

TO: AUTHORIZED INSPECTOR
HSB CT.

DATE: 03-DEC-04

SUBJECT: TRANSMITTAL OF ASME SUBMITTAL CALCULATIONS FOR A.I. ACCEPTANCE

GENTLEMEN:

ATTACHED ARE ASME PRESSURE VESSEL CODE CALCULATIONS ACCORDING TO THE 2001 EDITION, 2003 ADDENDA OF SECTION VIII, DIVISION 1, OF THE ASME CODE. THE CALCULATIONS SUPPORT THE DESIGN OF THE FOLLOWING VESSEL.

ASSEMBLY DRAWING -----	SALES ORDER -----	CUSTOMER -----
15772A REV A	509.1	AL-DEUTSCHLAND

LOADINGS LISTED IN UG-22 HAVE BEEN CONSIDERED IN THE DESIGN OF THE VESSEL AND THE CUSTOMER ADVISED OF THE MAXIMUM LOADS THAT MAY BE APPLIED. YOUR ACCEPTANCE OF THESE CALCULATIONS AND THE VESSEL DESIGN AS MEETING THE MINIMUM REQUIREMENTS OF THE ASME CODE, SECTION VIII, DIV. 1, IS RESPECTFULLY REQUESTED. PLEASE ACKNOWLEDGE YOUR ACCEPTANCE BY SIGNING AND DATING THIS FORM IN THE SPACE PROVIDED.


BEST REGARDS,



PRODUCT ENGINEERING
CHART HEAT EXCHANGERS

A.I. ACCEPTANCE

I HAVE REVIEWED THE CALCULATIONS AND THE ABOVE LISTED DRAWING. IN MY OPINION THIS DESIGN DOES MEET THE MINIMUM REQUIREMENTS OF THE ASME CODE SECTION VIII, DIV. 1

 12-27-04

AUTHORIZED INSPECTOR DATE
HSB CT.

SUBJECT: ASME SUBMITTAL CALCULATIONS PER THE 2001 EDITION,
2003 ADDENDA OF SECTION VIII, DIVISION 1.

CUSTOMER: AL-DEUTSCHLAND
SALES ORDER: 509.1
ASSEMBLY DRAWING: 15772A REV A
ITEM: W21001

DESIGN BASIS:

- CODE JURISDICTION ENDS AT FIRST NOZZLE CIRCUMFERENTIAL WELD JOINT.
- MAXIMUM DESIGN TEMPERATURE= 150. DEGREES F
- CORROSION ALLOWANCE: NONE
- ASME CODE REQUIRED RADIOGRAPHY:

NONE.

FIN DESIGN:

THE MAXIMUM ALLOWABLE DESIGN PRESSURE OF THE FINS USED IN THIS HEAT EXCHANGER MEET OR EXCEED THE STREAM DESIGN PRESSURE. THE RATINGS WERE CALCULATED PER PARAGRAPH U-2(G). THE PROPRIETARY CALCULATION METHOD WAS APPROVED BY CHART AND REVIEWED AND ACCEPTED BY HSB CT.

PIPING DESIGN:

CONNECTION	HEADER			NOZZLE			DESIGN PRESSURE P.S.I.G.
	O.D.	X WALL	X MATERIAL	O.D.	X WALL	X MATERIAL	
	IN.	X IN.		IN.	X IN.		
A IN	16.000	0.375	SB-209-5083	14.000	0.375	SB-209-5083	149.
A OUT	12.750	0.375	SB-209-5083	10.750	0.365	SB-241-5083	149.
A VENT				1.315	0.133	SB-241-5083	149.

NOTE: PER UG-36(C)(3)(a), REINFORCEMENT CALCULATIONS ARE NOT
MADE FOR 2" NPS NOZZLES OR SMALLER.

NOTE: DESIGN PRESSURE INCREASED BY A FACTOR OF 1.50/1.10 TO ACCOUNT FOR
ELEVATED PNEUMATIC TEST PRESSURE.

CALCULATIONS SUBMITTED BY:



PRODUCT ENGINEERING
CHART HEAT EXCHANGERS

CHECKED BY:



PRODUCT ENGINEERING
CHART HEAT EXCHANGERS

Reviewed

TÜV Süddeutschland Bau und Betrieb GmbH

Notified body acc. to Pressure

Equipment Directive 97/23/EC

Testing Laboratory FEB 01 2005



HEADER OPENING AND REINFORCING CALCULATION
PER ASME SECTION VIII, DIV 1., PAR UG-36,UG-40,AND UG-42
(NOZZLE ABUTTS THE HEADER BODY, REF FIG UW-16.1(a))

STREAM	A IN
DESIGN PRESSURE (P)	149. PSIG
HEADER SIZE (O.D.)	16.000 INCHES
MATERIAL	SB-209-5083-0
ALLOWABLE STRESS (S)	11400. PSI
WALL THICKNESS (T)	0.375 INCHES
INSIDE RADIUS (R)	7.625 INCHES
MINIMUM HEADER THICKNESS (UG-27)	
TR=PR/(SE-.6P) (E=1.0 REFERENCE NOTE (4))	0.100 INCHES
NOZZLE SIZE (O.D.)	14.000 INCHES
MATERIAL	SB-209-5083-0
ALLOWABLE STRESS (S)	11400. PSI
WALL THICKNESS (TN)	0.375 INCHES
INSIDE DIAMETER (D)	13.250 INCHES
INSIDE RADIUS (R)	6.625 INCHES
MINIMUM NOZZLE THICKNESS	
TRN=PR/(SE-.6P) (E=1.0 REFERENCE NOTE (4))	0.087 INCHES
HEADER/NOZZLE WELD JOINT	
MIN. WELD LEG =SMALLER OF (T), (TN) OR .25/.707	0.354 INCHES
ACTUAL WELD LEG (W)	0.375 INCHES

REINFORCEMENT CALCULATION UG-37

AVAILABLE AREA	
SHELL: LARGER OF: (NOTE 1)	E1=1.00
A1A $D(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	
A1B $2(T + TN)(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	3.638 IN2
NOZZLE: SMALLER OF:	
5(TN-TRN)(FR2)(T) OR	
A2 5(TN-TRN)(FR2)(TN)	0.539 IN2
ADDITIONAL AREA IF USED (RE-PAD OR INWARD NOZZLE)	
A3 (DP-D-2TN)TE(FR4) OR 2(TN)FR2*H	0.000 IN2
WELD AREA	
A4 $W \cdot W \cdot (FR2)$	0.141 IN2
ATOT $ATOT = A1 + A2 + A3 + A4$	4.318 IN2
REQUIRED AREA	
AREQ $AREQ = D \cdot TR \cdot F + 2 \cdot TN \cdot TR \cdot F(1 - FR1)$ (F=1.0)	1.331 IN2

REINFORCEMENT CALCULATION APPENDIX (1-7a). (NOTE 2) $R_n/R = 0.87$

A1(1-7) = LARGER OF A1(1-7)A OR A1(1-7)B	
A1(1-7)A $.5 \cdot D(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	
A1(1-7)B $2(T + TN)(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	1.819 IN2
ATOT(1-7) = A1(1-7) + A2 + A3 + A4	2.499 IN2
AREQ(1-7) = (2/3) X AREQ	0.887 IN2

- (1) E1 NORMALLY EQUALS 1.0. WHEN THE NOZZLE PASSES THROUGH A CATEGORY A WELD JOINT E1 IS TAKEN FROM TABLE UW-12.
- (2) REFERENCE PAR. UG-36(B-1). THIS CALCULATION IS REQUIRED WHEN THE OPENING IS GREATER THAN HALF THE HEADER I.D. OR THE OPENING EXCEEDS 20 INCHES.
- (3) FR1=1.0 OR SN/SV FOR INSERTED NOZZLES.
FR2=SN/SV, FR3=(LESSER OF SN OR SP)/SV, FR4=SP/SV.
- (4) TR & TRN ARE BASED ON SEAMLESS MATERIAL PER DEFINITIONS IN UG-37.

EUR HAWK
Belongs to the Main Drawing.
Prüfvermerk vom / Review dates

FEB 01 2005

T. K.

HEADER OPENING AND REINFORCING CALCULATION
PER ASME SECTION VIII, DIV 1., PAR UG-36,UG-40,AND UG-42
(NOZZLE ABUTTS THE HEADER BODY, REF FIG UW-16.1(a))

STREAM	A OUT
DESIGN PRESSURE (P)	149. PSIG
HEADER SIZE (O.D.)	12.750 INCHES
MATERIAL	SB-209-5083-0
ALLOWABLE STRESS (S)	11400. PSI
WALL THICKNESS (T)	0.375 INCHES
INSIDE RADIUS (R)	6.000 INCHES
MINIMUM HEADER THICKNESS (UG-27)	
TR=PR/(SE-.6P) (E=1.0 REFERENCE NOTE (4))	0.079 INCHES
NOZZLE SIZE (O.D.)	10.750 INCHES
MATERIAL	SB-241-5083-0
ALLOWABLE STRESS (S)	10700. PSI
WALL THICKNESS (TN)	0.365 INCHES
INSIDE DIAMETER (D)	10.020 INCHES
INSIDE RADIUS (R)	5.010 INCHES
MINIMUM NOZZLE THICKNESS	
TRN=PR/(SE-.6P) (E=1.0 REFERENCE NOTE (4))	0.070 INCHES
HEADER/NOZZLE WELD JOINT	
MIN. WELD LEG =SMALLER OF (T), (TN) OR .25/.707	0.354 INCHES
ACTUAL WELD LEG (W)	0.365 INCHES

REINFORCEMENT CALCULATION UG-37

AVAILABLE AREA	
SHELL: LARGER OF: (NOTE 1)	E1=1.00
A1A $D(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	
A1B $2(T + TN)(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	2.966 IN2
NOZZLE: SMALLER OF:	
5(TN-TRN)(FR2)(T) OR	
A2 $5(TN-TRN)(FR2)(TN)$	0.505 IN2
ADDITIONAL AREA IF USED (RE-PAD OR INWARD NOZZLE)	
A3 $(DP-D-2TN)TE(FR4) \text{ OR } 2(TN)FR2 \cdot H$	0.000 IN2
WELD AREA	
A4 $W \cdot W \cdot (FR2)$	0.125 IN2
ATOT $ATOT = A1 + A2 + A3 + A4$	3.595 IN2
REQUIRED AREA	
AREQ $= D \cdot TR \cdot F + 2 \cdot TN \cdot TR \cdot F(1 - FR1) \quad (F=1.0)$	0.792 IN2

REINFORCEMENT CALCULATION APPENDIX (1-7a). (NOTE 2) $R_n/R = 0.84$

A1(1-7) = LARGER OF A1(1-7)A OR A1(1-7)B	
A1(1-7)A $.5 \cdot D(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	
A1(1-7)B $2(T + TN)(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	1.483 IN2
ATOT(1-7) = A1(1-7) + A2 + A3 + A4	2.113 IN2
AREQ(1-7) = (2/3) X AREQ	0.528 IN2

- (1) E1 NORMALLY EQUALS 1.0. WHEN THE NOZZLE PASSES THROUGH A CATEGORY A WELD JOINT E1 IS TAKEN FROM TABLE UW-12.
- (2) REFERENCE PAR. UG-36(B-1). THIS CALCULATION IS REQUIRED WHEN THE OPENING IS GREATER THAN HALF THE HEADER I.D. OR THE OPENING EXCEEDS 20 INCHES.
- (3) $FR1 = 1.0$ OR SN/SV FOR INSERTED NOZZLES.
 $FR2 = SN/SV$, $FR3 = (\text{LESSER OF } SN \text{ OR } SP)/SV$, $FR4 = SP/SV$.
- (4) TR & TRN ARE BASED ON SEAMLESS MATERIAL PER DEFINITIONS IN UG-37.

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:

FEB 01 2005

[Signature]

HEADER AND NOZZLE WALL THICKNESS CALCULATIONS PER APPENDIX 1, PAR. 1-1(a)(1)

NOTE: ALL NOZZLES ARE A MINIMUM OF STD WALL WHICH SATISFIES UG-45(b) REQUIREMENTS

A IN HEADER 16.000 O.D. X 0.375 WALL X SB-209-5083-0 WITH BACKING STRIPS
----- NOZZLE 14.000 O.D. X 0.375 WALL X SB-209-5083-0 TYPE (2) BUTT JOINT
 DESIGN PRESSURE = 149. PSIG.

$$\begin{aligned} T \text{ REQ. (HEADER)} &= \frac{149. \text{ PSIG} \times 8.000 \text{ INCHES}}{11400. \text{ PSI} \times 0.65 + .4 \times 149. \text{ PSIG}} = 0.160 \text{ INCHES} \end{aligned}$$

MINIMUM HEADER THICKNESS = 0.375 INCHES - 0.023 INCH M.T. = 0.352 INCHES

$$\begin{aligned} T \text{ REQ. (NOZZLE)} &= \frac{149. \text{ PSIG} \times 7.000 \text{ INCHES}}{11400. \text{ PSI} \times 0.65 + .4 \times 149. \text{ PSIG}} = 0.140 \text{ INCHES} \end{aligned}$$

MINIMUM NOZZLE THICKNESS = 0.375 INCHES - 0.023 INCH M.T. = 0.352 INCHES
NOZZLE WALL MACHINED TO 0.250 INCHES > 0.140 INCHES REQUIRED

A OUT HEADER 12.750 O.D. X 0.375 WALL X SB-209-5083-0 WITH BACKING STRIPS
----- NOZZLE 10.750 O.D. X 0.365 WALL X SB-241-5083-0 SEAMLESS
 DESIGN PRESSURE = 149. PSIG.

$$\begin{aligned} T \text{ REQ. (HEADER)} &= \frac{149. \text{ PSIG} \times 6.375 \text{ INCHES}}{11400. \text{ PSI} \times 0.65 + .4 \times 149. \text{ PSIG}} = 0.127 \text{ INCHES} \end{aligned}$$

MINIMUM HEADER THICKNESS = 0.375 INCHES - 0.023 INCH M.T. = 0.352 INCHES

$$\begin{aligned} T \text{ REQ. (NOZZLE)} &= \frac{149. \text{ PSIG} \times 5.375 \text{ INCHES}}{10700. \text{ PSI} \times 1.00 + .4 \times 149. \text{ PSIG}} = 0.074 \text{ INCHES} \end{aligned}$$

MINIMUM NOZZLE THICKNESS = 0.365 INCHES X .875 = 0.319 INCHES
NOZZLE WALL MACHINED TO 0.158 INCHES > 0.074 INCHES REQUIRED

A VENT NOZZLE 1.315 O.D. X 0.133 WALL X SB-241-5083-0 SEAMLESS
----- DESIGN PRESSURE = 149. PSIG

$$\begin{aligned} T \text{ REQ. (NOZZLE)} &= \frac{149. \text{ PSIG} \times 0.658 \text{ INCHES}}{10700. \text{ PSI} \times 1.00 + .4 \times 149. \text{ PSIG}} = 0.009 \text{ INCHES} \end{aligned}$$

MINIMUM NOZZLE THICKNESS = 0.133 INCHES X .875 = 0.116 INCHES

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:
FEB 01 2005 TJC

ASME REQUIREMENTS FOR ALUMINUM FLAT UNSTAYED DISKS

DISK DESIGN FOR A IN NOZZLE 14.000 INCH O.D. BY 0.375 INCH WALL

DESIGN PRESSURE = 149. PSIG
OUTSIDE DIAMETER OF PIPE = 14.000 INCHES
WALL THICKNESS OF PIPE = 0.375 INCHES
INSIDE DIAMETER OF PIPE (D) = 13.250 INCHES
PIPE MATERIAL = SB-209-5083-0 ALUMINUM
ALLOWABLE STRESS OF PIPE = 11400. PSI
DISK MATERIAL = SB-209-5083-0 ALUMINUM
ALLOWABLE STRESS OF DISK = 11400. PSI
THE DISK IS WELDED WITH A BACKING RING.

FACTOR FOR HEAD ATTACHMENT (C) = .33 PER FIG UG-34(H)
JOINT EFFICIENCY (E) = 1.0 FOR SEAMLESS DISKS

PER UG-34(C) (2), SECTION VIII, DIVISION 1, OF THE ASME CODE:

$$T_{MIN}(1) = D \cdot \text{SQRT OF } (C/P/SE) = 0.870 \text{ INCHES}$$

PER FIG UW-13.2(C): $T_{MIN}(2) = TP + B$

WHERE: TP = THE SMALLER OF TN OR .25
B = TN FOR DISKS BEVELED AT A 45 DEGREE ANGLE

$$T_{MIN}(2) = 0.625 \text{ INCHES}$$

WHEN A DISK CLOSURE IS USED A CHECK MUST BE MADE ON THE REQUIRED PIPE WALL THICKNESS. TO COMPLY WITH FIG UG-34(H), A NOZZLE THICKNESS OF 1.25(TR) IS REQUIRED.

PER UG-27(C) (1):

$$TR = PR / (SE - .6P)$$

THUS THE MINIMUM REQUIRED NOZZLE THICKNESS IS:

$$TR = 1.25PR / (SE - .6P) = 0.109 \text{ INCHES}$$

$$\text{MINIMUM NOZZLE THICKNESS} = 0.375 \text{ INCHES} - 0.023 \text{ INCH M.T.} = 0.352 \text{ INCHES}$$

SINCE THE DISK THICKNESS 0.945 IN. (1.000 IN - 0.055 IN M.T.), MEETS OR EXCEEDS $T_{MIN}(1)$ AND $T_{MIN}(2)$ AND THE ACTUAL PIPE WALL THICKNESS EXCEEDS 1.25(TR) THE DESIGN MEETS THE MINIMUM REQUIREMENTS OF THE ASME CODE.

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:
FEB 01 2005 7/2

ASME REQUIREMENTS FOR ALUMINUM FLAT UNSTAYED DISKS

DISK DESIGN FOR A OUT NOZZLE 10.750 INCH O.D. BY 0.365 INCH WALL

DESIGN PRESSURE = 149. PSIG
OUTSIDE DIAMETER OF PIPE = 10.750 INCHES
WALL THICKNESS OF PIPE = 0.365 INCHES
INSIDE DIAMETER OF PIPE (D) = 10.020 INCHES
PIPE MATERIAL = SB-241-5083-0 ALUMINUM
ALLOWABLE STRESS OF PIPE = 10700. PSI
DISK MATERIAL = SB-209-5083-0 ALUMINUM
ALLOWABLE STRESS OF DISK = 11400. PSI
THE DISK IS WELDED WITH A BACKING RING.

FACTOR FOR HEAD ATTACHMENT (C) = .33 PER FIG UG-34(H)
JOINT EFFICIENCY (E) = 1.0 FOR SEAMLESS DISKS

PER UG-34(C) (2), SECTION VIII, DIVISION 1, OF THE ASME CODE:

$$T_{MIN}(1) = D \cdot \text{SQUARE ROOT OF } (C/P/SE) = 0.658 \text{ INCHES}$$

PER FIG UW-13.2(C): $T_{MIN}(2) = TP + B$

WHERE: TP = THE SMALLER OF TN OR .25
B = TN FOR DISKS BEVELED AT A 45 DEGREE ANGLE

$$T_{MIN}(2) = 0.615 \text{ INCHES}$$

WHEN A DISK CLOSURE IS USED A CHECK MUST BE MADE ON THE REQUIRED PIPE WALL THICKNESS. TO COMPLY WITH FIG UG-34(H), A NOZZLE THICKNESS OF 1.25(TR) IS REQUIRED.

PER UG-27(C) (1):

$$TR = PR / (SE - .6P)$$

THUS THE MINIMUM REQUIRED NOZZLE THICKNESS IS:

$$TR = 1.25PR / (SE - .6P) = 0.088 \text{ INCHES}$$

$$\text{MINIMUM NOZZLE THICKNESS} = 0.365 \text{ INCHES} \times .875 = 0.319 \text{ INCHES}$$

SINCE THE DISK THICKNESS 0.707 IN. (0.750 IN - 0.043 IN M.T.), MEETS OR EXCEEDS $T_{MIN}(1)$ AND $T_{MIN}(2)$ AND THE ACTUAL PIPE WALL THICKNESS EXCEEDS 1.25(TR) THE DESIGN MEETS THE MINIMUM REQUIREMENTS OF THE ASME CODE.

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:
FEB 01 2005 T.K.

MINIMUM ASME THICKNESS REQUIREMENTS FOR ALUMINUM FLATENDS:

FLATEND DESIGN FOR A IN HEADER 16.000 INCH O.D. BY 0.375 INCH WALL

TWO SETS OF CRITERIA MUST BE MET WHEN ATTACHING UNSTAYED FLATENDS TO HEADERS.

THE FIRST IS FOUND IN SECTION VIII, PARA. UG-34(C) (3)
WHICH YIELDS THE FORMULA:

$$T = d \cdot \text{SQARE ROOT OF}(ZCP/SE)$$

WHERE:

d = SHORT SPAN OF A FLAT HEAD (RAD/COS 45) = 10.780 INCHES
D = LONG SPAN OF A FLAT HEAD (THE DIAMETER) = 15.250 INCHES
C = HEAD ATTACHMENT FACTOR WHICH = .33m PER FIGURE UG-34(E)
m = tr/ts BUT CONSERVATIVELY SET AT 1.0 THUS C = .33
E = JOINT EFFICIENCY FOR CATEGORY A WELDS; THE PLATE IS
SEAMLESS SO E = 1.0
P = DESIGN PRESSURE = 149. PSIG
S = MAXIMUM ALLOWABLE ASME STRESS VALUE (PSI)

FOR SB-209-5083-0 ALUMINUM S = 11400. PSI

$$Z = 3.4 - (2.4 \cdot d/D)$$

$$\text{HENCE } Z = 3.4 - (2.4 \cdot 10.780/15.250) = 1.70$$

THEREFORE, TMIN, BASED ON THE ABOVE CRITERIA IS:

$$T_{\text{MIN}} = d \cdot \text{SQARE ROOT OF}(Z \cdot .33 \cdot P/SE) = 0.924 \text{ INCHES}$$

THE SECOND CRITERIA IS BASED ON FIGURE UG-34(E) WHICH SPECIFIES THE
FLATEND MUST EXTEND BEYOND THE HEADER BY A DISTANCE NO LESS THAN THE
THICKNESS OF THE SHELL (TS). DESIGN PRACTICE IS TO SELECT A NOMINAL
PLATE THICKNESS OF AT LEAST (TS+.125 IN) TO ALLOW SOME INSERTION OF THE
FLATEND INTO THE HEADER BODY.

THEREFORE THE MINIMUM NOMINAL PLATE THICKNESS IS:

$$T(\text{SHELL}) + 0.125 = 0.500 \text{ INCHES}$$

THE MINIMUM FLATEND THICKNESS 0.945 IN. (1.000 IN NOM.- 0.055 IN M.T.)
MEETS OR EXCEEDS TMIN THEREFORE THE DESIGN MEETS THE MINIMUM REQUIREMENTS
OF THE ASME CODE.

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfer/Reviewer: / Review date:

FEB 01 2005

T.R.

MINIMUM ASME THICKNESS REQUIREMENTS FOR ALUMINUM FLATENDS:

FLATEND DESIGN FOR A OUT HEADER 12.750 INCH O.D. BY 0.375 INCH WALL

TWO SETS OF CRITERIA MUST BE MET WHEN ATTACHING UNSTAYED FLATENDS TO HEADERS.

THE FIRST IS FOUND IN SECTION VIII, PARA. UG-34(C)(3)
WHICH YIELDS THE FORMULA:

$$T = d \cdot \text{SQUARE ROOT OF } (ZCP/SE)$$

WHERE:

d = SHORT SPAN OF A FLAT HEAD (RAD/COS 45) = 8.490 INCHES
D = LONG SPAN OF A FLAT HEAD (THE DIAMETER) = 12.000 INCHES
C = HEAD ATTACHMENT FACTOR WHICH = .33m PER FIGURE UG-34(E)
m = tr/ts BUT CONSERVATIVELY SET AT 1.0 THUS C = .33
E = JOINT EFFICIENCY FOR CATEGORY A WELDS; THE PLATE IS
SEAMLESS SO E = 1.0
P = DESIGN PRESSURE = 149. PSIG
S = MAXIMUM ALLOWABLE ASME STRESS VALUE (PSI)

FOR SB-209-5083-0 ALUMINUM S = 11400. PSI

$$Z = 3.4 - (2.4 \cdot d/D)$$

$$\text{HENCE } Z = 3.4 - (2.4 \cdot 8.490/12.000) = 1.70$$

THEREFORE, TMIN, BASED ON THE ABOVE CRITERIA IS:

$$T_{\text{MIN}} = d \cdot \text{SQUARE ROOT OF } (Z \cdot .33 \cdot P/SE) = 0.727 \text{ INCHES}$$

THE SECOND CRITERIA IS BASED ON FIGURE UG-34(E) WHICH SPECIFIES THE
FLATEND MUST EXTEND BEYOND THE HEADER BY A DISTANCE NO LESS THAN THE
THICKNESS OF THE SHELL (TS). DESIGN PRACTICE IS TO SELECT A NOMINAL
PLATE THICKNESS OF AT LEAST (TS+.125 IN) TO ALLOW SOME INSERTION OF THE
FLATEND INTO THE HEADER BODY.

THEREFORE THE MINIMUM NOMINAL PLATE THICKNESS IS:

$$T(\text{SHELL}) + 0.125 = 0.500 \text{ INCHES}$$

THE MINIMUM FLATEND THICKNESS 0.945 IN. (1.000 IN NOM.- 0.055 IN M.T.)
MEETS OR EXCEEDS TMIN THEREFORE THE DESIGN MEETS THE MINIMUM REQUIREMENTS
OF THE ASME CODE.

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:

FEB 01 2005

SUBJECT: EXTERNAL PRESSURE CALCULATIONS FOR THE FINS AND PIPING

CUSTOMER: AL-DEUTSCHLAND
SALES ORDER: 509.1
ASSEMBLY DRAWING: 15772A REV A
ITEM: W21001

DESIGN BASIS:

- CODE JURISDICTION ENDS AT FIRST NOZZLE CIRCUMFERENTIAL WELD JOINTS PAST THE HEADER TO NOZZLE JOINTS.
- DESIGN PRESSURES: A STREAM = 149. PSIG (INTERNAL PRESSURE)
A STREAM = 44. PSIG (EXTERNAL PRESSURE)
B STREAM = NO DIFFERENTIAL PRESSURE

FIN DESIGN (EXTERNAL PRESSURE):

TO ESTABLISH THE MAXIMUM WORKING PRESSURE OF FINS, NUMEROUS FINS WERE EXTERNALLY PRESSURE TESTED TO FAILURE. A CORRELATION WAS DERIVED TO PREDICT THE FAILURE PRESSURE OF ALL FINS. FOR FINS WHICH HAVE BEEN CRUSH TESTED, RATINGS ARE DETERMINED BY DIVIDING THE CRUSH PRESSURES BY 3 AS SPECIFIED IN UG-101(P). OTHER FINS ARE RATED BY DIVIDING THE PREDICTED CRUSH PRESSURE BY 3 AND THEN MULTIPLYING BY A .88 SAFETY FACTOR.

FIN SUMMARY:

STREAM	FIN DIE#	FIN TYPE	FIN HEIGHT	FIN THICK	FINS PER IN	MAXIMUM EXTERNAL WORKING PRESSURE (PSIG)	EXTERNAL DESIGN PRESSURE (PSIG)
A	CT-7132	5.0% PERF	.250	.0100	25.0	344.	> 44.
A	CT-7106	5.0% PERF	.250	.0160	8.0	306.	> 44.

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:

FEB 01 2005

TR

CALCULATIONS FOR EXTERNAL PRESSURE PER ASME SECTION II, PART D, SUBPART 3

CONNECTION		O.D. X WALL X MATERIAL	COMPONENT	CORROSION ALLOWANCE	MILL TOL	MIN. CORR WALL
		IN. X IN.		IN.	IN.	IN.
A IN	HDR	16.000	0.375 SB-209-5083-0	.0000	.023	0.352
A IN	NOZ	14.000	0.375 SB-209-5083-0	.0000	.023	0.352
A OUT	HDR	12.750	0.375 SB-209-5083-0	.0000	.023	0.352
A OUT	NOZ	10.750	0.365 SB-241-5083-0	.0000	12.5 %	0.319
A VENT	NOZ	1.315	0.133 SB-241-5083-0	.0000	12.5 %	0.116

* OUTSIDE ASME SECTION VIII JURISDICTION BUT INCLUDED FOR REFERENCE ONLY.

EXTERNAL PRESSURE CALCULATIONS

PIPE		O.D. (Do)	MIN. CORR. (T)	CHART	Do/T	MAX L	L/Do	FACTOR A*	FACTOR B	MAX EXTERNAL PRESSURE (Pa)****	DESIGN PRESS PSIG
A IN	HDR	16.000	0.352	NFA-11-1	45.45	89.	5.5	.000684	3453.	101.>	44.
A IN	NOZ	14.000	0.352	NFA-11-1	39.77	***	50.0	.000751	3732.	125.>	44.
A OUT	HDR	12.750	0.352	NFA-11-1	36.22	89.	6.9	.000912	4344.	160.>	44.
A OUT	NOZ	10.750	0.319	NFA-11-3	33.66	***	50.0	.001049	4166.	165.>	44.
A VENT	NOZ	1.315	0.116	NFA-11-3	11.30	***	50.0	.009307	7436.	877.>	44.

* FROM FIG. G FROM SECTION II PART D

*** LENGTH UNKNOWN. DEPENDENT ON EXTERNAL PIPING SO MAXIMUM L/Do RATIO USED; L/Do=50

**** PER UG-28 (C) (1): $P_a = \frac{4 \cdot B}{3 \cdot (D_o/T)}$

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:
FEB 01 2005

TR

HEADER OPENING AND REINFORCING CALCULATION (FOR EXTERNAL PRESSURE)
PER ASME SECTION VIII, DIV 1., PAR UG-36,UG-40,AND UG-42
(NOZZLE ABUTTS THE HEADER BODY, REF FIG UW-16.1(a))

STREAM	A IN	
EXTERNAL DESIGN PRESSURE (P)		44. PSIG
HEADER SIZE (O.D.)		16.000 INCHES
HEADER LENGTH		88.51 INCHES
MATERIAL		SB-209-5083-0
ALLOWABLE STRESS (S)		11400. PSI
WALL THICKNESS (T)		0.375 INCHES
INSIDE RADIUS (R)		7.625 INCHES
MINIMUM HEADER THICKNESS PER (ASME SECT. II, SUBPART 3)		
TR (E=1.0 REFERENCE NOTE (4))		0.251 INCHES
NOZZLE SIZE (O.D.)		14.000 INCHES
NOZZLE LENGTH (NOTE 5)		0.00 INCHES
MATERIAL		SB-209-5083-0
ALLOWABLE STRESS (S)		11400. PSI
WALL THICKNESS (TN)		0.375 INCHES
INSIDE DIAMETER (D)		13.250 INCHES
INSIDE RADIUS (R)		6.625 INCHES
MINIMUM NOZZLE THICKNESS PER (ASME SECT. II, SUBPART 3)		
TRN (E=1.0 REFERENCE NOTE (4))		0.245 INCHES
HEADER/NOZZLE WELD JOINT		
MIN. WELD LEG =SMALLER OF (T), (TN) OR .25/.707		0.354 INCHES
ACTUAL WELD LEG (W)		0.375 INCHES

REINFORCEMENT CALCULATION UG-37

AVAILABLE AREA	
SHELL: LARGER OF: (NOTE 1)	E1=1.00
A1A $D(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	
A1B $2(T + TN)(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	1.644 IN2
NOZZLE: SMALLER OF:	
5(TN - TRN)(FR2)(T) OR	
A2 $5(TN - TRN)(FR2)(TN)$	0.244 IN2
ADDITIONAL AREA IF USED (RE-PAD OR INWARD NOZZLE)	
A3 $(DP - D - 2TN)TE(FR4) \text{ OR } 2(TN)FR2 \cdot H$	0.000 IN2
WELD AREA	
A4 $W \cdot W \cdot (FR2)$	0.141 IN2
ATOT $ATOT = A1 + A2 + A3 + A4$	2.029 IN2
REQUIRED AREA	
AREQ $= .5 \cdot D \cdot TR \cdot F + 2 \cdot TN \cdot TR \cdot F(1 - FR1) \quad (F=1.0)$	1.662 IN2

REINFORCEMENT CALCULATION APPENDIX (1-7a). (NOTE 2) $R_n/R = 0.87$

A1(1-7) = LARGER OF A1(1-7)A OR A1(1-7)B	
A1(1-7)A $.5 \cdot D(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	
A1(1-7)B $2(T + TN)(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	0.822 IN2
ATOT(1-7) = A1(1-7) + A2 + A3 + A4	1.207 IN2
AREQ(1-7) = (2/3) X AREQ	1.108 IN2

- (1) E1 NORMALLY EQUALS 1.0.
- (2) REFERENCE PAR. UG-36(B-1). THIS CALCULATION IS REQUIRED WHEN THE OPENING IS GREATER THAN HALF THE HEADER I.D. OR THE OPENING EXCEEDS 20 INCHES.
- (3) $FR1 = 1.0$ OR SN/SV FOR INSERTED NOZZLES.
 $FR2 = SN/SV$, $FR3 = (\text{LESSER OF } SN \text{ OR } SP)/SV$, $FR4 = SP/SV$.
- (4) TR & TRN ARE BASED ON SEAMLESS MATERIAL PER DEFINITIONS IN UG-37.
- (5) IF LENGTH=0 (NOT DEFINED) THE MAXIMUM L/Do RATIO IS USED; L/Do=50.

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:

FEB 01 2005

TK

HEADER OPENING AND REINFORCING CALCULATION (FOR EXTERNAL PRESSURE)
PER ASME SECTION VIII, DIV 1., PAR UG-36,UG-40,AND UG-42
(NOZZLE ABUTTS THE HEADER BODY, REF FIG UW-16.1(a))

STREAM	A OUT
EXTERNAL DESIGN PRESSURE (P)	44. PSIG
HEADER SIZE (O.D.)	12.750 INCHES
HEADER LENGTH	88.51 INCHES
MATERIAL	SB-209-5083-0
ALLOWABLE STRESS (S)	11400. PSI
WALL THICKNESS (T)	0.375 INCHES
INSIDE RADIUS (R)	6.000 INCHES
MINIMUM HEADER THICKNESS PER (ASME SECT. II, SUBPART 3)	
TR (E=1.0 REFERENCE NOTE (4))	0.216 INCHES
NOZZLE SIZE (O.D.)	10.750 INCHES
NOZZLE LENGTH (NOTE 5)	0.00 INCHES
MATERIAL	SB-241-5083-0
ALLOWABLE STRESS (S)	10700. PSI
WALL THICKNESS (TN)	0.365 INCHES
INSIDE DIAMETER (D)	10.020 INCHES
INSIDE RADIUS (R)	5.010 INCHES
MINIMUM NOZZLE THICKNESS PER (ASME SECT. II, SUBPART 3)	
TRN (E=1.0 REFERENCE NOTE (4))	0.188 INCHES
HEADER/NOZZLE WELD JOINT	
MIN. WELD LEG =SMALLER OF (T), (TN) OR .25/.707	0.354 INCHES
ACTUAL WELD LEG (W)	0.365 INCHES

REINFORCEMENT CALCULATION UG-37

AVAILABLE AREA	
SHELL: LARGER OF: (NOTE 1)	E1=1.00
A1A $D(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	
A1B $2(T + TN)(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	1.597 IN2
NOZZLE: SMALLER OF:	
5(TN-TRN)(FR2)(T) OR	
A2 5(TN-TRN)(FR2)(TN)	0.303 IN2
ADDITIONAL AREA IF USED (RE-PAD OR INWARD NOZZLE)	
A3 $(DP - D - 2 \cdot TN)TE(FR4)$ OR $2(TN)FR2 \cdot H$	0.000 IN2
WELD AREA	
A4 $W \cdot W \cdot (FR2)$	0.125 IN2
ATOT $ATOT = A1 + A2 + A3 + A4$	2.024 IN2
REQUIRED AREA	
$AREQ = .5 \cdot D \cdot TR \cdot F + 2 \cdot TN \cdot TR \cdot F(1 - FR1)$ (F=1.0)	1.080 IN2

REINFORCEMENT CALCULATION APPENDIX (1-7a). (NOTE 2) $R_n/R = 0.84$

A1(1-7) = LARGER OF A1(1-7)A OR A1(1-7)B	
A1(1-7)A $.5 \cdot D(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	
A1(1-7)B $2(T + TN)(E1 \cdot T - F \cdot TR) - 2 \cdot TN(E1 \cdot T - F \cdot TR)(1 - FR1)$	0.798 IN2
ATOT(1-7) = A1(1-7) + A2 + A3 + A4	1.226 IN2
AREQ(1-7) = (2/3) X AREQ	0.720 IN2

- (1) E1 NORMALLY EQUALS 1.0.
- (2) REFERENCE PAR. UG-36(B-1). THIS CALCULATION IS REQUIRED WHEN THE OPENING IS GREATER THAN HALF THE HEADER I.D. OR THE OPENING EXCEEDS 20 INCHES.
- (3) $FR1 = 1.0$ OR SN/SV FOR INSERTED NOZZLES.
 $FR2 = SN/SV$, $FR3 = (\text{LESSER OF } SN \text{ OR } SP)/SV$, $FR4 = SP/SV$.
- (4) TR & TRN ARE BASED ON SEAMLESS MATERIAL PER DEFINITIONS IN UG-37.
- (5) IF LENGTH=0 (NOT DEFINED) THE MAXIMUM L/Do RATIO IS USED; L/Do=50.

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:
FEB 01 2005

Subject: Supplemental ASME submittal calculations per the 2001 Edition, 2003 Addenda of Section VIII, Division 1.

Customer: AL-DEUTSCHLAND
Sales Order: 509.1
Assembly drawing: 15772A REV A
ITEM: W21001

Maximum design temperature 150. F

Test pressure calculation:

Stream	Test Method	CUSTOMER SPECIFIED DESIGN PRESSURE	CORRECTION Factor	EQUIVALENT DESIGN		TEST FACTOR	S test/ S design	Test Pressure	
		PSIG		PSIG	PSIG			PSIG	PSIG
A	PNEU	109.	X 1.50/1.1	= 149.	X 1.10	X 1.000	=	164.	

NOTE: CUSTOMER MANDATED PNEU TEST PRESSURE OF 1.50 TIMES THEIR SPECIFIED DESIGN PRESSURE. CALCULATIONS WERE BASED ON AN EQUIVALENT DESIGN PRESSURE TO CORRECT FOR THE ELEVATED PNEUMATIC TEST PRESSURES.

Calculations for Core block components:

Parting sheet calculations:

The parting sheet thickness is selected to carry the outward pressure force on the bar columns of the exchanger. The required thickness is a function of the layer heights and pressures. The calculation method is outlined as follows.

Equation:

$$t_{\text{required}} = \frac{\text{outward pressure}}{\# \text{ of layers} \times S_a}$$

Where: S_a is the allowable parting sheet stress.

Outward pressure = sum of the product of the layer heights x layer pressure.

Section 1 :

Stream A	76. layers, 0.250" high at 149. psig =	2831. lb/in
Stream B	75. layers, 0.250" high at 0. psig =	0. lb/in
sum	151. layers	2831. lb/in

$$\text{min sheet} = \frac{2831. \text{ lb/in}}{151. \times 3400. \text{ psi}} = 0.006 \text{ in} < 0.039 \text{ in}$$

Zur Hauptzeichnung zugehörig.
Belongs to the Main Drawing.
Prüfvermerk vom / Review date:

FEB 01 2005

TR