV.	0	
	DOCUMENT NO. : PRJ/9742/17		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	12.00	600.00	306	INFINITY	1.96	NO
CHANNEL SHELL	SA 516 GR 70	10.00	600.00	305	INFINITY	1.64	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	102.00	107.00	INFINITY	7.01	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 = $0.17 \cdot \text{DISHED END ID}$

D'ENDS SHALL BE STRESS RELIEVED.

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER	PAGE	28	
	ITEM NO. : 117-EE-485	REV.	0	
	DOCUMENT NO. : PRJ/9742/17	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: CONDENSER	PAGE	29
	ITEM NO. : 117-EE-485	REV.	0
	DOCUMENT NO. : PRJ/9742/17	DATE	28-Feb-10
	IMPACT TEST REQUIREMENTS (UCS-66)	PRPD.	CHKD.
		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	12.00	UCS-66(a)
PIPES	SA 333 GR 6	B	NOT EXEMPTED	11.13	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	8.56	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: CONDENSER		PAGE	30	
	ITEM NO. : 117-EE-485		REV.	0	
	DOCUMENT NO. : PRJ/9742/17		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.					

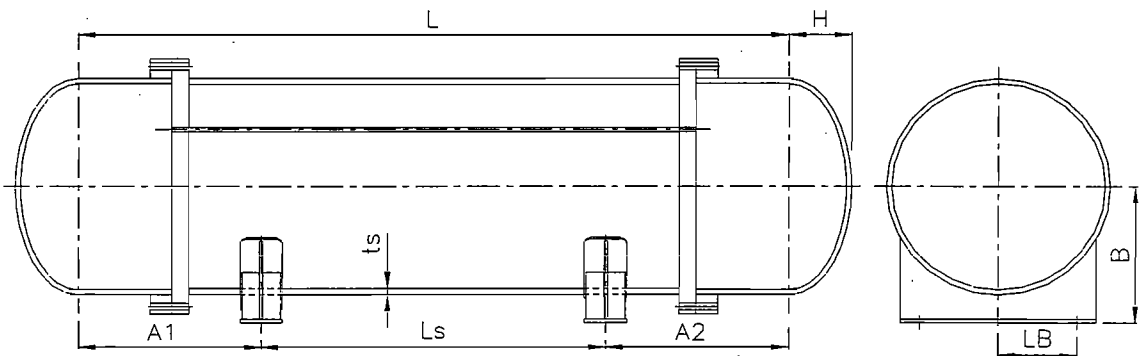
KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	31	
	ITEM NO. : 117-EE-485		REV.	0	
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10	
	TEST PRESSURE (UG-99,UG-100)		PRPD.	CHKD.	APPD.
			KK	KK	RCS
FOR SHELL SIDE					
DESIGN PRESSURE	P	KG/CM ² (g)	21.200		
MINIMUM STRESS RATIO (REF. PAGE NO. 7)	(Sh/S) _{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)	23.320		
=1.1 * P * (Sh/S) _{MIN}		BAR (g)			
FOR CHANNEL SIDE					
DESIGN PRESSURE	P	KG/CM ² (g)	16.400		
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)	21.320		
=1.3 * P * (Sh/S) _{MIN}		BAR (g)			

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE		33	
	ITEM NO. : 117-EE-485		REV.		0	
	DOCUMENT NO. : PRJ/9742/17		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	5325	
EMPTY WEIGHT			We	KG	4250	
TEST WEIGHT			Wh	KG	4922	
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	0.550	
SEISMIC LOAD FOR VARIOUS CONDITIONS:						
DESCRIPTION		UNIT	OPERATING	TEST	EMPTY	
W = WEIGHT		KG	5325	4922	4250	
Fe = SEIS. FORCE AT BASE = Ah * W		KG	1956.94	0.00	1561.88	
Me = SEIS. MOMENT AT BASE = Fe*B		KG-M	1076.32	0.00	859.03	
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: CONDENSER	PAGE	34	
	ITEM NO. : 117-EE-485	REV.	0	
	DOCUMENT NO. : PRJ/9742/17	DATE	28-Feb-10	
	SUPPORT DESIGN (ZICK ANALYSIS)	PRPD.	CHKD.	APPD.
		KK	KK	RCS

DESIGN INPUT

T.L. TO T.L. LENGTH	L	MM	6202.00
T.L. TO SUPPORT DISTANCE (MAX OF A1 & A2)	A	MM	1134.00
DISTANCE BETWEEN TWO SUPPORTS	Ls	MM	4000.00
DISHED END OUTSIDE HEIGHT	H	MM	160.00
INSIDE DIAMETER (CORRODED)	Di	MM	606.00
INSIDE RADIUS (CORRODED)	R	MM	303.00
CORROSION ALLOWANCE	C	MM	3.00
SHELL THICKNESS (CORRODED)	ts	MM	9.00
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	550.00
SADDLE WIDTH	b	MM	134.00



ELEVATION

SUPPORT DESIGN

	SYMBOL	UNIT	OPERATING	TEST	EMPTY
INTERNAL PRESSURE	P	KG/CM ² (g)	21.228	23.320	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	5325.00	4922.00	4250.00
TRANSEVERSE LOAD (MAX OF WIND/SEIS.)	F _T	KG	1956.94	198.70	1561.88
LONGITUDINAL LOAD (MAX OF WIND/SEIS.)	F _L	KG	1956.94	22.81	1561.88
CG LOCATION FROM FIXED SUPPORT	l ₁	MM	2000.00	2000.00	2000.00
Ls - l ₁	l ₂	MM	2000.00	2000.00	2000.00
Q ₁ = W * (MAX OF l ₁ & l ₂) / Ls + F _L *B / Ls	Q ₁	KG	2931.58	2464.14	2339.76
Q ₂ = W * (MAX OF l ₁ & l ₂) / Ls + 3 * F _T *B / 2a	Q ₂	KG	5545.49	2753.72	4425.98
Q = MAX OF Q ₁ & Q ₂	Q	KG	5545.49	2753.72	4425.98

LONGITUDINAL BENDING MOMENT

AT SUPPORTS = Q/2*(8*A*H+6*A ² -3*R ² +3H ²)/(3*L+4*H)	M ₁	KG-MM	1292097.76	641617.04	1031251.73
AT MID-SPAN = Q/4*(3*L ² + 6*R ² -6H ² -12*A*L-16*A*H)/(3*L+4*H)	M ₂	KG-MM	2052387.49	1019154.15	1638055.74

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER				PAGE	35
	ITEM NO. : 117-EE-485				REV.	0
	DOCUMENT NO. : PRJ/9742/17				DATE	28-Feb-10
	SUPPORT DESIGN (ZICK ANALYSIS) - Contd..				PRPD.	CHKD.
				KK	KK	RCS

CALCULATIONS FOR STRESSES :						
WHETHER STIFFENERS PROVIDED				NO		
LONG. BENDING STRESS AT SADDLE = $M_1/(K_1 \cdot R^2 \cdot ts)$ $K_1 = 0.335$	S_1	KG/MM ²	4.668	2.318	3.726	
LONG. BENDING STRESS AT SADDLE = $-M_1/(K_7 \cdot R^2 \cdot ts)$ $K_7 = 0.603$	S_2	KG/MM ²	-2.593	-1.288	-2.070	
LONG. BENDING STRESS AT SADDLE = $M_1/(\pi \cdot R^2 \cdot ts)$	S_3	KG/MM ²	N.A.	N.A.	N.A.	
LONG. BENDING STRESS AT MID SPAN = $M_2/(\pi \cdot R^2 \cdot ts)$	S_4	KG/MM ²	0.791	0.393	0.631	
TANGENTIAL SHEAR(Shell stiff.in saddle plane) = $Q \cdot ((L-2 \cdot A)/(L+4/3 \cdot H))/(\pi \cdot R \cdot ts)$	S_5	KG/MM ²	N.A.	N.A.	N.A.	
TANGENTIAL SHEAR = $K_2 \cdot Q \cdot ((L-2 \cdot A)/(L+4/3 \cdot H))/(R \cdot ts)$ $K_2 = 1.171$	S_6	KG/MM ²	1.460	0.725	1.165	
TANGENTIAL SHEAR IN SHELL = $K_3 \cdot Q/(R \cdot ts)$ $K_3 = 0.880$	S_7	KG/MM ²	N.A.	N.A.	N.A.	
TANGENTIAL SHEAR IN HEAD = $K_3 \cdot Q/(R \cdot th)$ $K_3 = 0.880$	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	4.728	2.348	3.773	
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 = $K_4 \cdot Q/(R \cdot th)$ $K_4 = 0.401$	S_{11}	KG/MM ²	N.A.	N.A.	N.A.	
CIRCUMFERENTIAL COMPRESSION = $-K_5 \cdot Q/(ts \cdot (b+1.56 \cdot \text{SQRT}(R \cdot ts)))$ $K_5 = 0.760$	S_{12}	KG/MM ²	-2.173	-1.079	-1.735	
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						
= $P \cdot (R + ts) / (2 \cdot ts)$	σ_x	KG/MM ²	3.680	4.042	0.000	
= $P \cdot (R + ts) / ts$	σ_s	KG/MM ²	7.359	8.084	0.000	
= $P \cdot (R + ts) / ts$	σ_h	KG/MM ²	7.359	8.084	0.000	
= $P_e \cdot (R + ts) / (2 \cdot ts)$	σ_e	KG/MM ²	0.183	0.000	0.183	

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				

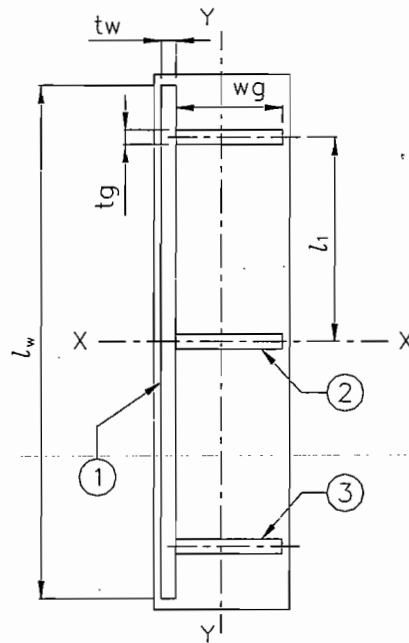
AS ALL THE STRESSES ARE WITHIN THE ALLOWABLE LIMITS, DESIGN IS SAFE.						
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KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER			PAGE	36	
	ITEM NO. : 117-EE-485			REV.	0	
	DOCUMENT NO. : PRJ/9742/17			DATE	28-Feb-10	
	SUPPORT DESIGN (ZICK ANALYSIS) - Contd..			PRPD.	CHKD.	APPD.
				KK	KK	RCS
DESIGN OF SADDLE						
	SYMBOL	UNIT	OPERATING	TEST	EMPTY	
TRANSVERSE WIND FORCE AT BASE	F_{TW}	KG	602.11	198.70	602.11	
TRANSEVERS WIND MOMENT AT BASE	M_{TW}	KG-M	331.16	109.28	331.16	
TRANSVERSE SEISMIC FORCE AT BASE	F_{TS}	KG	1956.94	0.00	1561.88	
TRANSVERSE SEISMIC MOMENT AT BASE	M_{TS}	KG-M	1076.32	0.00	859.03	
DISTANCE BETWEEN BOLT & VESSEL C.L.	L_B	MM	190.00	190.00	190.00	
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	2.290E+08	2.290E+08	2.290E+08	
SECTION MODULUS OF ONE SADDLE SUPP.	Z_{xx}	MM ³	8.180E+05	8.180E+05	8.180E+05	
(REFER NEXT PAGE FOR CALCULATIONS OF I_{xx} & Z_{xx})						
MAXIMUM SHEAR FORCE AT BASE	F_T	KG	1956.94	198.70	1561.88	
MAXIMUM BENDING MOMENT AT BASE	M_T	KG-M	1076.32	109.28	859.03	
BENDING STRESS IN SADD.AT BASE= M/Z_{xx}	S_b	KG/CM ²	131.584	13.360	105.020	
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	-919.54	-1885.82	-382.04	
TENSILE LOAD DUE TO SEISMIC LOADING $M_T / L_B - W/2$	T_{b2}	KG	3002.32	-2461.00	2396.22	
MAXIMUM TENSILE LOAD=MAX OF T_{b1} & T_{b2}	T_b	KG	3002.32	-1885.82	2396.22	
REQUIRED ROOT AREA OF ONE BOLT						
FOR TENSION = $T_b/(N*N_B/2)/S_T$	A_r	MM ²	1.26	N.A.	1.00	
FOR SHEAR = $F/(N*N_B)/(S_S)$			61.39	6.23	49.00	
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	560.00	560.00	560.00	
WIDTH OF BASE PLATE	b	MM	150.00	150.00	150.00	
BEARING STRESS = $Q/(a*b)$	P_B	KG/CM ²	6.60	3.28	5.27	
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	8.90	6.27	7.95	
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: CONDENSER	PAGE	37
	ITEM NO. : 117-EE-485	REV.	0
	DOCUMENT NO. : PRJ/9742/17	DATE	28-Feb-10
	CALCULATIONS FOR I_{xx} & Z_{xx} FOR SADDLES	PRPD.	CHKD.
		KK	RCS

CALCULATIONS FOR I_{xx} & Z_{xx}

WEB PLATE THICKNESS	tw	MM	12.00
WEB PLATE LENGTH	lw	MM	560.00
GUSSET PLATE THICKNESS	tg	MM	12.00
GUSSET PLATE WIDTH (MARKED AS 2)	wg	MM	122.00
GUSSET PLATE DISTANCE FROM X-X AXIS	l ₁	MM	135.00
MOMENT OF INERTIA @ X-X AXIS FOR			
WEB PLATE (MARKED AS 1) = $tw \cdot lw^3 / 12$	I_{xx1}	MM ⁴	1.756E+08
GUSSET PLATE (MARKED AS 2) = $wg \cdot tg^3 / 12$	I_{xx2}	MM ⁴	1.757E+04
GUSSET PLATE PAIR (MARKED AS 3) = $(wg \cdot tg^3 / 12 + wg \cdot tg \cdot l_1^2) \cdot 2$	I_{xx3}	MM ⁴	5.340E+07
TOTAL FOR CROSS SECTION = $I_{xx1} + I_{xx2} + I_{xx3}$	I_{xx}	MM ⁴	2.290E+08
SECTION MODULUS = $I_{xx} / (lw/2)$	Z_{xx}	MM ³	8.180E+05
CROSS SECTIONAL AREA = $tw \cdot lw + 3 \cdot wg \cdot tg$	A	MM ²	11112.00



PLAN FOR SADDLE

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER	PAGE	38	
	ITEM NO. : 117-EE-485	REV.	0	
	DOCUMENT NO. : PRJ/9742/17	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	-	-	150 NB	100 NB	100 NB	
FLANGE RATING	-	-	300#	300#	150#	
RADIAL LOAD (AXIAL LOAD)	F_A	KG	405.0	270.0	270.0	
CIRCUMFERENTIAL SHEAR LOAD	F_C	KG	600.0	400.0	400.0	
LONGITUDINAL SHEAR LOAD	F_L	KG	600.0	400.0	400.0	
CIRCUMFERENTIAL MOMENT	M_C	KG-M	270.0	120.0	120.0	
LONGITUDINAL MOMENT	M_L	KG-M	360.0	160.0	160.0	
TORSIONAL MOMENT	M_T	KG-M	450.0	200.0	200.0	

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: CONDENSER		PAGE	39
	ITEM NO. : 117-EE-485		REV.	0
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10
	LOCAL LOAD ANALYSIS FOR NOZZLE N1		PRPD.	CHKD. APPD.
	(WRC 297)		KK	KK RCS

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N1 NOZZLE SIZE : 150 NB LOADING CASE (A)

STRESSES AT THE EDGE OF ATTACHMENT :

RADIAL LOAD	KG	F_A	405.0	PAD THICKNESS	MM	T_p	0.00
CIRC. SHEAR LOAD	KG	F_C	600.0	$T_e = \text{SQRT}(T^2 + T_p^2)$	MM	T_e	9.00
LONG. SHEAR LOAD	KG	F_L	600.0	NOZZLE OUTSIDE DIA.	MM	d	168.30
CIRC. MOMENT	KG-M	M_C	270.0	NOZZLE THICKNESS	MM	t	6.60
LONG. MOMENT	KG-M	M_L	360.0	FACTOR = $(d/D)(D/T_e)^{1/2}$	-	λ	2.262
TORSIONAL MOMENT	KG-M	M_T	450.0	RATIO	-	d/t	25.50
INTERNAL DESIGN PRESS.	KG/CM ² (g)	P_r	21.228	RATIO	-	T_e/t	1.36
SHELL MEAN DIA (CORR.)	MM	D	615.00	SHELL ALLOWABLE STRESS	KG/CM ²	S	1406.2
SHELL THK (CORRODED)	MM	T	9.00	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	20.00	4	0.0760	20.00	9	0.0560	20.00	14	0.0370	20.00	19	0.1100
	30.00	5	0.1200	30.00	10	0.0470	30.00	15	0.0400	30.00	20	0.1200
	25.50	-	0.1002	25.50	-	0.0510	25.50	-	0.0387	25.50	-	0.1155
M_C	10.00	23	0.2500	20.00	28	0.1000	10.00	32	0.0850	20.00	37	0.1000
	30.00	24	0.2500	30.00	29	0.0820	30.00	33	0.0900	30.00	38	0.1250
	25.50	-	0.2500	25.50	-	0.0901	25.50	-	0.0889	25.50	-	0.1138
M_L	10.00	41	0.1150	20.00	46	0.0540	10.00	50	0.0430	20.00	55	0.1600
	30.00	42	0.1100	30.00	47	0.0480	30.00	51	0.0360	30.00	56	0.1750
	25.50	-	0.1111	25.50	-	0.0507	25.50	-	0.0376	25.50	-	0.1683

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	25.5	300.7	326.2	2	57.8	116.0	173.7
	NOZZLE	5	11.6	416.9	428.5	7	57.8	0.0	57.8
M_C	VESSEL	3	178.4	2970.9	3149.3	4	225.3	1056.2	1281.5
	NOZZLE	6	183.9	4530.7	4714.6	8	225.3	0.0	225.3
M_L	VESSEL	3	133.9	1760.7	1894.6	4	444.3	595.3	1039.7
	NOZZLE	6	245.2	2528.2	2773.4	8	444.3	0.0	444.3

SHEAR STRESS DUE TO M_T	153.3	SHEAR STRESS DUE TO F_L	34.4
SHEAR STRESS DUE TO F_C	34.4	TOTAL SHEAR STRESS τ (KG/CM ²)	222.1

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	611.2	2061.4	2267.6
		INNER	611.2	2061.4	2267.6
	TRANSVERSE	OUTER	469.1	3271.5	3499.6
		INNER	469.1	3271.5	3499.6
NOZZLE	LONGITUDINAL	OUTER	633.1	2945.0	3220.0
		INNER	633.1	2945.0	3220.0
	TRANSVERSE	OUTER	465.6	4947.6	5153.2
		INNER	465.6	4947.6	5153.2

MAXIMUM COMBINED STRESS IN SHELL 3499.6 < 3*S, SAFE (Absolute values)

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	40
	ITEM NO. : 117-EE-485		REV.	0
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10
	LOCAL LOAD ANALYSIS FOR NOZZLE N1		PRPD.	CHKD.
	(WRC 297)		KK	RCS

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N1 NOZZLE SIZE : 150 NB LOADING CASE (B)

STRESSES AT THE EDGE OF ATTACHMENT :

RADIAL LOAD	KG	F_A	202.5	PAD THICKNESS	MM	T_p	0.00
CIRC. SHEAR LOAD	KG	F_C	300.0	$T_e = \text{SQRT}(T^2 + T_p^2)$	MM	T_e	9.00
LONG. SHEAR LOAD	KG	F_L	300.0	NOZZLE OUTSIDE DIA.	MM	d	168.30
CIRC. MOMENT	KG-M	M_C	135.0	NOZZLE THICKNESS	MM	t	6.60
LONG. MOMENT	KG-M	M_L	180.0	FACTOR = $(d/D)(D/T_e)^{1/2}$	-	λ	2.262
TORSIONAL MOMENT	KG-M	M_T	225.0	RATIO	-	d/t	25.50
INTERNAL DESIGN PRESS.	KG/CM ² (g)	P_r	0.000	RATIO	-	T_e/t	1.36
SHELL MEAN DIA (CORR.)	MM	D	615.00	SHELL ALLOWABLE STRESS	KG/CM ²	S	1406.2
SHELL THK (CORRODED)	MM	T	9.00	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	20.00	4	0.0760	20.00	9	0.0560	20.00	14	0.0370	20.00	19	0.1100
	30.00	5	0.1200	30.00	10	0.0470	30.00	15	0.0400	30.00	20	0.1200
	25.50	-	0.1002	25.50	-	0.0510	25.50	-	0.0387	25.50	-	0.1155
M_C	10.00	23	0.2500	20.00	28	0.1000	10.00	32	0.0850	20.00	37	0.1000
	30.00	24	0.2500	30.00	29	0.0820	30.00	33	0.0900	30.00	38	0.1250
	25.50	-	0.2500	25.50	-	0.0901	25.50	-	0.0889	25.50	-	0.1138
M_L	10.00	41	0.1150	20.00	46	0.0540	10.00	50	0.0430	20.00	55	0.1600
	30.00	42	0.1100	30.00	47	0.0480	30.00	51	0.0360	30.00	56	0.1750
	25.50	-	0.1111	25.50	-	0.0507	25.50	-	0.0376	25.50	-	0.1683

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	12.8	150.3	163.1	2	28.9	58.0	86.9
	NOZZLE	5	5.8	208.4	214.2	7	28.9	0.0	28.9
M_C	VESSEL	3	89.2	1485.4	1574.7	4	112.7	528.1	640.7
	NOZZLE	6	92.0	2265.3	2357.3	8	112.7	0.0	112.7
M_L	VESSEL	3	66.9	880.4	947.3	4	222.2	297.7	519.8
	NOZZLE	6	122.6	1264.1	1386.7	8	222.2	0.0	222.2

SHEAR STRESS DUE TO M_T	76.6	SHEAR STRESS DUE TO F_L	17.2
SHEAR STRESS DUE TO F_C	17.2	TOTAL SHEAR STRESS τ (KG/CM ²)	111.0

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	305.6	1030.7	1133.8
		INNER	305.6	1030.7	1133.8
	TRANSVERSE	OUTER	234.5	1635.8	1749.8
		INNER	234.5	1635.8	1749.8
NOZZLE	LONGITUDINAL	OUTER	316.6	1472.5	1610.0
		INNER	316.6	1472.5	1610.0
	TRANSVERSE	OUTER	232.8	2473.8	2576.6
		INNER	232.8	2473.8	2576.6

MAXIMUM COMBINED STRESS IN SHELL 1749.8 < 1.5*S, SAFE (Absolute values)

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	41
	ITEM NO. : 117-EE-485		REV.	0
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10
	LOCAL LOAD ANALYSIS FOR NOZZLE N2		PRPD.	CHKD.
	(WRC 297)		KK	RCS

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N2 NOZZLE SIZE : 100 NB LOADING CASE (A)

STRESSES AT THE EDGE OF ATTACHMENT :

RADIAL LOAD	KG	F _A	270.0	PAD THICKNESS	MM	T _p	0.00
CIRC. SHEAR LOAD	KG	F _C	400.0	Te = SQRT (T ² + T _p ²)	MM	Te	9.00
LONG. SHEAR LOAD	KG	F _L	400.0	NOZZLE OUTSIDE DIA.	MM	d	114.30
CIRC. MOMENT	KG-M	M _C	120.0	NOZZLE THICKNESS	MM	t	6.74
LONG. MOMENT	KG-M	M _L	160.0	FACTOR = (d/D)(D/Te) ^{1/2}	-	λ	1.536
TORSIONAL MOMENT	KG-M	M _T	200.0	RATIO	-	d/t	16.96
INTERNAL DESIGN PRESS. KG/CM ² (g)		Pr	21.228	RATIO	-	Te/t	1.34
SHELL MEAN DIA (CORR.)	MM	D	615.00	SHELL ALLOWABLE STRESS	KG/CM ²	S	1406.2
SHELL THK (CORRODED)	MM	T	9.00	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	0.1400	10.00	8	0.1100	10.00	13	0.0480	10.00	18	0.1100
	20.00	4	0.0960	20.00	9	0.0700	20.00	14	0.0520	20.00	19	0.1200
	16.96	-	0.1094	16.96	-	0.0822	16.96	-	0.0508	16.96	-	0.1170
M _C	10.00	23	0.2650	10.00	27	0.1450	10.00	32	0.0960	10.00	36	0.0370
	30.00	24	0.2700	20.00	28	0.1050	30.00	33	0.1000	20.00	37	0.0860
	16.96	-	0.2667	16.96	-	0.1172	16.96	-	0.0974	16.96	-	0.0711
M _L	10.00	41	0.1500	10.00	45	0.0920	10.00	50	0.0550	10.00	54	0.1400
	30.00	42	0.1600	20.00	46	0.0740	30.00	51	0.0540	20.00	55	0.1700
	16.96	-	0.1535	16.96	-	0.0795	16.96	-	0.0547	16.96	-	0.1609

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	27.4	218.7	246.1	2	39.0	101.6	140.6
	NOZZLE	5	11.2	243.6	254.8	7	39.0	0.0	39.0
M _C	VESSEL	3	151.8	2074.4	2226.2	4	92.2	757.4	849.6
	NOZZLE	6	173.5	2887.6	3061.1	8	92.2	0.0	92.2
M _L	VESSEL	3	137.3	1591.5	1728.8	4	278.0	566.7	844.7
	NOZZLE	6	231.4	2103.8	2335.2	8	278.0	0.0	278.0

SHEAR STRESS DUE TO M _T	144.6	SHEAR STRESS DUE TO F _L	33.1
SHEAR STRESS DUE TO F _C	33.1	TOTAL SHEAR STRESS τ (KG/CM ²)	210.7

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	465.0	1810.2	2017.9
		INNER	465.0	1810.2	2017.9
	TRANSVERSE	OUTER	367.3	2293.1	2501.7
		INNER	367.3	2293.1	2501.7
NOZZLE	LONGITUDINAL	OUTER	493.8	2347.4	2609.4
		INNER	493.8	2347.4	2609.4
	TRANSVERSE	OUTER	370.4	3131.2	3329.8
		INNER	370.4	3131.2	3329.8

MAXIMUM COMBINED STRESS IN SHELL 2501.7 < 3*S, SAFE (Absolute values)

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	42
	ITEM NO. : 117-EE-485		REV.	0
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10
	LOCAL LOAD ANALYSIS FOR NOZZLE N2		PRPD.	CHKD.
	(WRC 297)		KK	RCS

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N2 NOZZLE SIZE : 100 NB LOADING CASE (B)

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	Te = SQRT (T ² + T _p ²)	MM	Te	9.00
LONG. SHEAR LOAD	KG	F _L	200.0	NOZZLE OUTSIDE DIA.	MM	d	114.30
CIRC. MOMENT	KG-M	M _C	60.0	NOZZLE THICKNESS	MM	t	6.74
LONG. MOMENT	KG-M	M _L	80.0	FACTOR = (d/D)(D/Te) ^{1/2}	-	λ	1.536
TORSIONAL MOMENT	KG-M	M _T	100.0	RATIO	-	d/t	16.96
INTERNAL DESIGN PRESS.	KG/CM ² (g)	Pr	0.000	RATIO	-	Te/t	1.34
SHELL MEAN DIA (CORR.)	MM	D	615.00	SHELL ALLOWABLE STRESS	KG/CM ²	S	1406.2
SHELL THK (CORRODED)	MM	T	9.00	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	0.1400	10.00	8	0.1100	10.00	13	0.0480	10.00	18	0.1100
	20.00	4	0.0960	20.00	9	0.0700	20.00	14	0.0520	20.00	19	0.1200
	16.96	-	0.1094	16.96	-	0.0822	16.96	-	0.0508	16.96	-	0.1170
M _C	10.00	23	0.2650	10.00	27	0.1450	10.00	32	0.0960	10.00	36	0.0370
	30.00	24	0.2700	20.00	28	0.1050	30.00	33	0.1000	20.00	37	0.0860
	16.96	-	0.2667	16.96	-	0.1172	16.96	-	0.0974	16.96	-	0.0711
M _L	10.00	41	0.1500	10.00	45	0.0920	10.00	50	0.0550	10.00	54	0.1400
	30.00	42	0.1600	20.00	46	0.0740	30.00	51	0.0540	20.00	55	0.1700
	16.96	-	0.1535	16.96	-	0.0795	16.96	-	0.0547	16.96	-	0.1609

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	13.7	109.4	123.1	2	19.5	50.8	70.3
	NOZZLE	5	5.6	121.8	127.4	7	19.5	0.0	19.5
M _C	VESSEL	3	75.9	1037.2	1113.1	4	46.1	378.7	424.8
	NOZZLE	6	86.8	1443.8	1530.6	8	46.1	0.0	46.1
M _L	VESSEL	3	68.7	795.7	864.4	4	139.0	283.3	422.4
	NOZZLE	6	115.7	1051.9	1167.6	8	139.0	0.0	139.0

SHEAR STRESS DUE TO M _T	72.3	SHEAR STRESS DUE TO F _L	16.5
SHEAR STRESS DUE TO F _C	16.5	TOTAL SHEAR STRESS τ(KG/CM ²)	105.4

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	232.5	905.1	1009.0
		INNER	232.5	905.1	1009.0
	TRANSVERSE	OUTER	183.7	1146.6	1250.9
		INNER	183.7	1146.6	1250.9
NOZZLE	LONGITUDINAL	OUTER	246.9	1173.7	1304.7
		INNER	246.9	1173.7	1304.7
	TRANSVERSE	OUTER	185.2	1565.6	1664.9
		INNER	185.2	1565.6	1664.9

MAXIMUM COMBINED STRESS IN SHELL 1250.9 < 1.5*S, SAFE (Absolute values)

KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	43
	ITEM NO. : 117-EE-485		REV.	0
	DOCUMENT NO. : PRJ/9742/17		DATE	28-Feb-10
	LOCAL LOAD ANALYSIS FOR NOZZLE N3,N4		PRPD.	CHKD.
	(WRC 297)		KK	RCS

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N3,N4 NOZZLE SIZE : 100 NB LOADING CASE (A)

STRESSES AT THE EDGE OF ATTACHMENT :

RADIAL LOAD	KG	F_A	270.0	PAD THICKNESS	MM	T_p	0.00
CIRC. SHEAR LOAD	KG	F_C	400.0	$T_e = \text{SQRT}(T^2 + T_p^2)$	MM	T_e	7.00
LONG. SHEAR LOAD	KG	F_L	400.0	NOZZLE OUTSIDE DIA.	MM	d	114.30
CIRC. MOMENT	KG-M	M_C	120.0	NOZZLE THICKNESS	MM	t	4.49
LONG. MOMENT	KG-M	M_L	160.0	FACTOR = $(d/D)(D/T_e)^{1/2}$	-	λ	1.745
TORSIONAL MOMENT	KG-M	M_T	200.0	RATIO	-	d/t	25.46
INTERNAL DESIGN PRESS. $\text{KG}/\text{CM}^2(g)$		P_r	16.460	RATIO	-	T_e/t	1.56
SHELL MEAN DIA (CORR.)	MM	D	613.00	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	20.00	4	0.0820	20.00	9	0.0700	20.00	14	0.0460	20.00	19	0.1450
	30.00	5	0.0880	30.00	10	0.0900	30.00	15	0.0520	30.00	20	0.1550
	25.46	-	0.0853	25.46	-	0.0809	25.46	-	0.0493	25.46	-	0.1505
M_C	10.00	23	0.0210	20.00	28	0.1350	10.00	32	0.1500	20.00	37	0.1500
	30.00	24	0.1850	30.00	29	0.1150	30.00	33	0.1250	30.00	38	0.1700
	25.46	-	0.1477	25.46	-	0.1241	25.46	-	0.1307	25.46	-	0.1609
M_L	10.00	41	0.1600	20.00	46	0.0660	10.00	50	0.1150	20.00	55	0.2600
	30.00	42	0.1200	30.00	47	0.0740	30.00	51	0.0640	30.00	56	0.2800
	25.46	-	0.1291	25.46	-	0.0704	25.46	-	0.0756	25.46	-	0.2709

STRESS CALCULATIONS:

LOAD	PART	EQ. NO.	$\sigma_r (\text{KG}/\text{CM}^2)$			EQ. NO.	$\sigma_\theta (\text{KG}/\text{CM}^2)$		
			MEMBRANE	BENDING	TOTAL		MEMBRANE	BENDING	TOTAL
F_A	VESSEL	1	44.6	281.9	326.5	2	82.9	162.9	245.8
	NOZZLE	5	16.7	360.1	376.9	7	82.9	0.0	82.9
M_C	VESSEL	3	265.9	1899.3	2165.2	4	344.8	1680.0	2024.7
	NOZZLE	6	260.5	2677.8	2938.3	8	344.8	0.0	344.8
M_L	VESSEL	3	201.0	2212.6	2413.7	4	773.9	1295.6	2069.5
	NOZZLE	6	347.3	3912.2	4259.5	8	773.9	0.0	773.9

SHEAR STRESS DUE TO M_T	217.1	SHEAR STRESS DUE TO F_L	49.6
SHEAR STRESS DUE TO F_C	49.6	TOTAL SHEAR STRESS $\tau (\text{KG}/\text{CM}^2)$	316.3

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM^2)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	991.0	2494.6	2908.8
		INNER	991.0	2494.6	2908.8
	TRANSVERSE	OUTER	690.7	2181.3	2716.2
		INNER	690.7	2181.3	2716.2
NOZZLE	LONGITUDINAL	OUTER	1011.4	4272.3	4662.6
		INNER	1011.4	4272.3	4662.6
	TRANSVERSE	OUTER	677.6	3037.9	3349.4
		INNER	677.6	3037.9	3349.4

MAXIMUM COMBINED STRESS IN SHELL	2908.8	< 3*S, SAFE	(Absolute values)
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KIRLOSKAR PNEUMATIC CO.LTD.	EQUIPMENT: CONDENSER		PAGE	44
	ITEM NO. : 117-EE-485		REV.	0
	DOCUMENT NO. : PR/J/9742/17		DATE	28-Feb-10
	LOCAL LOAD ANALYSIS FOR NOZZLE N3,N4		PRPD.	CHKD.
	(WRC 297)		KK	RCS

LOCAL LOAD ANALYSIS FOR EXTERNAL LOADINGS ON CYLINDRICAL SHELL (AS PER WRC 297)
FOR NOZZLE : N3,N4 NOZZLE SIZE : 100 NB LOADING CASE (B)

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	114.30
CIRC. MOMENT	KG-M	M_c	60.0	NOZZLE THICKNESS	MM	t	4.49
LONG. MOMENT	KG-M	M_L	80.0	FACTOR = $(d/D)(D/T_e)^{1/2}$	-	λ	1.745
TORSIONAL MOMENT	KG-M	M_T	100.0	RATIO	-	d/t	25.46
INTERNAL DESIGN PRESS.	KG/CM ² (g)	P_r	0.000	RATIO	-	T_e/t	1.56
SHELL MEAN DIA (CORR.)	MM	D	613.00	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	20.00	4	0.0820	20.00	9	0.0700	20.00	14	0.0460	20.00	19	0.1450
	30.00	5	0.0880	30.00	10	0.0900	30.00	15	0.0520	30.00	20	0.1550
	25.46	-	0.0853	25.46	-	0.0809	25.46	-	0.0493	25.46	-	0.1505
M_c	10.00	23	0.0210	20.00	28	0.1350	10.00	32	0.1500	20.00	37	0.1500
	30.00	24	0.1850	30.00	29	0.1150	30.00	33	0.1250	30.00	38	0.1700
	25.46	-	0.1477	25.46	-	0.1241	25.46	-	0.1307	25.46	-	0.1609
M_L	10.00	41	0.1600	20.00	46	0.0660	10.00	50	0.1150	20.00	55	0.2600
	30.00	42	0.1200	30.00	47	0.0740	30.00	51	0.0640	30.00	56	0.2800
	25.46	-	0.1291	25.46	-	0.0704	25.46	-	0.0756	25.46	-	0.2709

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	22.3	141.0	163.3	2	41.5	81.5	122.9
	NOZZLE	5	8.4	180.1	188.4	7	41.5	0.0	41.5
M_c	VESSEL	3	132.9	949.7	1082.6	4	172.4	840.0	1012.4
	NOZZLE	6	130.2	1338.9	1469.1	8	172.4	0.0	172.4
M_L	VESSEL	3	100.5	1106.3	1206.8	4	387.0	647.8	1034.8
	NOZZLE	6	173.6	1956.1	2129.7	8	387.0	0.0	387.0

SHEAR STRESS DUE TO M_T	108.5	SHEAR STRESS DUE TO F_L	24.8
SHEAR STRESS DUE TO F_c	24.8	TOTAL SHEAR STRESS τ (KG/CM ²)	158.1

COMBINED STRESS CALCULATIONS:

PART	PLANE	SURFACE	STRESS (KG/CM ²)		
			MEMBRANE	BENDING	TOTAL
VESSEL	LONGITUDINAL	OUTER	495.5	1247.3	1454.4
		INNER	495.5	1247.3	1454.4
	TRANSVERSE	OUTER	345.4	1090.6	1358.1
		INNER	345.4	1090.6	1358.1
NOZZLE	LONGITUDINAL	OUTER	505.7	2136.2	2331.3
		INNER	505.7	2136.2	2331.3
	TRANSVERSE	OUTER	338.8	1519.0	1674.7
		INNER	338.8	1519.0	1674.7

MAXIMUM COMBINED STRESS IN SHELL 1454.4 < 1.5*S, SAFE (Absolute values)