DUKE POWER COMPANY
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HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
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July 24, 1985

Dr. J. Nelson Grace, Regional Administrator
U.S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

Reference: Catawba Nuclear Station, Unit 2
Docket No. 50-414
Significant Deficiency No. 414/85-06

Dear Dr. Grace:

Please find attached a supplement to our status report dated July 15, 1985, on corrective actions taken on the subject deficiency. This supplemental information, requested by Region II staff, is an engineering evaluation of the undamaged portions of the Chemical and Volume Control System for overpressurization.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

LTP:smh

Attachment

IE27

cc: Director
Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

NRC Resident Inspector
Catawba Nuclear Station

Palmetto Alliance
2135½ Devine Street
Columbia, South Carolina 29205

INPO Records Center
Suite 1500
1100 Circle 75 Parkway
Atlanta, Georgia 30339

Mr. Robert Guild, Esq.
Attorney-at-Law
P. O. Box 12097
Charleston, South Carolina 29412

Mr. Jesse L. Riley
Carolina Environmental Study Group
854 Henley Place
Charlotte, North Carolina 28207

Catawba Nuclear Station
SD 414/85-06
Supplement
July 24, 1985

25679 (R2-83)

FORM Q - 1A REVISION 14

Requisition No.	Vendor/Location	Documents Violated
MPS PO NO.	Mech/Elec System	

DUKE POWER COMPANY

Project CATAWBA Unit 2

NONCONFORMING ITEM REPORT

Serial No. 19631

ATTACHMENT NO. 10

Page 1 of 32

QA Condition	Class	Identification Method
		☐ Q-IB's ☐ Other ☐ NCI Tape ☐ Not Practical

Location of Item

Description of Nonconformance

Responsibility for Nonconformance Disposition ☐ Const. ☐ Design ☐ QA ☐ Nuclear Production ☐ Group

Reportability Evaluation, Q-ID, Requested from (Provide Department or N/A)

Originated By Date QA Review Date

Disposition of Nonconformance

DNC (PR-202) Applicable (Design Eng. Only) ☐ Yes ☒ No

PART 9 NV PIPING PRESSURIZED TO 700 PSIG WAS REVIEWED AND FOUND TO BE ACCEPTABLE. MSME REVIEW FOR PIPING MATERIALS THRU 6" IS SUMMARIZED BY PAGES 2 AND 3 OF ATTACHMENT NO-10. STRESS ANALYSIS REVIEW FOR 1", 1½", 2", 3", 4" AND 6" FLANGES IS INCLUDED AS PAGES 4 THRU 32.

Spec/Calc/Dwg Revised: NA Rev No.

R-6A Assigned to Dept.

For 10CFR 50 App. B Criterion XVI Evaluation

6-6-85

Resolved By R. L. Williams Date 6/7/85 Technical Approval DM Gell Date 6/7/85 QA Approval J H Lamb Date 6-10-85

REWORK/INSPECTION/REPLACEMENT TO IMPLEMENT DISPOSITION

Assigned To	Performed By	Date

By Date QA Approval Date

Action/Inspection Remarks

Distribution		Const Mgr	Eng Mgr	Con Eng	Con Eng	Project QA Mgr	QA Vendors	QA	QA	Whse Supv	Design	ANI	NRC			
Number of Copies	Initial															
	Final															

Trend Info. Final QA Review Date

Dev./Station CATAWBA Unit 2 File No. NCIR 19631

Subject MSME EVALUATION

By [illegible] Date 6-4-85

Sheet No. 2 of ____ Problem No. ____ Checked By [illegible] Date 6-6-85

MSME EVALUATION CONSISTED OF REVIEWING 3/4", 1", 1½", 2", 3", 4" and 6" STAINLESS STEEL PIPING PRESSURIZED TO 700 PSIG.

PIPING

EVALUATION IS BASED ON LIMITING CASE OF 6", SA 312 TP 304, SCH 40, CLASS C PIPING. PIPING ALLOWABLE PRESSURE IS 1146 PSIG (100°F) FROM CNC 1232.00-00-0010, PST 4.8. SINCE 1146 PSIG > 700 PSIG, PIPING IS ACCEPTABLE.

THREADED JOINTS

ALLOWABLE PRESSURES FOR 3/4", 1", & 1½" THREADED JOINTS ARE TABULATED BELOW FROM CNC-1232.00-0035. (SA 312 TP 304)

NPS	SCH.	P_a (300°F)	MAX. HYDRO PRESS.(1)	
3/4	40	582 psig	925 psig	THD. JTS. ARE ACCEPTABL
1	↓	502 ↓	798 ↓	SINCE MAX. HYDRO PRESS
1½		486	772	> 700 psig

(1) MAX. HYDRO. PRESS. = $(P_a)(1.5)(1.06)$

THREADED JOINTS FOR 2", SCH 40 PIPE ARE ACCEPTABLE BASED ON REVIEW OF MATERIAL YIELD STRENGTH. MATERIAL STRESS AS PREDICTED BY THE CODE EQUATION IS:

$$S = \frac{(700)(2.375-(2)(0.4)(0.031350))}{2(0.031350)}$$

$S = 26,235$ psi OR 87% S_y (MIN.) $\left(\frac{26,235}{30,000}\right)$

2" THREADED JOINTS ARE QUALIFIED FOR THE 700 PSIG OVERPRESSURIZATION SINCE THE MATERIAL YIELD STRENGTH WAS NOT EXCEEDED.

Dev./Station CATAWBA Unit 2 File No. NCLR 19631

Subject

By [illegible] Date 6-4-85

Sheet No. 3 of ____ Problem No. ____ Checked By W.H. Bailey Date 6-6-85

BENDS

EVALUATION IS BASED ON REVIEW OF CNC 1232.00-00-0042. THE STRESS FACTOR FOR BENDS THRU 6" IS 0.069949.

P_a (100°F) = (0.069949)(18,800)(0.8)

P_a = 1052 psig

PIPING BENDS FOR 6", SCH 40, SA 312 TP304 PIPE ARE ACCEPTABLE FOR 700 PSIG PRESSURE.

FLANGES

TYPE 304, 150 LB. PIPE FLANGES FOR 1", 1½", 2", 3", 4" AND 6" PIPE SIZES WERE REVIEWED BY STRESS ANALYSIS GROUP AND FOUND TO BE ACCEPTABLE FOR THE 700 PSIG PRESSURE EVENT.

TYPE 304, 300 LB., FLANGES ARE ACCEPTABLE BASED ON B16.5 (1968) FLANGE RATINGS AND THE MAXIMUM HYDROTEST PRESSURE PERMITTED BY THE CODE.

P_{HT} = (615)(1.5)(1.06) = 978 PSIG

SINCE 978 PSIG > 700 PSIG, 300 LB FLANGES ARE ACCEPTABLE.

NCI
REQUEST FOR REVIEW

MATERIALS GROUP

The attached NCI is being sent to you for your review and comments. Please respond by completing this form and returning it to the Materials Group.

NCI Number: 19631

Materials Group Responsible Engineer D.O. Lefler Jr.

Materials Group Need Date June 4, 1985

Please review and evaluate the flanges for the valves listed by the attached table. These flanges were subjected to 700 psig pressure during testing.

Date Sent: 5-30-85

CATAWBA STRESS ANALYSIS

Comments:

- [x] NCI is acceptable
- [ ] NCI is not acceptable
- [ ] No Comments

Reason: Attached calculation shows that the flanges and bolts were not permanently yielded. Therefore the flanges and bolts have the same pressure and load carrying capability and do not need to be replaced.

Specification/Calculation/Drawing Revised by
Catawba Stress Analysis: _____

Specification/Calculation/Drawing to be revised
by other groups: _____

By: T. A. Crow

Technical Approval: R. S. Hoo 6/6/85

Form 00184 (6-81) DUKE POWER COMPANY

Dev./Station Catawba Unit 2 File No. NCER 19631

Subject

By [signature] Date 5-30-85

Sheet No. 1 of 1 Problem No. Checked By Date

Valve No.	NPS (in.)	FLANGE RATING	DPCO. CLASS	FLANGE MATERIAL	FLOW DIAGRAM	DESIGN ISOMETRIC
2NM 92	1	150	B	SA 182 F304	2572-1.2 (K-6)	—
2NR 114	2	150	B		2555-1.1 (K-9)	2492 NR 054
2NV 151	4	150	B		2554-1.6 (G-13)	2492 NV 005
2NV 182	3	150	B		2554-1.1 (J-9)	2492 NV 221
2NV 205	6 (1)	150	B		2554-1.1 (G-4)	2492 NV 186
2NV 222	1½	150	B		2554-1.1 (E-6)	2492 NV 182
2NV 223	6 (1)	150	C		2554-1.1 (H-7)	2492 NB 270
2NV 232	1½	150	B		2554-1.7 (H-11)	2492 NV 050
2NV 235	1½	150	B		2554-1.7 (G-12)	2492 NV 051
2NV 497	1	150	B	↓	2554-1.2 (C-13)	2492 NV 061

(1) 6" x 4" Reducing Flange

Form 00184 (6-81) DUKE POWER COMPANY

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TDC Date 6-3-85

Sheet No. 1 of 27 Problem No. Checked By EKR Date 6-5-85

Problem: NCI 19631 states that several lines were overpressurized to 700 PSIG. Check the following flange sizes to see if they received permenant deformation or damage:

1" 150 lb
1½" 150 lb
2" 150 lb
3" 150 lb
4" 150 lb
6"x4" 150 lb Reducing Flange

References:

1) Catawba Piping Analysis Handbook CNSA-DOC-80-002 Section 10.12

2) ASME Boiler + Pressure Vessel Code Section III, 1977 Edition, Appendices

3) ITT Grinnel Welding Fittings + Flanges Catalog WFF-79

Assumptions

1) Gravity moment on flanges will be considered negligable, and only stress do to pressure will be considered.
2) Since this was a cold hydro thermal moments will be considered to be zero, and material yield points will be at ambient temperature.

Body

Form 00184 (6-81) DUKE POWER COMPANY

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TDC Date 6-3-85

Sheet No. 2 of 27 Problem No. Checked By EKR Date 6-5-85

1" Raised Face 150# Flange, Method 2A, SA 182. F304 Gasket Code G-4, Bolt Code B-5 SW

$N = \frac{17/8 - 1.25}{2} = 0.31"$ Gasket Dimensions Control

$b = b_o = \frac{0.31}{2} = 0.155"$

$G = \frac{17/8 + 1.25}{2} = 1.56"$

$m = 3.0$

$W_{m1} = .785(1.56)^2 700 + 6.28(0.155)(1.56)(3.0)(700) = 4526\#$

$S_y = 105{,}000$ PSI Yield Stress will be used to ensure that there is no permanant deformation or damage.

Required Bolt Area $= \frac{4526}{105000} = 0.0431$ IN^2

Actual Bolt Area $= 4(.1257) = 0.502$ IN^2

Bolts are ok since they were not taken beyond yield stress.

Dev./Station Catawba Unit 2 File No.
Subject NCI # 19631
By TDC Date 6-3-85
Sheet No. 3 of 27 Problem No. Checked By EKR Date 6-5-85

$W_{m1} = 4526\#$

$C = 3\frac{1}{8}'' = 3.125''$

$G = 1.56''$

$B = 1.36''$

$g_1 = 0.289''$

$g_0 = 0.289''$

$$R = \frac{3.125 - 1.36}{2} - 0.289 = 0.593''$$

$h = \frac{7}{16} = 0.125''$

$H = 0.785\,(1.56)^2\,700 = 1337\ \#$

$H_G = 4526 - 1337 = 3189\ \#$

$$h_g = \frac{3.125 - 1.56}{2} = 0.783''$$

$M_G = 3189\,(0.783) = 2497$ IN-LB

$H_D = 0.785\,(1.36)^2\,700 = 1016\ \#$

$$h_d = \frac{3.125 - 1.36}{2} = 0.883''$$

$M_D = 1016\,(0.883) = 897$ IN-LB

Dev./Station Catawba Unit 2 File No.
Subject NCI # 19631
By TDC Date 6-3-85
Sheet No. 4 of 27 Problem No. Checked By EKR Date 6-5-85

$H_T = 1337 - 1016 = 321\ \#$

$h_T = \frac{.753 + .882}{2} = 0.833''$

$M_T = 321(0.833) = 267$ IN-LB

$h = 0.125''$

$h_o = \sqrt{1.36(.289)} = 0.627$

$g_1/g_o = 1.0 \qquad h/h_o = 0.125/0.627 = 0.199$

$f = 1.0$

$A = 4.25''$

$B = 1.36''$

$V_L = 18$

$K = 4.25/1.36 = 3.13$

$$U = \frac{(3.13)^2(1+8.55246\log_{10}3.13)-1}{1.36136\,(3.13^2-1)(3.13-1)} = 1.972$$

$$d = \frac{1.972}{18}(0.627)(.289)^2 = 0.0057$$

$F_L = 3.9$

$e = 3.9/.627 = 6.22$

Dev./Station Catawba Unit 2 File No.
Subject NCI # 19631
By TDC Date 6-3-85
Sheet No. 5 of 27 Problem No. Checked By EKR Date 6-5-85

$$T = \frac{(3.13)^2(1+8.55246\log_{10}3.13)-1}{(1.04720+1.9448(3.13)^2)(3.13-1)} = 1.175$$

$$X = 9/16 - 1/16 = 8/16 = 1/2"$$

$$L = \frac{(.5)(6.22)+1}{1.175} + \frac{(.5)^3}{0.0057} = 25.43$$

$$Y = \frac{1}{3.13-1}\left[0.66845+5.71690\,\frac{3.13^2\log_{10}3.13}{3.13^2-1}\right] = 1.795$$

$$Z = \frac{3.13^2+1}{3.13^2-1} = 1.227$$

$M_o = 2497 + 897 + 267 = 3661$ IN-LB

$$S_T = \frac{1.795(3661)}{(.5)^2(1.36)} - 1.227(2175) = 16659 \text{ PSI}$$

$$S_H = \frac{1.0(3661)}{25.43(.289)^2 1.36} + \frac{700(1.36)}{4(.289)} = 2091 \text{ PSI}$$

$$S_R = \frac{(1.33(.5)(6.22)+1)\,3661}{25.43(.5)^2\,1.36} = 2175 \text{ PSI}$$

Failure will be Taken at the point the material yields and Takes permanant deformation $S_y = 30{,}000$ PSI

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TDC Date 6-3-85

Sheet No. 6 of 27 Problem No. Checked By EKR Date 6-5-85

Using the distortion energy theory for ductile failure

$\sigma_3 = 2091$ PSI , $\sigma_2 = 2175$ PSI , $\sigma_1 = 16659$ PSI

$$1/2\left[(16659 - 2175)^2 + (2175 - 2091)^2 + (2091 - 16659)^2\right] \leq 30000^2$$

$$2.11 \times 10^8 \leq 9 \times 10^8$$

Form 00184 (6-81) DUKE POWER COMPANY

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TPC Date 6-3-85

Sheet No. 7 of 27 Problem No. Checked By EKR Date 6-5-85

1½" Raised Face 150 # Flange, Method 2A, SA182 F304

Gasket Code G-4, Bolt Code B-5 SW

$$N = \frac{2\frac{3}{4} - 2\frac{1}{2}}{2} = 0.31"$$ Gasket Dimensions Control

$$b = b_o = \frac{0.31}{2} = 0.155"$$

$$G = \frac{2\frac{3}{4} + 2\frac{1}{2}}{2} = 2.44"$$

$m = 3.0$

$$W_{M1} = .785(2.44)^2 700 + 6.28(.155)(2.44)(3.0)(700) = 8259\ \#$$

$S_y = 105{,}000$ PSI Yield Stress will be used to ensure that there is no permenant deformation or damage.

$$\text{Required Bolt Area} = \frac{8259}{105{,}000} = 0.0787\ IN^2$$

$$\text{Actual Bolt Area} = 4(.1257) = 0.502\ IN^2$$

Bolts are OK since they were not taken beyond Yield Stress.

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TPC Date 6-3-85

Sheet No. 8 of 27 Problem No. Checked By EKR Date 6-5-85

$W_{M1} = 8259\#$

$C = 3\frac{7}{8}" = 3.875"$

$G = 2.44"$

$B = 1.95"$

$g_1 = g_0 = 0.3062"$

$R = \frac{3.875 - 1.95}{2} - 0.3062 = 0.6563"$

$h = \frac{3}{16} = .1875"$

$H = 0.785 (2.44)^2 700 = 3272\#$

$H_G = 8259 - 3272 = 4987\#$

$h_G = \frac{3.875 - 2.44}{2} = 0.7175"$

$M_G = 4987 (0.7175) = 3578$ IN-LB

$H_D = 0.785 (1.95)^2 700 = 2090\#$

$h_d = \frac{3.875 - 1.95}{2} = 0.9625"$

$M_D = 2090 (0.9625) = 2012$ IN-LB

$H_T = 3272 - 2090 = 1182\#$

$h_T = \frac{.7175 + 0.9625}{2} = 0.84$

$M_T = 1182 (0.84) = 993$ IN-LB

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TDC Date 6-3-85

Sheet No. 9 of 27 Problem No. Checked By EKR Date 6-5-85

$h = .1875$

$h_o = \sqrt{1.95(.3062)} = 0.7727$

$g_1/g_o = 1.0 \qquad h/h_o = .1875/.7727 = 0.2427$

$f = 1.0$

$A = 5''$

$B = 1.95''$

$V_L = 9$

$K = 5/1.95 = 2.564$

$$U = \frac{(2.564)^2\left(1 + 8.55246\ \text{Log}_{10} 2.564\right) - 1}{1.36136\left(2.564^2 - 1\right)(2.564 - 1)} = 2.407$$

$$d = \frac{2.407}{9}(.7727)(.3062)^2 = 0.0194$$

$F_L = 3$

$e = 3/.7727 = 3.8825$

$$T = \frac{(2.564)^2\left(1 + 8.55246\ \text{Log}_{10} 2.564\right) - 1}{\left(1.04720 + 1.9448(2.564)^2\right)(2.564 - 1)} = 1.320$$

$I = 5/8''$

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TDC Date 6-3-85

Sheet No. 10 of 27 Problem No. Checked By EKR Date 6-5-85

$$L = \frac{(5/8)(3.825+1)}{1.320} + \frac{(5/8)^3}{.0194} = 15.1804$$

$$Y = \frac{1}{2.564-1}\left[0.66845 + 5.71690\,\frac{2.564^2 \log_{10} 2.564}{2.564^2-1}\right] = 2.190$$

$$Z = \frac{2.564^2+1}{2.564^2-1} = 1.359$$

$$M_o = 3578 + 2012 + 993 = 6583 \text{ IN-LB}$$

$$S_H = \frac{1.0\,(6583)}{15.18\,(.3062)^2\,1.95} + \frac{700\,(1.95)}{4(.3062)} = 3486 \text{ PSI}$$

$$S_R = \frac{\left(1.33\,(5/8)(3.883)+1\right)6583}{15.18\,(5/8)^2\,1.95} = 2407 \text{ PSI}$$

$$S_T = \frac{2.190\,(6583)}{(5/8)^2\,1.95} - 1.359(2407) = 15656 \text{ PSI}$$

Failure will be taken at the point the material yields and takes permenant deformation. Using the distortion energy theory of ductile failure

$\sigma_1 = 15656$ PSI, $\sigma_2 = 3486$ PSI, $\sigma_3 = 2407$ PSI, $S_y = 30{,}000$,

$$\frac{1}{2}\left[(15656-3486)^2 + (3486-2407)^2 + (2407-15656)^2\right] \le 30{,}000^2$$

$$1.624 \times 10^8 \le 9 \times 10^8$$

Form 00184 (6-81) DUKE POWER COMPANY

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TDC Date 6-3-85

Sheet No. 11 of 27 Problem No. Checked By EKL Date 6-5-85

2" Raised Face 150# Flange, Method 2A, SA 182 F304

Gasket Code G-4, Bolt Code B-5 SW

$N = \frac{3\frac{3}{8} - 2\frac{3}{4}}{2} = 0.3125"$ Gasket Dimensions Control

$b = b_o = \frac{0.3125}{2} = 0.156"$

$G = \frac{3\frac{3}{8} + 2\frac{3}{4}}{2} = 3.06"$

$m = 3.0$

$W_{M1} = .785(3.06)^2 700 + 6.28(.156)(3.06)(3.0)(700) = 11441\ \#$

$S_y = 105{,}000$ PSI Yield Stress will be used to ensure that there is no permanent deformation or damage.

Required Bolt Area $= \frac{11441}{105{,}000} = 0.109"$

Actual Bolt Area $= 4(.202) = 0.808\ IN^2$

Bolts are ok since they were not taken beyond yield stress.

Dev./Station Catawba Unit 2 File No.
Subject NCI # 19631
By THC Date 6-3-85
Sheet No. 12 of 27 Problem No. Checked By EKR Date 6-5-85

$W_{NI} = 11441^{\#}$

$C = 4.75$ IN

$G = 3.06$ IN

$B = 2.44''$

$g_1 = g_0 = 0.5$ IN

$R = \frac{4.75 - 2.44}{2} - 0.5 = 0.655''$

$h = 0.25''$

$H = 0.785(3.06)^2 700 = 5145$ lb

$H_G = 11441 - 5145 = 6296$ lb

$h_g = \frac{4.75 - 3.06}{2} = 0.845$ IN

$M_G = 6296\ (.845) = 5320$ IN-LB

$H_D = 0.785\ (2.44)^2 700 = 3272$ lb

$h_d = \frac{4.75 - 2.44}{2} = 1.155$ IN

$M_D = 3272\ (1.155) = 3779$ IN-LB

$H_T = 5145 - 3272 = 1873$ lb

$h_x = \frac{0.845 + 1.155}{2} = 1.0$

$M_T = 1873$ IN-LB

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TDC Date 6-3-85

Sheet No. 13 of 27 Problem No. Checked By EKR Date 6-5-85

$h = 0.25$

$h_o = \sqrt{2.44\,(0.5)} = 1.10$

$g_1/g_o = 1.0 \qquad h/h_o = 0.25/1.1 = 0.23$

$f = 1.0$

$A = 6$ IN

$B = 2.44$

$V_L = 11.4$

$K = 6/2.44 = 2.459$

$$U = \frac{(2.459)^2\left(1 + 8.55246 \log_{10} 2.459\right) - 1}{1.36136\left(2.459^2 - 1\right)\left(2.459 - 1\right)} = 2.519$$

$$d = \frac{2.519}{11.4}(1.1)(.5)^2 = 0.061$$

$F_L = 3.32$

$e = \frac{3.32}{1.1} = 3.018$

$$T = \frac{(2.459)^2\left(1 + 8.55246 \log_{10} 2.459\right) - 1}{\left(1.04720 + 1.9448\,(2.459)^2\right)(2.459 - 1)} = 1.352$$

$\chi = 11/16'' = 0.6875''$

Dev./Station Catawba Unit 2 File No.
Subject NCI # 19631
By TDC Date 6-3-85
Sheet No. 14 of 27 Problem No. Checked By EKR Date 6-5-85

$$L = \frac{(0.6875)(3.018)+1}{1.352} + \frac{(0.6875)^3}{0.061} = 7.601$$

$$Y = \frac{1}{2.459-1}\left[0.66845 + 5.71690\,\frac{(2.459)^2 \log_{10} 2.459}{(2.459^2-1)}\right] = 2.29$$

$$Z = \frac{2.459^2+1}{2.459^2-1} = 1.396$$

$$M_o = 5320 + 3779 + 1873 = 10972 \text{ IN-LB}$$

$$S_H = \frac{1.0(10972)}{7.601(.5)^2 2.444} + \frac{700(2.444)}{4(.5)} = 3220 \text{ PSI}$$

$$S_R = \frac{\left(1.33(.6875)(2.018)+1\right)10972}{7.601(.6875)^2\,2.44} = 4706 \text{ PSI}$$

$$S_T = \frac{2.29(10972)}{(.6875)^2\,2.444} - 1.396(4706) = 15217 \text{ PSI}$$

Failure will be taken at the point the material yields and takes permanent deformation.
Using the distortion energy theory for ductile failure

$\sigma_1 = 15217$ PSI , $\sigma_2 = 4706$ PSI , $\sigma_3 = 3220$ PSI , $S_y = 30{,}000$ PSI

$$\tfrac{1}{2}\left[(15217-4706)^2 + (4706-3220)^2 + (3220-15217)^2\right] \le 30000^2$$

$$1.28 \times 10^8 \le 9 \times 10^8$$

Dev./Station Catawba Unit 2 File No.
Subject NCI # 19631
By TDC Date 6-3-85
Sheet No. 15 of 27 Problem No. Checked By EKR Date 6-5-85

3" Raised Face 150# Flange, Method 2A, SA 182 F304

Gasket Code G-4, Bolt Code B-5 Welding Neck

$N = \frac{4.75 - 4}{2} = 0.375$ Gasket Dimensions Control

$b = b_o = \frac{0.375}{2} = 0.1875"$

$G = \frac{4.75 + 4}{2} = 4.375"$

$W_{M1} = .785(4.375)^2 700 + 6.28(.1875)(4.375)(3.0)(700) = 21336\ \#$

$S_y = 105{,}000$ PSI Yield Stress will be used to ensure that there is no permenant deformation or damage.

Required Bolt Area $= \frac{21336}{105000} = 0.203\ IN^2$

Actual Bolt Area $= 4(.202) = 0.808\ IN^2$

Bolts are OK since they were not taken beyond yield stress

Dev./Station Catawba Unit 2 File No.

Subject NCI # 19631

By TPC Date 6-3-85

Sheet No. 16 of 27 Problem No. Checked By EKR Date 6-5-85

$W_{H1} = 21336\ \#$

$C = 6''$

$G = 4.375''$

$B = 3.07''$

$g_1 = 0.590''$

$g_0 = 0.215''$

$R = \frac{6 - 3.07}{2} - .590 = 0.875''$

$h = 1.8125'' - 1.5(.215) = 1.49$ Ref Fig 6a in code

$H = 0.785(4.375)^2 700 = 10518\ \#$

$H_G = 21336 - 10518 = 10818\ \#$

$h_G = \frac{6 - 4.375}{2} = 0.8125''$

$M_G = 10818(0.8125) = 8790$ IN-LB

$H_D = 0.785(3.07)^2 700 = 5179\ \#$

$h_d = 0.875 + 0.5(.590) = 1.17$

$M_D = 5179(1.17) = 6059$ IN-LB

$H_T = 10518 - 5179 = 5339\ \#$

$h_T = \frac{0.875 + .59 + 0.8125}{2} = 1.139''$

$M_T = 5339(1.139) = 6081$ IN-LB

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$h = 1.8125" - 1.5(.215) = 1.490$

$h_o = \sqrt{3.07(.215)} = 0.812$

$g_1/g_o = \frac{.590}{.215} = 2.74$ $\qquad h/h_o = \frac{1.490}{0.812} = 1.834$

$f = 1.0$

$V = 0.07$

$A = 7\frac{1}{2}"$

$K = 7\frac{1}{2}/3.07 = 2.443$

$$U = \frac{(2.443)^2(1+8.55246\log_{10}2.443)-1}{1.36136(2.443^2-1)(2.443-1)} = 2.538$$

$$d = \frac{2.538}{0.07}(.812)(.215)^2 = 1.36$$

$F = 0.62$

$$e = \frac{0.62}{0.812} = 0.764$$

$$T = \frac{(2.443)^2(1+8.55246\log_{10}2.443)-1}{(1.04720+1.9448(2.443)^2)(2.443-1)} = 1.356$$

$$x = 15/16 - 1/16 = 7/8"$$

$$L = \frac{(7/8)(.764)+1}{1.356} + \frac{(7/8)^3}{1.36} = 1.723$$

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$$Y = \frac{1}{2.443-1}\left[0.66845 + 5.71690\,\frac{2.443^2 \log 2.443}{2.443^2-1}\right] = 2.309$$

$$Z = \frac{2.443^2+1}{2.443^2-1} = 1.403$$

$$M_o = 8790 + 6059 + 6081 = 20930 \text{ PSI}$$

$$S_H = \frac{1.0\,(20930)}{1.723(.590)^2(3.07)} + \frac{700\,(3.07)}{4\,(.215)} = 13866 \text{ PSI}$$

$$S_R = \frac{\left(1.33\left(\frac{7}{8}\right)(.764)+1\right)20930}{1.723\left(\frac{7}{8}\right)^2 3.07} = 9763 \text{ PSI}$$

$$S_T = \frac{2.309\,(20930)}{\left(\frac{7}{8}\right)^2 3.07} - 1.403(9763) = 6863 \text{ PSI}$$

Failure will be taken at the point the material yields and takes permenant deformation.
Using the distortion energy theory for ductile failure

$\sigma_1 = 13866$ PSI , $\sigma_2 = 9763$ PSI , $\sigma_3 = 6863$ PSI

$$\frac{1}{2}\left[(13866-9763)^2 + (9763-6863)^2 + (6863-13866)^2\right] \le 30000^2$$

$$3.714 \times 10^7 \le 9 \times 10^8$$

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4" Raised Face 150# Flange, Method 2A, SA182 F304

Gasket Code G-4, Bolt Code B-5 Welding Neck

$N = \frac{5\frac{7}{8}" - 5}{2} = 0.437"$ Gasket Dimensions Control

$b = b_o = \frac{.437}{2} = 0.2185"$

$G = \frac{5\frac{7}{8} + 5}{2} = 5.4375"$

$m = 3.0$

$W_{m1} = .785(5.4375)^2\,700 + 6.28(.2185)(5.4375)(3.0)(700) =$

$31915\ \#$

$S_y = 105{,}000$ PSI Yield Stress will be used to ensure that there is no permanent deformation or damage.

Required Bolt Area $= \frac{31915}{105{,}000} = 0.304\ IN^2$

Actual Bolt Area $= 8(.202) = 1.616\ IN^2$

Bolts are OK since they were not taken beyond yield stress

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$W_{M1} = 31915\ \#$

$C = 7\frac{1}{2}"$

$G = 5.4375"$

$B = 4.03"$

$g_1 = 0.64"$

$g_0 = 0.235"$

$R = \frac{7\frac{1}{2} - 4.03}{2} - .64 = 1.095"$

$h = 3 - \frac{15}{16} - 1.5(.235) = 1.71"$

$H = 0.785\,(5.4375)^2\,700 = 16247\ \#$

$H_G = 31915 - 16247 = 15668\ \#$

$h_g = \frac{7\frac{1}{2} - 5.435}{2} = 1.0325"$

$M_G = 15668\,(1.0325) = 16177\ \text{in-lb}$

$H_D = .785\,(4.03)^2\,700 = 8924\ \#$

$h_d = 1.095 + 0.5\,(0.64) = 1.415"$

$M_D = 8924\,(1.415) = 12627\ \text{in-lb}$

$H_T = 16247 - 8924 = 7323\ \#$

$h_T = \frac{1.095 + (.64) + 1.0325}{2} = 1.384"$

$M_T = 7323\,(1.384) = 10135\ \text{IN-LB}$

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$h = 1.71''$

$h_o = \sqrt{4.03\,(.235)} = 0.97$

$g_1/g_o = \frac{.64}{.235} = 2.72$ $\qquad h/h_o = \frac{1.71}{0.97} = 1.76$

$f = 1.0$

$V = 0.07$

$A = 9''$

$K = 9/4.03 = 2.233$

$$U = \frac{(2.233)^2\,(1. + 8.55246 \log_{10} 2.233) - 1}{1.36136\,(2.233^2 - 1)(2.233 - 1)} = 2.819$$

$$d = \frac{2.819}{0.07}\,(.97)(.235)^2 = 2.157$$

$F = 0.63$

$$e = \frac{0.63}{0.97} = 0.65$$

$$T = \frac{(2.233)^2\,(1 + 8.55246 \log_{10} 2.233) - 1}{(1.04720 + 1.9448\,(2.233)^2)(2.233 - 1)} = 1.424$$

$t = 15/16 - 1/16 = 7/8''$

$$L = \frac{(7/8)(.65) + 1}{1.424} + \frac{(7/8)^3}{2.157} = 1.412$$

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$$Y = \frac{1}{2.233-1}\left[0.66815 + 5.71690\,\frac{2.233^2 \log_{10} 2.233}{2.233^2 - 1}\right] = 2.566$$

$$Z = \frac{2.233^2 + 1}{2.233^2 - 1} = 1.502$$

$$M_o = 16177 + 12627 + 10135 = 38939 \text{ IN-LB}$$

$$S_H = \frac{1.0\,(38939)}{1.412\,(.64)^2\,4.03} + \frac{700\,(4.03)}{4(.235)} = 19708 \text{ PSI}$$

$$S_R = \frac{\left(1.33(7/8)(.65)+1\right)38939}{1.412\,(7/8)^2\,4.03} = 15699 \text{ PSI}$$

$$S_T = \frac{2.566\,(38939)}{(7/8)^2\,4.03} - 1.502\,(15699) = 8803 \text{ PSI}$$

Failure will be taken at the point the material yields and takes permanent deformation.
Using the distortion energy theory for ductile failure

$\sigma_1 = 19708$ PSI, $\sigma_2 = 15699$ PSI, $\sigma_3 = 8803$ PSI, $S_y = 30{,}000$ PSI

$$\tfrac{1}{2}\left[(19708-15699)^2 + (15699-8803)^2 + (8803-19708)^2\right] \le 30000^2$$

$$9.127 \times 10^7 \le 9 \times 10^8$$

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By THC Date 6-3-85

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6" X 4" Reducing Flange Raised Face 150#, Method 2A, SA182 F30

Gasket Code G-4, Bolt Code B-5 Welding Neck

$N = \frac{8\frac{1}{4} - 7\frac{3}{16}}{2} = 0.531"$ Gasket Dimensions Control - 6" 150#

$b_o = \frac{0.531}{2} = 0.266"$

$b = \frac{\sqrt{.266}}{2} = 0.258"$

$G = 8\frac{1}{4} - 2(.258) = 7.734"$ 6" 150#

$m = 3.0$

$W_{m_1} = 0.785(7.734)^2 700 + 6.28(.258)(7.734)(3.0)700 = 59183\#$

$S_y = 105,000$ psi Yield Stress will be used to ensure that there is no permenant deformation or damage.

Required Bolt Area $= \frac{59183}{105,000} = 0.564 \ IN^2$

Actual Bolt Area $= 8(.302) = 2.416 \ IN^2$

Bolts are ok since they were not taken beyond yield stress.

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$W_{m1} = 59183\ \#$

$C = 9\frac{1}{2}"$ 6" 150 #

$G = 7.734"$

$B = 4.03"$ Bore from 4" 150 #

$g_1 = 0.64"$ Same as 4" 150 #

$g_0 = 0.735"$ Same as 4" 150 #

$$R = \frac{9\frac{1}{2} - 4.03}{2} - 0.64 = 2.095"$$

$h = 1.71"$ Same as 4" 150 #

$H = 0.785(7.734)^2\ 700 = 32868\ \#$

$H_G = 59183 - 32868 = 26315\ \#$

$$h_g = \frac{9\frac{1}{2} - 7.734}{2} = 0.883"$$

$M_G = 26315\ (0.883) = 23236$ IN-LB

$H_D = .785\ (4.03)^2\ 700 = 8924\ \#$

$h_d = 2.735 + 0.5\ (.64) = 3.055"$

$M_D = 8924\ (3.055) = 27263$ IN-LB

$H_T = 32868 - 8924 = 23944$ IN-LB

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$$h_T = \frac{2.095 + .64 + .883}{2} = 1.809$$

$$M_T = 23944\ (1.809) = 43315 \text{ IN-LB}$$

$$h = 1.71"$$

$$h_o = \sqrt{4.03\ (.235)} = 0.97$$

$$g_1/g_o = 2.72 \qquad h/h_o = 1.76$$

$$f = 1.0$$

$$V = 0.07$$

$$A = 11$$

$$K = 11/4.03 = 2.730$$

$$U = \frac{(2.730)^2\ (1 + 8.55246 \log_{10} 2.730) - 1}{1.36136\ (2.730^2 - 1)(2.730 - 1)} = 2.254$$

$$d = \frac{2.254}{0.07}\ (.97)\ (.235)^2 = 1.725$$

$$F = 0.63$$

$$C = \frac{0.63}{0.97} = 0.65$$

$$T = \frac{(2.730)^2\ (1 + 8.55246 \log_{10} 2.730) - 1}{(1.04720 + 1.9448\ (2.730)^2)(2.730 - 1)} = 1.274$$

$$x = 15/16"$$

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$$L = \frac{\frac{15}{16}(0.65)+1}{1.274} + \frac{\left(\frac{15}{16}\right)^2}{1.725} = 1.741$$

$$Y = \frac{1}{2.730-1}\left[0.66845 + 5.71690\,\frac{2.730^2 \log_{10} 2.730}{2.730^2-1}\right] = 2.051$$

$$Z = \frac{2.730^2+1}{2.730^2-1} = 1.310$$

$$M_0 = 23236 + 27263 + 43315 = 93814 \text{ IN-LB}$$

$$S_H = \frac{1.0(93814)}{1.741(.641)^2(4.03)} + \frac{700(4.03)}{4(.235)} = 35645 \text{ PSI}$$

$$S_R = \frac{\left(1.33\left(\frac{15}{16}\right)(0.65)+1\right)(93814)}{1.741\left(\frac{15}{16}\right)^2(4.03)} = 27543 \text{ PSI}$$

$$S_T = \frac{2.051(93814)}{\left(\frac{15}{16}\right)^2(4.03)} - 1.310(27543) = 18242 \text{ PSI}$$

Failure will be taken at the point the material yields and takes permanant deformation.
Using the distortion energy theory for ductile failure

$\sigma_1 = 35645$ PSI, $\sigma_2 = 27543$ PSI, $\sigma_3 = 18242$ PSI

$$\frac{1}{2}\left[(35645-27543)^2 + (27543-18242)^2 + (18242-35645)^2\right] \le (30000)^2$$

$$2.28 \times 10^8 \le 9 \times 10^8$$