OPPD ENGINEERING STUDY

88-32

120 DAY NRC REPORT

AS REQUIRED

BY

NRC BULLETIN 88-05

Prepared By:

D. S. Douin (S&L) 8-25-88

Reviewed By:

J. L. Skiles (S&L)

Approved By:

M. E. Eidem (OPPD)

SARGENT & LUNDY PROJECT NO. 7751-10

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1.0 Scope

This report addresses all documentation review actions requested in support of resolution of NRC Bulletin 88-05 by Omaha Public Power District's Fort Calhoun Nuclear Station - Unit 1.

2.0 Applicability

This report applies to review of documentation, material tests, evaluations, and engineering analysis activities associated with flanges and fittings supplied by West Jersey Manufacturing Company (WJM), as identified in NRC Bulletin 88-05.

3.0 References

NRC Bulletin 88-05, dated May 6, 1988
NRC Bulletin 88-05, Supplement 1, dated June 15, 1988
NRC Bulletin 88-05, Supplement 2, dated August 3, 1988
OPPD Modification Request Records
OPPD Quality Assurance Purchase Orders
WJM - Identified Material Data Information (CMTR's)
Orr MicroDur/Spectrograph Testing Report
Taussig Equotip Test Report No. 82138
Sargent & Lundy Evaluation of Taussig Test Results
Sargent & Lundy Engineering Analysis of Flanges

4.0 General

Circumstances which led to the issue of NRC Bulletin 88-05 involved three material suppliers providing alleged false testing information concerning material supplied to the nuclear power industry. As a result, all holders of operating licenses or construction permits for nuclear power plants were requested to take actions to determine if the suspect material had been received, perform tests on identified suspect material and assure the identified suspect material complies with ASME Code and design specifications or replace the material.

OPPD retained the services of Sargent & Lundy Engineers to coordinate all activities in support of compliance with NRC Bulletin 88-05.

Sargent & Lundy identified three programmatic activities to comprise the appropriate action necessary for compliance with NRC Bulletin 88-05. These are document review, material testing, and engineering evaluation. The remainder of this report focuses on the details of each of the three activities.

5.0 Document Review

5.1 Modification Request Records

5.1.1 The records review process included two types of OPPD documents; modification request records (MRR) and quality assurance purchase orders. Purchasers identified in NRCB 88-05 were also contacted to augment the review process.

5.1.2 Modification request records are engineering modification change packages which contain design, construction, procurement and equipment records. Flange and fitting material purchase orders with certified mill test reports are included or referenced within the MRR package.

MRR's totalling 17,673 were initially identified as the documents requiring disposition. This initial list consisted of all MRR's from 1973 (Fort Calhoun startup year) through 1988 which also included two fossil-fuel plants. A computer search reduced the population to 2,387 MRR's. This list included Fort Calhoun Nuclear Station MRR's for both safety and non-safety related applications. A comparison was then made to verify output data between the first and second list to ensure the MRR's shown on the first list were also included on the second list.

After the computer search was completed, a manual screening process followed based on word association taken from the MRR computer generated list description column. Flange, fitting, piping, valves, pumps, heat exchanger, containment penetration, equipment and applicable plant system identifier terms were used to manually screen the list. From this process, 435 relevant MRR's were identified and reviewed individually to determine whether flange or fitting material was supplied by Piping Supplies Incorporated (PSI), West Jersey Manufacturing Company (WJM) or Chews Landing Metal Manufacturers Incorporated (CLM). The MRR review did not identify any suspect material based on NRCB 88-05.

5.2 Quality Assurance Purchase Orders

5.2.1 The second type of document search, quality assurance purchase orders, was done by Fort Calhoun Nuclear Station Quality Assurance.

5.2.2 The computers data base was used to identify safety related purchase orders from 1976 through 1988.

A word search approach using flange, fitting, carbon, and stainless as the identifying word description was used. This process produced 170 purchase orders for further screening.

The 170 purchase orders were then reviewed and resulted in identifying Chicago Tube & Iron (CT&I) which appeared in NRC Bulletin 88-05.

CT&I was previously identified by OPPD during an informal review. Detail of further action is in the following section (5.3).

5.3 Review of Purchasers

5.3.1 OPPD performed a cursory review of purchasers identified in NRCB 88-05. It was identified as a cursory review because it was the first action taken by OPPD Production Engineering and was considered informal.

5.3.2 After reviewing NRC Bulletin 88-05, it was noted that Chicago Tube & Iron (CT&I) was listed. CT&I was contacted to identify the purchase order numbers under which WJM supplied flanges. Two purchase orders showing (4) 1 1/2", (2) 1" and (4) 10" SA-105 flanges were identified as the only material WJM supplied to Omaha Public Power District, See Attachment 1. These flanges were installed in the Waste Gas Disposal System (1 1/2" and 1") and Electrical Penetration E-11 through Containment (10"). Other purchasers from the bulletin list were also contacted which did not lead to identifying additional purchase orders.

6.0 Testing

6.1 Material Testing

6.1.1 After the WJM-supplied material was identified and subsequently located in the plant, testing was initially performed by Orr Metallurgical Consulting Service, Inc. and Taussig Associates.

6.2 MicroDur Test

6.2.1 Initial testing was performed by Orr Metallurgical for informational purposes only. Orr Metallurgical performed tests using the MicroDur method to determine hardness. Orr Metallurgical also tested for manganese content using a Portaspec portable x-ray spectrograph.

6.2.2 The Orr Metallurgical hardness test (MicroDur ultrasonic hardness tester) measures hardness test in Vickers hardness values. The x-ray spectrograph used to determine manganese content, is accomplished by analyzing the characteristic lines of elements emitted when bombarded by radiation.

6.2.3 The results of both informational tests, described above, resulted in anomalous values and were disregarded.

6.3 Equotip Test

6.3.1 Final testing was performed by Taussig Associates using the Equotip hardness testing method as identified by the NRC and NUMARC. See Attachment 2 for test results. Taussig Associates performed hardness tests in accordance with an approved procedure.

6.3.2 The test results showed that the (4) 1 1/2" and (1) 10" flanges were below the minimum tensile strength requirements per SA-105 material specification (70,000 PSI minimum). The flanges approximate values ranged from 65-68,000 PSI. These values based on design, service conditions and present operating conditions are within acceptable ranges. See Attachment 3 for S&L evaluation.

7.0 <u>Results</u>

7.1 Engineering Evaluation/Analysis

7.1.1 Two flanges were deemed inaccessible and were not tested. S&L demonstrated the acceptability of these flanges using the lowest reported tensile strength value reported to date in the industry (42 KSI). In addition, S&L performed calculations based on actual test results, for the accessible flanges, taken from the Taussig report, which showed the acceptability of these flanges (See Attachment 4).

7.2 Conclusions

7.2.1 Based on all test data and location of accessible and inaccessible flanges, no further corrective action is required. The lower than minimum values for the flanges are well within factors that ensure the material is acceptable for its intended service.

7.2.2 Unless otherwise directed by the NRC, this report completes OPPD actions, associated with NRCB 88-05, Supplement 1&2. Based on the action taken to date, the installed material will not be replaced and therefore the 60 day report required by the bulletin, is not required.

NRC BULLETIN NO. 88-05
MATERIALS DATA INFORMATION
OMAHA PUBLIC POWER DISTRICT
FORT CALHOUN NUCLEAR STATION UNIT 1

ATTACHMENT 1

SAMP	PLANT	DIAMETER	COMM	RATING	TYPE	SPEC ASTM/ASME	GRADE	SCH	VNDR	HEAT/LOT	CMTR DATE	QTY	QTY ON HOLD	(-INSTALLED-) ACC	NOT ACC	SOURCE	ASME CLS	TEST	SYSTEM LOCATION
A,B,C,D	FCS1	1.5	Flg.	150	SW	105	---	40	WJM	N86975	110882	4	0	4		CT&I	2	Y	Waste Gas Disposal
E,F	FCS1	1.0	Flg.	150	SW	105	---	40	WJM	N86041	110882	2	0	2		CT&I	2	Y	Waste Gas Disposal
G,H	FCS1	10	Flg.	150	WN	105	---	40	WJM	E40	122882	2	0	1	1	CT&I	2	Y	E-11 Penetration/ Containment
G,H	FCS1	10	Flg.	150	BL	105	---	40	WJM	B11	122882	2	0	1	1	CT&I	2	Y	E-11 Penetration/ Containment

LEGEND

SAMP - Letter Designation Taken from Samples in Attachment 2 Testing Results
PLANT - FCS1 - Fort Calhoun Station - Unit 1
COMM - Commodity Type
RATING Flange Pressure Rating
CMTR - Certified Mill Test Report
ACC - Accessible (for Testing)
SOURCE - CT&I - Chicago Tube & Iron

Taussig Associates Inc.

Metallurgical Engineers 7530 Frontage Road • Skokie, Illinois 60077 • 1 312 676-2100

Attachment 2

Report No. 82138/ August 24,1988

Omaha Public Power District
1623 Harney
Omaha, NE 68102

Attention: Mr. Tom Blair

S U B J E C T

OPPD Engineering Study 88-32.
Equotip Hardness Testing of Eight (8) Flanges at Omaha Public Power District, Fort Calhoun Power Station.

Background:

Hardness testing was performed on eight (8) flanges at the Fort Calhoun Power Station in compliance with NRC Bulletin #88-05 The eight samples included four (4) 1-1/2", and two (2) 1" ASME SA-105 flanges identified in PKS Drawing WD-4303 sheet 1 of 5. In addition, two (2) 10" ASME SA-105 flanges were identified in Graver Drawing #003773. The testing was performed in accordance with Taussig Associates Procedure Q.A.H. 1.81, revision 0, dated 7/28/88. The flanges were further identified as follows:

Sample	Material Type/Grade	Stamped Identification	Location
A	SA-105	WJ 1-1/2" 150 GDKH 105	Far South of Valve FCV-532A
B	SA-105	WJ 1-1/2" 150 GDKH 105	Near South of Valve FCV-532A
C	SA-105	WJ 1-1/2" 150 GDKH 105	Far South of Valve WD-165
D	SA-105	WJ 1-1/2" 150 GDKH 105	Near South of Valve WD-165
E	SA-105	GDEL SA-105 B16.5 CL. 2	South of Valve WD-157
F	SA-105	GDEL SA-105 B16.5 CL. 2	Above Valve WD-156
G	SA-105	10" WJ 150 SA-105 E-40 STD. CL. 2	Electrical Penetration E-11
H	SA-105	10" WJ 150 SA-105 B-11 STD. Cl. 2	Electrical Penetration E-11

We were requested to perform the aforementioned test to determine the hardness and approximate tensile strength of the flanges.

Test Results:

Hardness Testing:

Prior to testing the paint was removed and surfaces prepared with a hand grinder equipped with 60 and 100 grit paper. The hardness tests were performed on the outer diameter of the eight (8) flanges utilizing a calibrated Equotip Hardness Tester. The calibration of the hardness tester was checked in accordance with Taussig Associates Procedure Q.A.H. 1.81, revision 0, dated 7/28/88. A minimum of five impressions were taken on each flange. The "L" values were documented and corrected for the angle of the indenter during the test and temperature of the flange. The high and low readings were deleted and an average was calculated from the remaining values. After testing the calibration of the Equotip Hardness Tester was rechecked to assure accuracy of the readings in compliance with the Taussig procedure. The "L" value results were then converted to equivalent Brinell hardness and approximate tensile strength in accordance with ASTM A370. The test results are shown in Tables I and II.

Conclusion:

Based upon the preceding test results, the converted approximate tensile strengths indicate that the flanges identified as A through D, and G would not meet the minimum tensile requirement (70,000 psi) of ASME SA 105 Sect. II 1980 edition. The approximate tensile strength of flanges E, F, and H would meet the aforementioned requirement.

Respectfully submitted,

TAUSSIG ASSOCIATES, INC.

Thomas C Raleigh

Thomas C. Raleigh
Staff Metallurgical Engineer

Table I

Raw
Equotip Hardness Results

Sample	Raw L- Values
A	395, 400, 393 389, 393, 393
B	389, 378, 393 390, 401, 404
C	406, 394, 393 408. 394,
D	393, 399, 395 405, 401
E	402, 462, 468 460, 455, 440
F	430, 406, 431 413, 427, 430
G	403, 404, 406 398, 407
H	425, 425, 422 424, 420

Table II

Corrected Hardness/ Tensile Results

Sample	Test Angle/ Correction Factor	Test Temperature/ Correction Factor	Average Corrected L-Value	Brinell Hardness (BHN)	Approximate Tensile Strength (PSI)
A	45°/-6	90°/+6	394	136	66,000
B	45°/-6	90°/+6	393	135	65,000
C	45°/-6	90°/+6	398	138	67,000
D	45°/-6	90°/+6	398	138	67,000
E	90°/-11	90°/+6	449	176	86,000
F	90°/-11	90°/+6	425	158	80,000
G	0	75°/0	404	143	68,000
H	0	75°/0	424	157	77,000

SARGENT & LUNDY

INTEROFFICE MEMORANDUM

ATTACHMENT 3

From E. Fernandez - 28, X8690 EF

Dept./Div. Services/Quality Control Division

Date August 25, 1988

Project No. 7751-10

Spec. No.

File No.

Client OPPD Stn. Ft. Calhoun Unit 1

Subject Evaluation of Taussig Report No. 82138 for OPPD Engineering Study 88-32

To: D. S. Douin - 28

CC: J. L. Skiles - 28

Per your request, I have reviewed Taussig Report No. 82138 concerning hardness testing of eight (8) flanges at the Omaha Public Power District (OPPD), Fort Calhoun Power Station, per NRC Bulletin #88-05. The material for these flanges were reportedly ASME SA105. Hardness tests were performed to obtain the correlating approximate tensile strengths to determine if they meet the 70,000 psi minimum tensile requirement of ASME SA105.

The results of the test indicate, the approximate tensile values of samples E, F, and H met the specified minimum tensile requirement, however, approximate tensile values of samples A through D and G did not meet the required minimum tensile strength. The approximate tensile values obtained for samples A through D and G were between 2,000 to 5,000 psi below the minimum tensile strength of ASME SA105.

The design pressure for these flanges (Samples A thru D and G) was reported to be 150 psig for samples A thru D and 60 psig for sample G at the design temperature of 200°F. The maximum allowable pressure for ASME SA105 at a temperature of 200°F is 260 psig for sample A thru D and 230 psig for sample G as identified in ANSI B16.5.

Since the design pressure is significantly below the maximum allowable pressure for the material and that tensile strength is directly proportional to the maximum allowable pressure, it is my opinion that flanges identified as samples A thru D and G are acceptable, based on the reduced tensile strength, for use under these design service conditions.

EF/gs

SARGENT & LUNDY
ENGINEERS
CHICAGO

ATTACHMENT 4

SAFETY-RELATED

Calc. No.: ES-88-32
Acc. No.: EMD-065135
Page 1 Rev.: 01

ENGINEERING ANALYSIS

10 INCH 150# UNUSED CONTAINMENT PENETRATION FLANGES AND 1 INCH AND 1½ INCH 150# GAS WASTE DISPOSAL SYSTEM FLANGES

OPPD ENGINEERING STUDY ES-88-32
AUGUST 25, 1988

OMAHA PUBLIC POWER DISTRICT
FORT CALHOUN - UNIT 1
PROJECT NO. 7751-01

SARGENT & LUNDY ENGINEERS
ENGINEERING MECHANICS DIVISION

SIGNATURE PAGE & REVISIONS SUMMARY

EMD Accession No.	Date	Analysis Prepared By	Analysis Reviewed By	Analysis Approved By	Stress Report Prepared By	Stress Report Reviewed By	Stress Report Approved By
EMD-064997 ES-88-32	08-01-88	R. Mahendranathan Date: 7/27/88	J. J. Patel Date: 7-27-88	R.Mahendranathan Date: 7/27/88	R.Mahendranathan Date: 8/3/88	J. J. Patel Date: 8/3/88	M. O. Callahan Date 8/3/88

...UE SUMMARY

EMD-065135 ES-88-32	08-23-88	R. Mahendranathan Date: 8/23/88	J. J. Patel Date: 8/23/88	R.Mahendranathan Date: 8/23/88	R.Mahendranathan Date: 8/23/88	J. J. Patel Date: 8/23/88	M. O. Callahan Date: [illegible]

...UE SUMMARY

Revised to incorporate the test results for 8 flanges. Revised pages: 1,2,3,10,11,12,13,14

		Date:	Date:	Date:	Date:	Date:	Date:

...UE SUMMARY

Calc. No.: ES-88-32

SARGENT & LUNDY
ENGINEERS
CHICAGO

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1.0 Purpose

The purpose of this calculation is to evaluate the acceptability of pipe flanges in response to NRC Bulletin 88-05. This calculation addresses potential material deficiencies related to the flanges listed below.

4 @ SA-105/RF,SW,Flg, 1.5"/[illegible]	Waste Disposal System (Gas)
2 @ SA-105/RF,SW,Flg, 1.0"/150#	Waste Disposal System (Gas)
2 @ SA-105/RF,WN,Flg, 10"/150#	Unused Containment Penetration
2 @ SA-105/RF,BLD,Flg, 10"/150#	Unused Containment Penetration

2.0 Input and Assumptions

(1) Pressure and Temperature Input

The maximum pressure and temperature information was obtained from the controlled copy of USAR, and is summarized below.

Containment (USAR Page 5.4.1)

Design Pressure - 60 psig
Max (Design) Accident Temperature - 305° F

Waste Disposal System (Gas)

Max Operating Temperature	140° F
Design Temperature	200° F
Max Operating Pressure	100 psig
Design Pressure	150 psig

(2) Associated Piping

Containment Penetration

Per Graver Tank and Manufacturing Company Drawing L24065, Rev. 02, the penetration is blind flanged at both ends and is not used. Penetration schedule at weld point is Schedule 40.

Waste Disposal System (Gas)

Per Piping Specification Class 152 of Contract 763, the piping is Schedule 40.

9.0 References

1. ASME Boiler and Pressure Code Section III, 1983 Edition, including up to Summer 84.
2. ANSI B16.5 1981 Edition
3. Fort Calhoun USAR
4. P&ID Diagram 11405M98, Rev. 40
5. Contract 763 Pipe Specification Class 152
6. Graver Tank and Manufacturing Company Drawing L24065, Rev. 2
7. NRC Bulletin 88-05 and Supplement 1
8. Taussig Associates Inc. Report No. 82138, August 19, 1988

4.2 Calculation of Pipe Minimum Wall Margin

The minimum (required) wall thickness is calculated using NC/ND-3641.1 of the ASME Code.

$$t_m \text{ required} = \frac{PD_o}{2(S+Py)} + A$$

A = 0 unused penetration of containment

0 for socket of SW flange; no fluid flow at the socket inside diameter (Waste Disposal)

D_o = Outside diameter of pipe or outside diameter of socket for SW flange.

P = Design Pressure

y = 0.4 per NC/ND-3641.1

S = 17500 psi per Appendix I of ASME Code Section III

t_m available = 0.875 of nominal thickness

10" WN Penetration Flange

D_o = 10.75 in.

P = 60 psig

t_m required = 0.0184

Actual Miminum Wall = .365 x .875
= .319 inch

Wall Thickness Margin = 94%

10" BLD Flange

Minimum wall check is for hoop stress and is not applicable for blind flanges.

1½" SW Flange

$$t_m \text{ Required} = \frac{150 \times 2.513}{2(17500 + 0.4 \times 150)} + 0$$

= 0.011 inch

Per ANSI B16.5 nominal wall thickness of hub

= ½ ((2.56 - 2(.88 - .69) tan 7°) - 1.95)

= .282

Actual minimum wall thickness = .282 x .875

= .246 inch

$$\text{Minimum wall thickness margin} = \frac{.246 - .011}{246}$$

= 95%

1" SW Flange

$$t_m \text{ Required} = \frac{150 \times 1.908}{2(17500 + 150 \times .4)} + 0$$

= .008 inch

Per ANSI B16.5 nominal wall thickness of hub

= ½ ((1.94-2(.69-.56)tan 7°) - 1.36)

= .274 inch

Actual wall thickness = 0.274 x 0.875

= 0.239 inch

$$\text{Minimum wall thickness margin} = \frac{.239 - .008}{.239}$$

= 96%

4.3 Stress Check at the Hub Weld Point

At the point the hub meets the pipe, it is treated as a pipe section and checked against the associated pipe to calculate the available margin. The pipe stress equation can be expressed in the following general form:

$$\frac{P \times A_1}{A_2} + i\,\frac{M}{Z} < S$$

P = Pressure

A_1 = Inside Area of Pipe

M = Moment

Z = Section Modulus

A_2 = Metal Area of Pipe

Socket Welded Flange

Metal area of pipe (A_2) is compared against metal area of socket. Also, section modulus of pipe is compared against the section modulus of socket. Based on the comparison, it is observed that the socket is stronger than the pipe. Generic margins are calculated.

Weld Neck and Blind Flanges

Since the above flanges are located on an unused penetration moment, term is zero, and as a result no stress check is required.

1½ Inch 150# Flange

Outside diameter of socket = 2.56-2(.88-.69) tan 7°

= 2.513

Inside diameter of socket = 1.95 inch

Metal area of socket = $\frac{\pi}{4}(2.513^2-1.95^2) = 1.973$ in²

Section modulus of socket = $\frac{\pi}{64}(2.513^4-1.95^4)/(2.313/2)$

= .993 in³

Metal Area of Sch. 40 Pipe = .800 in^2

Section Modulus of Pipe = .3262 in^3

Metal Area Margin = $\frac{1.973-.800}{1.973}$ = 59%

Section Modulus Margin = $\frac{.993-.3262}{.993}$ = 67%

Minimum Generic Stress Margin = 59%

1 Inch 150# Flange

Outside diameter of socket = 1.94-2(.69-.56) tan 7°

= 1 908 inch

Inside diameter of socket = 1 36 inch

Metal area of socket = $\frac{\pi}{4}(1.908^2-1.36^2) = 1.406$ in^2

Section modulus of socket = $\frac{\pi}{64}(1.980^4-1.36^4)/(1.908/2)$

= .506 in^3

Metal area of Sch. 40 Pipe = .430 in^2

Section modulus of pipe (Sch. 40) = .1328 in^3

Metal area margin = $\frac{1.406-.49}{1.406}$ = 65%

Section modulus margin = $\frac{.506-.1328}{.506}$ = 74%

Minimum generic stress margin = 65%

4.4 External Moment Load on Flange

Since the 10" WN and 10" BLD flanges are located on an unused penetration, there are no moment loads on them. As a result, no moment check is required.

Since the 1 inch and $1\frac{1}{2}$ inch flanges are located on small bore piping system, no moment load information is available at the flange location. It is conservatively assumed that all moment are such that the stresses will be at the allowable limits. Since the piping is cold (less than 150°F) the thermal moments are ignored. Based on the above, the moments are as follows:

Service Level A = $S_h \times Z$

Service Level B = $1.2\ S_h \times Z$

Service Level C = $1.8\ S_h \times Z$

Service Level D = $2.4\ S_h \times Z$

Note: It is conservatively assumed that an i value less than 1.33 and S_h of 15000 psi for pipe was used in the original design.

Design Basis Allowable Moments

The code design basis allowable moments are as follows. All nomenclature are per NC-3658.

Service Level A = $3125\ CA_bS_y/36$

Service Level B = $6250\ CA_bS_y/36$

Service Level C/D = $\left(11250\ A_b - (\pi/16)\ D_f^2 P_{fd}\right) C\ (S_y/36)$

Calculation of moment margin

	$1\frac{1}{2}$ inch 150#	1 inch 150#
D_f	2.88 inch	2 inch
C	3.88 inch	3.12 inch
A_b	.1419 x 4 in²	.1419 x 4 inch²
P_{fd}	150	150

Using tnc above design basis margins are calculated. The margins are tabulated below.

1 incn 150#

	Design Margin
Service Level A	60%
Service Level B	76%
Service Level C	80%
Service Level D	73%
Min. Moment Margin	60%

1½ incn 150#

	Design Margin
Service Level A	22%
Service Level B	53%
Service Level C	59%
Service Level D	46%
Min. Moment Margin	22%

4.5 Functional Capability

Since the 10 inch flanges do not pass flow, no functional capability check is needed. The stress equation is of the same form as the stress check equation and as a result, the margin calculated for stress can be conservatively used for functional capability check.

5.0 Hardness Test Results

The subject flanges were tested by Taussig Associates Inc. The results of the tests are summarized below.

Sample	Identification	Location	Approximate Tensile Strength - psi
A	WJ 1-½" 150 GDKH 105	Far South of Vulve FCV-532A	66000
B	WJ 1-½" 150 GDKH 105	Near South of Valve FCV-532A	65000
C	WJ 1-½" 150 GDKH 105	Far South of Valve WO-165	67000
D	WJ 1-½" 150 GDKH 105	Near South of Valve WO-165	67000

Sample	Identification	Location	Approximate Tensile Strength - psi
E	GDEL SA-105 B16.5 CL.2	South of Valve WD-157 (1 inch)	86000
F	GDEL SA-105 B16.5 CL.2	Above Valve WD-156 (1 inch)	80000
G	10" WJ 150 SA-105 E-40 STD. CL.2	Electrical Penetration E-11 (Outside)(Weldneck)	68000
H	10" WJ 150 SA-105 B11 STD. CL. 2	Electrical Penetration E-12 (Outside)(Blind)	77000

One 10 inch weldneck flange and one 10 inch blind flange inside containment are inaccessible and are therefore not tested.

6.0 Required Margin

The required margin is the percent reduction in material strength properties. The relevant material strength properties are:

(a) Tensile strength at Ambient Temperature
(b) Tensile strength at Design Temperature
(c) Yield strength at Ambient Temperature
(d) Yield strength at Design Temperature

One pair of 10 inch flanges on the inside of unused electrical penetration is inaccessible and therefore was not tested. Other flanges were tested for hardness. The hardness values were correlated to estimate the tensile strength at room temperature. No other test results are available. The following assumptions were used to estimate other relevant material strength properties.

(a) The WJM-supplied flange material properties change with temperature in the same manner as SA-105 material.

(b) The percent reduction in yield strength is the same as the percent reduction in tensile strength. Even though there is no correlation between yield strength and tensile strength, the data reported through INPO network indicates that the percent reduction in yield strength is lower than that of tensile strength. Therefore, the above assumption is conservative.

Based on the above, the required margin is the percent reduction in tensile strength at room temperature. The required minimum tensile strength is 70 ksi.

Flange	Minimum Value Reported	(Percent Reduction)
1½ SW Flange	65000 psi	8%
1 SW Flange	80000 psi	0%
10 WN Flange (Outside)	68000 psi	3%
10 BLD Flange (Outside)	77000 psi	0%
10 WN Flange (Inside)	Not Tested*	40%
10 BLD Flange (Inside)	Not Tested*	40%

* Tensile strength was assumed to be equal to the lowest value reported so far (42 ksi).

7.0 Summary of Results

The design margins calculated so far are summarized below.

	10" 150# Blind Flange		10" 150# WN Flange		1½" 150# SW Flange	1" 150# SW Flange
	Inside	Outside	Inside	Outside		
Pressure Rating	74%	74%	74%	74%	42%	42%
Min. Wall Check	-	-	94%	94%	95%	96%
Hub Stress Check	-	-	-	-	59%	65%
Moment Load	-	-	-	-	22%	60%
Functional Capability	-	-	-	-	59%	65%
Minimum Available Operability Margin	74%	74%	74%	74%	22%	42%
Required Margin	40%	0%	40%	3%	8%	0%

8.0 Conclusions and Recommendations

Based on the analysis there is sufficient margin in the original design to account for the lower material strength of the tested flanges. The inaccessible flanges have a design margin of 74% which is higher than the required margin of 40%. As a result, there are no strength concerns related to leaving the flanges in place indefinitely.

9.0 References

1. ASME Boiler and Pressure Code Section III, 1983 Edition, including up to Summer 84.
2. ANSI B16.5 1981 Edition
3. Fort Calhoun USAR
4. P&ID Diagram 11405M98, Rev. 40
5. Contract 763 Pipe Specification Class 152
6. Graver Tank and Manufacturing Company Drawing L24065, Rev. 2
7. NRC Bulletin 88-05 and Supplement 1
8. Taussig Associates Inc. Report No. 82138, August 19, 1988