Washington Public Power Supply System
A JOINT OPERATING AGENCY

P. O. Box 968 3000 Geo. Washington Way Richland, Washington 99352 Phone (509) 946-9681

September 5, 1975
G02-75-253

DOCKET #50-397

Mr. R. H. Engelken, Director
Nuclear Regulatory Commission
Region V
1900 N. California Blvd.
Walnut Creek, California 94596

Subject: WPPSS NUCLEAR PROJECT NO. 2
FABRICATION DIFFICULTIES, STEEL CONTAINMENT VESSEL

Reference:
1. G02-75-178, same subject, dtd 6/23/75.
2. G02-75-213, same subject, dtd 7/28/75.
3. BRWP-75-2056, "Completion of Repair of Containment Vessel, NCR-213-00058, -00059, -00060", dtd 8/20/75.
4. BRPDM-213-F-75-128, "Containment Vessel U.T. Test Report", dtd 7/7/75.
5. BRPDM-213-F-75-162, "Repair of Containment Vessel, NCR-213-00058, 00059, 00060", dtd 8/20/75.

Dear Mr. Engelken:

This is the final report on the successful disposition of the fabrication difficulties on the WNP-2 Containment Vessel. References 1 and 2 were interim status reports, describing the earlier actions in the repair of lamellar tears in the shell adjacent to two reinforcing ring attachments. Reference 2 mentioned two activities yet to be performed. These were an engineering evaluation of a 1" x 2" indication and a final review of the examination reports.

The engineering evaluation in reference 3 (attached) describes the basis for the conclusion that the indications found by ultrasonic examination following the first pneumatic test were not caused by the pneumatic test. The meeting requested by item 2 of reference 5 took place on August 26, and satisfactory documentation has been provided.

The 1" x 2" indication will be removed because it is the only indication remaining that required the use of Code Class 1 plate acceptance criteria. This acceptance criteria would require more engineering evaluation than had been provided by the contractor. By removing this indication, there is no need for the engineering evaluation. An examination and vacuum box test will be performed following the removal and repair of the indication.

September 5, 1975
G02-75-253

A wrap-up of the documentation is being done as described in references 4 and 5 (attached), including correction of some inconsistencies.

We have a commitment (reference 4) for the examination of areas where the scaffold and ladder brackets were previously restricting access. A significant percentage of these areas have been examined without detection of lamellar tears (reference 3 attached). Because of personnel safety considerations, the inspection of these areas and the repair of the 1" x 2" indication will not be accomplished for several months when scaffolding is installed for other construction activities.

As described in reference 3, the actions taken will assure that the vessel will not be subject to lamellar tearing from containment vessel leakage tests, normal operation, or design accident loading.

A complete record of technical evaluations, meetings, repairs, examinations, and tests associated with the resolution of the fabrication problem has been maintained and is available for review.

Very truly yours,

N O Strand

N. O. STRAND
Assistant Director
Generation & Technology

NOS:JCM:lm

Attachments-References 3-5

cc: JJ Byrnes, Burns & Roe, NY
JJ Verderber, Burns & Roe, NY
JD Wilson, Burns & Roe, Site
D Roe, BPA, Richland

Reference #3

RECEIVED

AUG 25 1975

Burns and Roe, Inc.

320 Fulton Avenue ▪ Hempstead, New York 11550 ▪ Telephone (516) 560-7070

TWX 510-222-4935 ▪ Cable BUROE HEMPSTEADNY

Main Office,
700 Kinderkamack Road
Oradell, New Jersey 07649

bject: W.O. 2808
Washington Public Power Supply System
WPPSS Nuclear Project No. 2
Completion of Repair of Containment Vessel
NCR-213-00058,-00059,-00060

August 20, 1975
BRWP-75-2056

Ref 3

Washington Public Power Supply System
3000 George Washington Way
Richland, Washington 99352

WNP NO. 2	
P. M SEC Admin	1
L LARIVIERE	2
OE TRAPP	1
GE DEEGAN	1
GL GELHAUS	
J HARRINGTON	
SITE MANAGER	
D HOWARD	
~~A BRESNIVEMO~~	
COMMIT CONTROL	✓

Attention: Mr. M. E. Witherspoon

rence:
1. Letter from JJByrnes to JEWoolsey, BRWP-75-307, dated 3/18/75
2. Letter from JJByrnes to JEWoolsey, BRWP-75-570, dated 4/30/75
3. Letter from JJByrnes to JEWoolsey, BRWP-75-755, dated 6/2/75
4. Letter from MSchulze to RCRoot, PDMBR-CM-131-75, dated 6/5/75
5. Letter from RCRoot to MSchulze, BRPDM-213-F-75-128, dated 7/7/75
6. Letter from JFStrunk to JJVerderber, PDMBR-213-75-27, dated 7/22/75
7. Letter from RCRoot to MSchulze, BRPDM-213-F-75-155, dated 8/6/75
8. Letter from JDWilson to MSchulze, BRPDM-213-F-75-162, dated 8/19/75
9. Letter from MEWitherspoon to JJByrnes, WPBR-75-845, dated 7/1/75

Gentlemen:

The purpose of this letter is to summarize events involved in the repair of the lamellar tears that developed in the containment vessel where the two pipe whip support girders are

attached. The details of the lamellar tears are contained in the subject non-conformance reports.

As you know, two cracks later identified as lamellar tears were found visually when the girder attachment welds were being cleaned preparatory to magnetic particle testing. Ultrasonic examination was used to confirm the extent of the tearing.

This examination revealed a number of indications of possible additional lamellar tears imbedded in the shell plates. The progress towards effecting acceptable repairs is described in references 1, 2 and 3.

At the time reference 3 was written, the repairs were thought to be complete. A pneumatic test had been performed successfully, and PDM was in the process of conducting the ultrasonic examination to determine if lamellar tears recurred or if unacceptable flaw growth had occurred. The events since that time are described below.

The ultrasonic examination after the pneumatic test showed that the small tears surrounding the repairs made from the outside did not grow in size. However, three previously unreported conditions were observed: a 2" long by 1" wide indication at the lower web of the upper pipe whip support adjacent to a scaffold bracket, and adjacent 10" long and 14" long areas of indications at the lower web of the lower pipe whip support. These conditions were described in reference 4. The remaining areas behind the attachment welds for the two pipe whip supports were found to be acceptable except that the areas behind scaffold brackets were not examined because they were inaccessible, and the areas repaired from the outside were not examined because they are immune to lamellar tearing being composed of weld metal through the full thickness of the shell plates.

Detailed examination of the reports documenting this examination by our site personnel uncovered a number of inadequacies and raised a number of questions. Consequently, reference 5 directed PDM to perform a UT inspection of the area behind the scaffold bracket next to the 2" by 1" indication to confirm the size of this indication. It further directed PDM to perform a UT inspection of all other areas that were

inaccessible for inspection because of brackets, etc. An amplified description of the "new" indications and an explanation of the use of the three UT procedures were also requested.

From further information supplied by PDM in reference 6 supplemented by phone conversations with the people involved, we learned the following additional information about the above conditions.

1. The 2" by 1" indication is behind a part of the pipe whip support attachment weld that was not repaired. Its location was marked in chalk by the inspector who performed the original ultrasonic survey to determine locations of discontinuities. His chalk marks indicate that he observed something requiring further exploration, but he did not include whatever it was in his report (Hamill Testing Laboratory Report #001 of March 1 and 2, 1975) as a reportable indication. Since the inspector was required to record only those indications with an amplitude greater than a stated amount at the prescribed high sensivitity, we assume this indication was unreported because it was of insufficient amplitude. However, we cannot be sure the omission was not inadvertent.

2. The two areas of indications at the lower web of the lower pipe whip support were at a location where repairs had been made from the inside. However, the UT report for the original examination of these areas (Hamill Testing Laboratory Report #002 dated March 12-16, 1975) shows no indications there. The repair resulted from "chasing" into this region a subsurface defect in the excavation of an adjacent repair. This extension to the repair, unfortunately, was not recorded. Thus, when the inspector performed the UT examination of the original repairs, he did not examine this region because he did not know it had been repaired. It was not examined until after the pneumatic test.

   PDM decided that the two areas of indications at the lower pipe whip support were unacceptable. The indications were removed and the areas were repaired and examined in accordance with the approved procedure. Then, the pneumatic test was

repeated. These areas were subjected to a soap solution test for leaks while the vessel was pressurized, and no leaks were found. The four attachment welds to the two pipe whip supports then were re-examined ultrasonically. No flaw growth was observed; no new indications were found.

PDM's attempt to examine the areas that were previously behind scaffolding brackets could not be fully carried out because of the impracticality of reaching certain areas after the scaffolding had been removed. Of 28 locations on the upper pipe whip support, they examined 19. Of the 28 on the lower pipe whip support, they examined only 4. Therefore, we instructed PDM to examine the remaining locations when the erection of the scaffolding for the installation of the insulation around the containment vessel reaches a level that can be used for support. See reference 8.

In addition, reference 8 directed PDM to remove and repair the 2" by 1" indication when they can work from the scaffolding. This repair is to be examined along with the remaining previously inaccessible locations, and will be subjected to the vacuum box leak test, too.

At this point we would like to respond to the questions posed in your letter, reference 9.

<u>Question 1</u> - Does the pneumatic test demonstrate that lamellar tearing will not occur under service stresses?

<u>Answer 1.1</u> - The pneumatic test, performed at 115% of design pressure, is a test for pressure integrity. Like hydrostatic tests, it is not intended to duplicate the service conditions of seismic, thermal transient, or postulated accident loading to which the vessel may be subjected. These other service loading conditions are justified by analysis.

<u>1.2</u> - Tabulated below are the through-thickness stresses at the upper and lower attachment welds of the upper pipe whip support for both pneumatic test and service loading conditions (Reference B&R Calculation No. 8.70.16. Book No. 8.70-2):

		Through-Thickness Tensile Stresses (psi)	
	Loading Condition	@ Weld Throat	@ Conical Shell
Upper Weld	Test	554	571
	Service	1738	1790
Lower Weld	Test	626	481
	Service	670	515

These through-thickness stress levels are quite low for both pneumatic test and service loading conditions. Their negligible magnitude may be compared to the specified 80,000 to 100,000 psi tensile strength (transverse direction, standard corner test location) and to the through-thickness tensile strengths observed by Spaeder [1*] on similar material: 70,000 to 80,000 psi.

For completeness of presentation, it should be noted that a maximum service tending stress level of ± 41,707 psi, coincident with a through-thickness compressive stress of 775 psi, exists at the throat of the upper weld attachment. The resulting total stress of 42,482 psi is within the 90% yield strength value of 43,128 psi. The bending component of stress is not considered as contributing to lamellar tearing since the pure bending stress results in zero net tension. (The value of 1738 psi is presented in the table above, since it represents a maximum through-thickness tensile stress; its corresponding bending stress @ the weld throat is ± 38,250 psi).

The through-thickness stress levels for both pneumatic test and service loading conditions cannot be considered significant with respect to generating tears or propagating cracks.

Question 2 - Can applied stresses enlarge an area of incipient tearing or initiate tearing in an area of high residual stress?

Answer 2 - The above discussion describes the service stresses in the through-thickness direction as a tiny fraction of the

*Technical references are listed at the end of this letter.

strength in this direction and of insufficient magnitude to be a credible cause of cracking or of crack extension. The case for their being additive to residual stresses of near fracture intensity is discussed below.

Where cracking occurred, one may conclude with validity that the true fracture stress (or true fracture strain) was generated locally. Such areas were repaired, and are now sound.

But what of the areas that did not crack. Weren't they exposed to conditions almost as severe, and, since the vessel was not stress relieved, aren't those conditions present even today?

The answer is yes, they must have been exposed to conditions almost as severe as those that caused tearing; but no, those conditions are not as severe today. In the intervening time, the plastic stresses and strains have relaxed to lower values and have been redistributed over larger volumes of metal thereby eliminating their potential for tearing.

This conclusion is supported by the two attached figures[2] illustrating room temperature creep in a carbon steel and in type 310 stainless steel. The former steel is known to have low resistance to creep; the latter is known to have high resistance to creep. The carbon-manganese-silicon steel of the shell plates can be expected to resemble the carbon steel in creep resistance.

These data indicate that peak stresses after welding should have already experienced stain relaxation in creep well in excess to 0.0005 in/in. Most of the relaxation, occurred within hours of welding. Additional relaxation, especially for stresses in excess of the yield strength, will occur over the years. This 0.0005 value may be compared with the strain associated with the service stresses, less than 0.0001 in./in.

Thus, the action of the service stresses tending to open and extend an incipient lamellar tear or to generate a new tear is less than the amount of relaxation that has occurred

already. Those locations that may have been on the verge of cracking after welding or after repairing have relaxed more than they will ever be loaded again, and will continue to relax.

Therefore, the service stresses are incapable of developing the fracture stress even when added to existing peak residual stresses.

Question 3 - WPPSS position that real flaw growth be subjected to engineering analysis.

Answer 3 - No flaw growth was observed. The "crack front" of the numerous small cracks surrounding all the repairs made from the outside was closely monitored. They exhibited no growth after the first pneumatic test and no growth after the second penumatic test. The initial size of the 2" by 1" indication was not recorded before the first penumatic test, but its size after both pneumatic tests was recorded. No growth occurred during the second pneumatic test. The initial sizes of the two areas of indications that were removed after the first pneumatic test at the lower pipe whip support were not recorded so that no observation of growth was possible.

Question 4 - Evaluation of "new" indications found in the shell after the pneumatic test.

Answer 4 - This concerns the 2" long by 1" wide ultrasonic indication at the lower web of the upper pipe whip support and the two adjacent areas of indications at the lower web of the lower pipe whip support.

4.1 - As noted above, the inspector's chalk marks on the vessel at the 2" by 1" indication indicate that he observed something requiring further exploration. One reasonably may conclude that an ultrasonic indication was present at this location before the pneumatic test. Dr. W. E. Cooper, our consultant, had pointed out earlier that indications just under the reportable level and, therefore, not reported before the pneumatic test, may grow slightly in amplitude during the test becoming reportably. They would then show as new indications when in reality they represent only minor changes. This caution from Dr. Cooper was noted in

reference 3. Later, Dr. Cooper commented on this again during the joint meeting in Waltham, Massachusetts on May 28, 1975. See Conference Notes 355, dated 5/28/75. Referring to the experience with the reactor pressure vessel at Pilgrim Station where an ultrasonic indication changed in amplitude from acceptable to a conditionally acceptable level. Dr. Cooper stated that the change was attributed to a very slight opening displacement of the discontinuity. He said this displacement had been estimated at 10^{-7} inch, about one atom layer.

The presence of the chalk marks from the initial examination lends credence to the conclusion that the 2" by 1" indication occurred in a similar manner.

We note further that the extreme sensitivity used in the ultrasonic examination contributes to the variability of the results. Some of the indications reported by the Hamill inspector and not repaired could not be found by the PDM inspector even though both were operating at the same sensitivity but at different times, for example. At this high level of sensitivity, consistent amplitude readings are virtually impossible even for the same operator and equipment at different times. Thus, the discovery of the 2" by 1" indication after the pneumatic test may not represent a really significant change.

4.2 - The known facts surrounding the two indications found and repaired after the first pneumatic test are described above. No additional indications were found after the second pneumatic test.

Summary

With the planned repair of the 2" by 1" indication and the anticipated examination of the remaining areas that were previously behind scaffolding brackets without further incident, the acceptability of the repair will have been demonstrated. The lamellar tears have been removed and replaced with sound weld metal in accordance with approved procedures. Some additional tears were produced in the process; and they were removed and replaced with sound weld metal. These subsequent repairs have small tears

around their edges. These imperfections were investigated and found to be acceptable. Close observation of them has shown they did not grow during two pneumatic tests. A small 2" by 1" indication was found after the first pneumatic test. It appears to be a discontinuity that intensified during the first pneumatic test by a process that was known to exist so that its amplitude after the pneumatic test was above the reportable level when examined at the high sensitivity. While it might seem to be a new discontinuity, a more likely explanation is that it is a minor modification of a pre-existing condition. This discontinuity did not grow during the second pneumatic test. Nevertheless, it will be repaired. Two other indications found after the first pneumatic test were repaired, and the adequacy of this repair was verified by a second pneumatic test. The likelihood that these indications were generated during the first pneumatic test is remote because the stress in the through-thickness direction is only a few hundred psi; while the strength is known (from other work) to be 70,000 to 80,000 psi, and, even when added to peak residual stresses, is incapable of developing the fracture stress. A more likely explanation is that they were present before the pneumatic test having been associated with a repair that was not examined ultrasonically because of a known failure of communication.

In conclusion, pending completion of the remaining work withour further incident we consider the lamellar tears to have been repaired acceptably, and the occurrence of additional tears in the future to be impossible. We have reviewed this matter with our consultant, Dr. W. E. Cooper, and he concurs with these conclusions.

We will advise you on completion of the remaining UT measurements and repair of the 2" by 1" indication.

Very truly yours,

James J. Byrnes
Project Director

JJB/at
Attachment

JJB/HEL/JRC
cc: Mr. D. J. Anderson, BPA w/1
Dr. W. E. Cooper, w/1

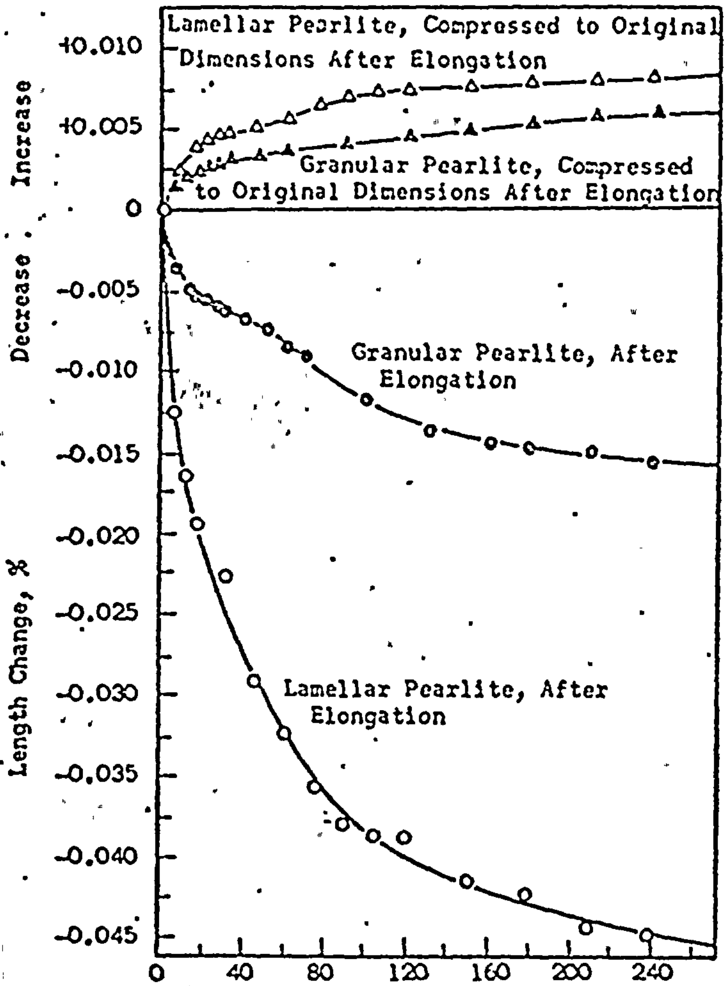

FIGURE 56. ELASTIC AFTER EFFECT OF EUTECTOID STEEL BAR AFTER ELONGATION OR COMPRESSION TO THE ORIGINAL DIMENSIONS AFTER 4% ELONGATION(22)

Room Temperature: about 10 degrees

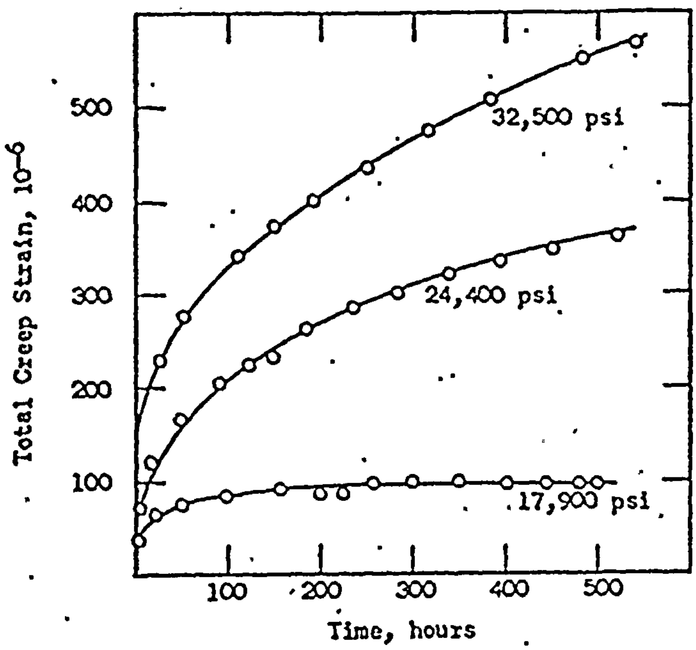

FIGURE 17. TOTAL CREEP CURVES OF 310 STAINLESS STEEL AT 85 F(13)

From Technical Reference 2

Technical References

1. G. J. Spaeder, "Effect of Sulfur on Through-Thickness Properties of C-Mn Steel Plates, "Welding Journal, June 1975, pp. 196s-200s.

2. R. E. Maringer, "Review of Dimensional Instability in Metals", DMIC Memorandum 213, June 23, 1966, Battelle Memorial Institute.

Burns and Roe, Inc.

Nuclear Project No. 2 – WPPSS ▫ P.O. Box 200 ▫ Richland, Washington 99352 ▫ Tele. 509–377-2301 Tele. 509–946-7621

July 7, 1975
BRPDM-213-F-75-128

Subject: W. O. 2808
WPPSS - Nuclear Projec· No. 2
Contract No. 213
Containment Vessel U.˜ ˜est Report

Pittsburgh-Des Moines Steel Com
P. O. Box 829
Richland, WA 99352

Attention: Mr. M. Schulze .

Gentlemen:

Preliminary review of the PDM NDE report documenting the Ultrasonic Inspection of the upper and lower pipe whip support welds reveals certain inspection inadequacies that must be corrected and/or explained and documented in an inspection report, before Burns and Roe can accept the vessel test results.

UT Report 40, which was accomplished after the first pneumatic test of the vessel, states; "the area inspected was the weld to the vessel wall, with the following <u>exceptions</u>:

1. Areas not accessable because of scaffold brackets, etc.
2. Areas inspected and reported on UT Report 39.
3. Areas where penetration inserts are installed and fillet welds were used, rather than partial penetration welds.

No change was found in the size of indications previously found and reported. All <u>new</u> indications are reported on Pages 3 and 4 of this report."

This report generates concern in the following areas:

WNP NO. 2
E adv.t.l
VIERE
APP
EGAN
LHAUS
RINGTON
MANAGER
HF-CONTROL
Howard

1. Page 3 of UT No. 40 records an indication 2 inches long. It has been revealed that this indication is adjacent to a scaffold bracket and therefore, the area of the vessel wall covered by the bracket (approx. 2") was not inspected and could contain a continuation of the reported indication.

2. Item 2 of UT No. 40 states that the areas inspected and reported on UT Report No. 39 were also excluded from UT inspection <u>after</u> the pneumatic test.

The criteria for inspection after the pneumatic test stipulated that 100% of the upper and lower pipe whip support welds and repaired areas would be U.T. inspected.

3. The statement in U.T. Report 40 that "all new indications are reported on pages 3 and 4 of this report" indicates that these new indications were induced as a result of the stresses imposed on the vessel by the pneumatic test. P.D.M. did not report the existence of new indications to Burns and Roe at the conclusion of the test.

P.D.M. is directed to take the following action and document the results in an inspection report which shall be submitted to Burns and Roe for evaluation and resolution of the vessel test results:

1. PerfomU.T. inspection (using the same procedure utilized for the original inspection) of the vessel wall and weld area of the upper whip support which was masked by the scaffold bracket at footage 141, where the 2" long indication was reported.

2. Perform U.T. inspection (using the same U.T. procedure utilized for the original inspection) of all areas which were inaccessable for inspection because of scaffold brackets, etc., reference item (1) of U.T. 40; and of all areas reported in U.T. Report #39, reference item (2) of U.T. 40.

3. Provide documented description of the "new" indications reported in U.T. #40, and/or a documented explanation of the statement.

4. Review of the inspection report package indicates the use of three U.T. procedures, U.T. 1, U.T. 2, and U.T. 9200. Please provide justification for the use of (3) different procedures and include same in the U.T. inspection report package.

5. Page (4) of U.T. #40 is missing from inspection package submitted to Burns and Roe Q.A.; please transmit the missing page.

Very truly yours,

BURNS AND ROE, INC.

R. C. Root
Acting Site Manager

RCR:KF:CWF:tbr

cc: ME Witherspoon-WPPSS (3)
RD Sahlberg-WPPSS

AUG 22 1975

Burns and Roe, Inc.

Nuclear Project No 2 – WPPSS • P.O. Box 200 • Richland, Washington 99352 • Tele. 509–377-2301 Tele. 509–946-7621

August 20, 1975
BRPDM-213-F-75-162

WNP NO. 2 cc	
P. M. SEC	Adc. + 1
L LARIVIERE	2
OE TRAPP	1
GE DEEGAN	1
~~GI GELHAUS~~	1
J HARRINGTON	1
SITE MANAGER	1
D HOWARD	\1/
A D. DESIDERO	
COMM. CONTROL	

Subject: W. O. 2808
WPPSS - Nuclear Project No. 2
Contract 213
Repair of Containment Vessel
NCR-213-00058, 00059, & 00060

Pittsburgh-Des Moines Steel Company
P. O. Box 928
Richland, Washington 99352

Attention: Mr. M, Schulze

Reference: BRPDM-213-F-75-155

Gentlemen:

In-depth review of the document package you submitted on the subject NCR's has revealed some inconsistencies and insufficiencies. Therefore, PDM is directed to take the following actions:

1. Provide a final ultransonic report, readable and understandable, without reference to previously submitted documents and correspondence, understandable to a technicallty qualified person unfamiliar with the problem. The report should be complete except for the local areas yet to be examined. We feel this report can be prepared from data already recorded. It should indlude the following:

   1.1 A report format similar to that used in the Hamill Testing Laboratory Report No. 001, 002, and 003.

   1.2 Charts of the four circumferential welds involved showing the areas examined; the location of reportable but acceptable indications, if any; the location of areas not examined, the reason these areas were not examined.

   1.3 Tabulations of reportable indications in each of the four circumferential welds showing size, depth, amplitude, and footage locations for all reportable indications in accordance with the approved procedures.

   1.4 The charts and tabulations called for in 1.2 and 1.3 should include indications found during the July 28, 1975, examination. In accordance with previous agreements, the individual indications surrounding the repairs made from the outside of the vessel need

not be tabulated, but their footage locations should be shown on the charts and tables along with your report with respect to their growth. The report should state also whether the examination covered shell plate only or shell plate plus weld metal.

1.5 An explanation for why each of the reportable indications is considered acceptable.

2. Arrange a PDM-B&R-WPPSS meeting after September 10, to discuss additional information needed to provide convincing answers to questions related to the indications that were observed for the first time after the first pneumatic test. At this meeting, we also want you to describe how the ultrasonic indications were evaluated; that is, the basis for your determination of which indications required repair and which did not. We hope we can agree upon written statements for PDM to transmit to Burns and Roe.

3. When the scaffolding for the installation of the insulation around the containment vessel reaches a level that can be used for support, remove and repair the 2" X 1" indication in the lower web of the upper pipe whip support in accordance with the approved procedure. When this repair is complete, it should be examined ultrasonically when the inspection called for by the above referenced letter is performed. The repair should be examined by the vacuum box method, too. Submit a report on these examinations similar to and as an addendum to the report described in 1.

Very truly yours,

BURNS AND ROE, INC.

J. D. Wilson

J. D. Wilson
Site Manager

JDW:KF:sl

cc: ME Witherspoon-WPPSS (3)
RD Sahlberg-WPPSS

Washington Public Power Supply System
A JOINT OPERATING AGENCY

P. O. Box 968 3000 Geo. Washington Way Richland, Washington 99352 Phone (509) 946-9681

July 28, 1975
G02-75-213

Docket 50-397

Mr. R. H. Engelken, Director
Nuclear Regulatory Commission
Region V
1990 North California Blvd.
Walnut Creek Plaza, Suite #202
Walnut Creek, California 94596

Subject: WPPSS NUCLEAR PROJECT NO. 2
STEEL CONTAINMENT VESSEL
FABRICATION DIFFICULTIES

Reference: WPPSS letter G02-75-178, N. O. Strand to R. H. Engelken, same subject, dated June 23, 1975.

Dear Mr. Engelken:

This letter is to advise you that as discussed with L. E. Vorderbrueggen of your staff on Friday, July 25, the final report on the repair of the WNP-2 lamellar tears will be delayed.

No new problems have arisen and no further physical work on the vessel is contemplated. One possible exception to this could be removal of the 1" x 2" indication. Removal of this indication will not be precluded by other construction activities until early next year. The delay is due to a longer than anticipated time to assemble the various facets of the repair program in a clear, concise manner and perform UT examination of areas that were covered by scaffold brackets. The contractor has been directed to examine these areas and is scheduled to perform this examination on July 28, 1975.

Mr. R. H. Engelken
Page 2

July 28, 1975
G02-75-213

The attachment identifies activities that are to occur prior to forwarding the final report. The Architect-Engineer, Burns and Roe, Inc., has advised that based upon the examination being performed on July 28 and assuming it does not reveal any new indications, they could finalize their letter to us on August 15. Accordingly, it is anticipated that the final report on the repair program will be forwarded to you by August 30, 1975.

Very truly yours,

N. O. STRAND
Assistant Director
Generation and Technology

NOS:JCM:lm

Attachment

cc: JJ Byrnes, B&R-NY
JJ Verderber, B&R-NY
JD Wilson, B&R-Site
K Fox, B&R-Site

WPPSS

Burns and Roe, Inc.

Nuclear Project No. 2 -- WPPSS ▫ P.O. Box 200 ▫ Richland, Washington 99352 ▫ Tele. 509-377-2301 Tele. 509-946-7621

July 7, 1975
BRPDM-213-F-75-128

Subject: W. O. 2808
WPPSS - Nuclear Project No. 2
Contract No. 213
Containment Vessel U.T. Test Report

Pittsburgh-Des Moines Steel Company
P. O. Box 829
Richland, WA 99352

Attention: Mr. M. Schulze

Gentlemen:

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2. Areas inspected and reported on UT Report 39.
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1. Page 3 of UT No. 40 records an indication 2 inches long. It has been revealed that this indication is adjacent to a scaffold bracket and therefore, the area of the vessel wall covered by the bracket (approx. 2") was not inspected and could contain a continuation of the reported indication.

2. Item 2 of UT No. 40 states that the areas inspected and reported on UT Report No. 39 were also excluded from UT inspection after the pneumatic test.

P NO. 2
RE
US
GION
AGER

The criteria for inspection after the pneumatic test stipulated that 100% of the upper and lower pipe whip support welds and repaired areas would be U.T. inspected.

3. The statement in U.T. Report 40 that "all new indications are reported on pages 3 and 4 of this report" indicates that these new indications were induced as a result of the stresses imposed on the vessel by the pneumatic test. P.D.M. did not report the existence of new indications to Burns and Roe at the conclusion of the test.

P.D.M. is directed to take the following action and document the results in an inspection report which shall be submitted to Burns and Roe for evaluation and resolution of the vessel test results:

1. Perform U.T. inspection (using the same procedure utilized for the original inspection) of the vessel wall and weld area of the upper whip support which was masked by the scaffold bracket at footage 141, where the 2" long indication was reported.

2. Perform U.T. inspection (using the same U.T. procedure utilized for the original inspection) of all areas which were inaccessable for inspection because of scaffold brackets, etc., reference item (1) of U.T. 40; and of all areas reported in U.T. Report #39, reference item (2) of U.T. 40.

3. Provide documented description of the "new" indications reported in U.T. #40, and/or a documented explanation of the statement.

4. Review of the inspection report package indicates the use of three U.T. procedures, U.T. 1, U.T. 2, and U.T. 9200. Please provide justification for the use of (3) different procedures and include same in the U.T. inspection report package.

5. Page (4) of U.T. #40 is missing from inspection package submitted to Burns and Roe Q.A.; please transmit the missing page.

Very truly yours,

BURNS AND ROE, INC.

R. C. Root

R. C. Root
Acting Site Manager

RCR:KF:CWF:tbr

cc: VF Witherspoon-WPPSS (3)
RD Sahlberg-WPPSS

Washington Public Power Supply System
A JOINT OPERATING AGENCY

P. O. Box 968 3000 Geo. Washington Way Richland, Washington 99352 Phone (509) 946-9681

June 23, 1975
G02-75-178

DOCKET 50-397

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JUN 26 1975
REGION V
INSPECTION & ENFORCEMENT

Mr. R. H. Engelken, Director
Nuclear Regulatory Commission
Region V
1990 N. California Blvd.
Walnut Creek Plaza, Suite #202
Walnut Creek, California 94596

Subject: WPPSS NUCLEAR PROJECT NO. 2
FABRICATION DIFFICULTIES, STEEL CONTAINMENT VESSEL

Reference: G02-75-72, "WPPSS Nuclear Project No. 2 (Docket 50-397) Fabrication Difficulties, Steel Containment Vessel", J.J. Stein to R.H. Engelken dated March 7, 1975.

Dear Mr. Engelken:

The purpose of this letter is to forward additional information on the fabrication difficulties experienced on the reinforcing ring attachment to the WNP-2 containment vessel and to summarize the progress toward resolution of the difficulties.

Reference 1 reported the existence of lamellar tears in the containment vessel shell at the location of the main steam relief valve platform support ring attachment. Subsequently, the shell at the attachment of the lower pipe whip support that is of construction similar to the main steam relief valve platform was examined (see Figure 1). The examination revealed the presence of eleven lamellar tears varying from 2 inches to 13 inches in length and one tear 60" long.

Repair of the lamellar tears was made from the inside of the vessel with a repair procedure that consisted of: (1) preheating the shell to 200°F and the reinforcing ring* to 300°F, (2) thermal gouging and grinding to remove the lamellar tear indication, (3) magnetic particle examination to

*The term reinforcing ring will be used henceforth for both the main steam relief valve platform support ring and the pipe whip support ring.

assure removal of the lamellar tear, (4) building the shell plate back to the original plate surface by welding, (5) ultrasonic examination to assure soundness of the shell plate repair and shell plate, (6) rewelding the reinforcing ring to the shell, maintaining a 300°F minimum interpass temperature, (7) heating to between 350°F and 400°F after completion of welding, maintaining for two hours, and then slowly cooling to ambient temperature, and (8) performing a UT examination of the repaired area to detect recurrence of lamellar tearing or the presence of other rejectable defects.

Upon UT examination of the completed repairs, indications immediately behind (deeper in the shell plate) some of the repair areas were found. (See Figures 2 and 3 for a more complete description of the original tears and indications behind the repairs). These defects were also removed and repaired using the same repair procedure as for the lamellar tears. The repairs were made from the outside surface of the vessel shell and were extended to a depth that tied into the weld repairs made from the inside (see Figure 4 for a more complete description). This resulted in a weld deposit through the thickness of the vessel shell that distributes residual and load stresses into the shell parent plate material in a shear mode rather than tensile mode.

Upon UT examination of the repairs made from the outside of the vessel, a different type of indication was found around the periphery of the repair welds. These indications were different than both the lamellar tears and indications behind the repair areas made from the inside. The new indications did not lay behind the weld, but began at the edge of the weld and extended a short distance into the parent material. They were located all around the periphery of the welds as shown in Figure 5. Since these were not the same type indications as had been repaired, an evaluation was made by Pittsburgh Des Moines and Burns & Roe to determine the type of defects, their cause, and their effect on the integrity of the vessel. This evaluation consisted of:

> A section of material was removed from the vessel and sent to U.S. Steel, the material supplier, for their evaluation. By metallurgical examination, these indications were determined to be of the lamellar tearing type. Since the indications were small, were in a plane parallel to the surface of the plate, were tied together at the end by sound weld metal, and were not located in the zone of high residual through-thickness tensile stress, they were determined not to be detrimental to the serviceability of the vessel by both Pittsburgh Des Moines and Burns & Roe. This evaluation was concurred with by Dr. William Cooper, of Teledyne Materials Research, whom Burns & Roe, the Architect-Engineer, retained as a consultant (see Attachments 1 and 2).

The defects were examined before and after the ASME Section III 115% design pressure pneumatic test and comparison of size was made to determine if defect growth had occurred during the pneumatic test. UT examination after the first pneumatic test determined that there had been no growth of the indications

around the periphery of the repair welds, but indications were detected on the lower reinforcing ring behind an area repaired from the inside and an indication was detected on the upper reinforcing ring near a repair (see Attachment 4). These indications were similar to those found earlier behind the repair areas made from the inside, but were more continuous within the area of indications. The indications on the lower reinforcing ring were removed, repaired, the vessel pneumatically tested a second time, and again ultrasonic examined with no new indications or growth of the existing acceptable indications.

Attachment 3 shows the extent of the repairs made in the areas exhibiting lamellar tearing.

Ultrasonic Examination

All ultrasonic examination used to determine the extent of lamellar tears and to monitor for new or changing indications was performed to an ultrasonic procedure which has a much higher sensitivity than required by ASME Section III. The indications identified around the periphery of the repair welds made from the outside by the sensitive UT procedure are not recordable indications when examined with a UT procedure for weld material in accordance with ASME Code.

Prior to the first pneumatic test run (on May 30, 31 and June 1,) the only indications in the shell opposite the four reinforcing ring attachment welds were around the periphery of the weld repairs made from the outside of the vessel.

Prior to the second pneumatic test (run on June 6, 7 and 8) the same indications around the repair areas made from the outside, plus indications of the same nature around the last repair area and the indication on the upper ring, were present. All four bands were again UT examined after the second pneumatic test. The indications had not grown nor had new indications occurred during the second pneumatic test.

Summary

The fabrication difficulties are being successfully resolved. Throughout the repair and evaluations, the assistance of technical experts has been retained, in that Dr. William Cooper of Teledyne Materials Research has been consultant to Burns & Roe, and Drs. William Love and Albert Kobyachi have been mechanical consultants to Washington Public Power Supply System to assist us in evaluating the actions and conclusions of Pittsburgh Des-Moines and Burns & Roe.

All repair, examination and test has been performed, as a minimum, in accordance with the requirements of ASME Section III and Appendix B of 10CFR50. They were performed not only on the basis of what actions were necessary to satisfy the requirements of the ASME Code Section III, but were also directed toward assuring the vessel's capability to perform its intended function.

Presently, the ultrasonic examination reports are being reviewed for completeness and an engineering evaluation of the indication revealed following the first pneumatic test, is being made. It is anticipated that a final report on the repair of the lamellar tears will be forwarded on July 28th.

Attached for your information are the significant documents developed for the resolution of this fabrication problem. If you have any questions or desire further information, please so advise.

Very truly yours,

N. O. Strand

N. O. STRAND, Assistant Director
Generation and Technology

NOS:JCM:ho

Attachments:
1. PDM Engineering Evaluation
2. Dr. Cooper's letters
3. Map of Repair Areas
4. Ultrasonic Examination Reports

WPPSS NUCLEAR PROJECT NO. 2
FABRICATION DIFFICULTIES, STEEL
CONTAINMENT VESSEL

STATE OF WASHINGTON)
) ss
COUNTY OF BENTON)

N. O. STRAND, Being first duly sworn, deposes and says: That he is the Assistant Director, Generation and Technology, of the WASHINGTON PUBLIC POWER SUPPLY SYSTEM, the applicant herein; that he is authorized to submit the foregoing on behalf of said applicant; that he has read the foregoing and knows the contents thereof; and believes the same to be true to the best of his knowledge.

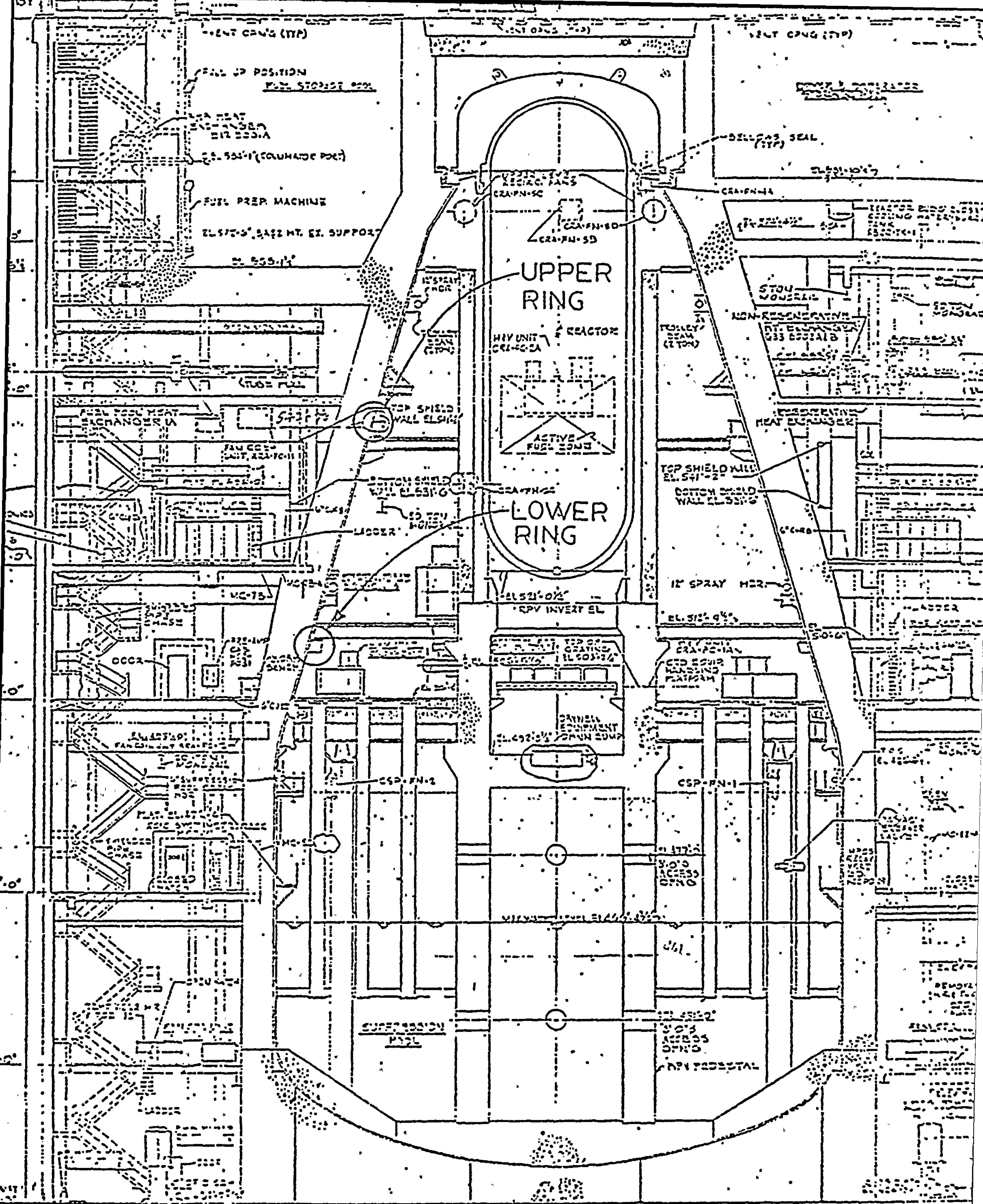
DATED June 23, 1975

N O Strand
N. O. STRAND

On this day personally appeared before me, N. O. Strand to me known to be the individual who executed the foregoing instrument and acknowledged that he signed the same as his free act and deed for the uses and purposes therein mentioned.

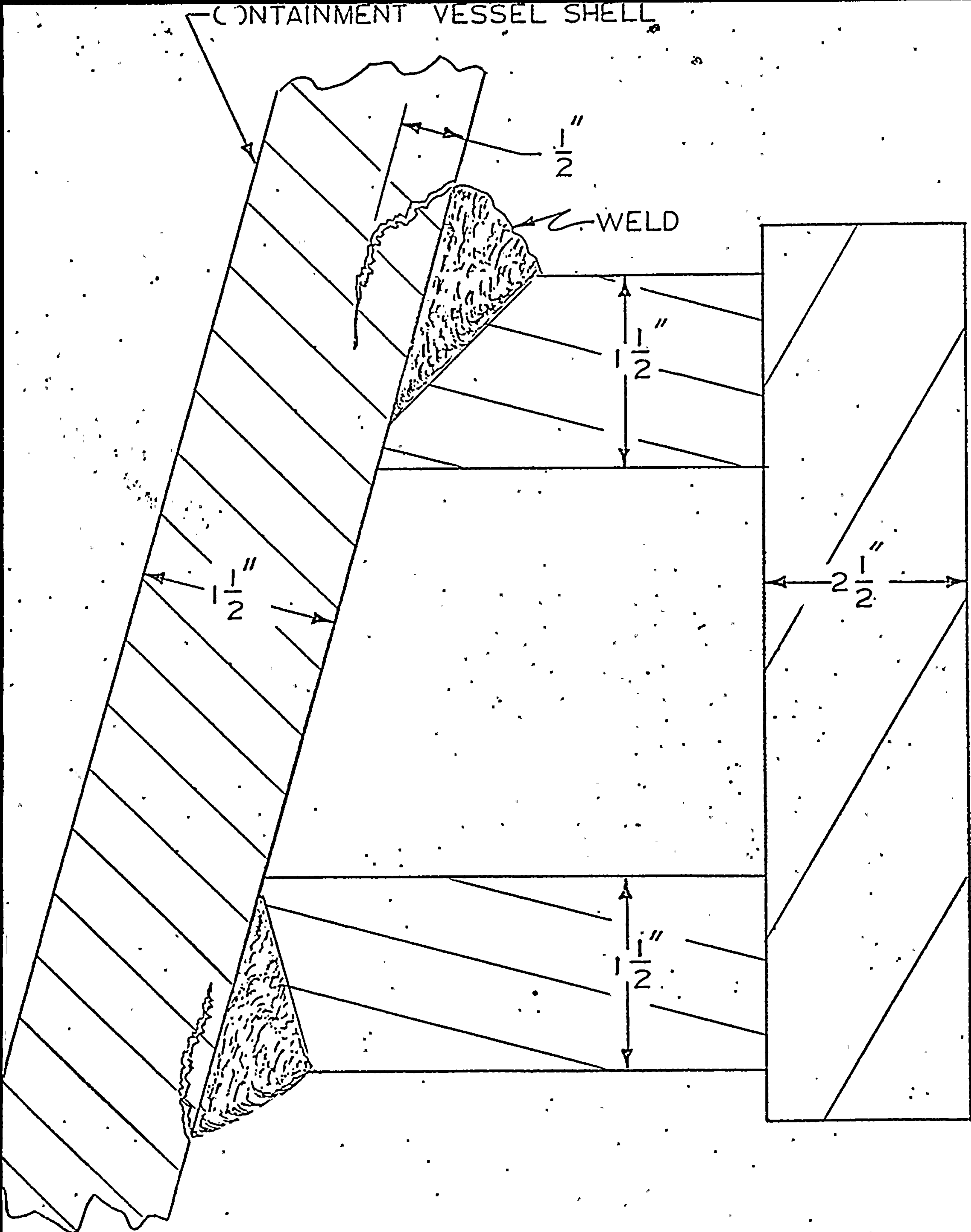
GIVEN under my hand and seal this 23 day of June 1975.

Robert B. Helgeson
Notary Public in and for the State of Washington 510 Sanford
Residing at Richland



UPPER RING
LOWER RING
REACTOR
ACTIVE FUEL ZONE
FUEL PREP MACHINE
TOP SHIELD WALL EL. 541'-2"
BOTTOM SHIELD WALL EL. 531'-6"
BELLOWS SEAL
RPV INVERT EL.
12" SPRAY HDR.
SUPPRESSION POOL
RPV PEDESTAL
NON-REGENERATIVE HT. EXCHANGER
REGENERATIVE HEAT EXCHANGER
LADDER
DOOR
CSP-FN-2
CSP-FN-1

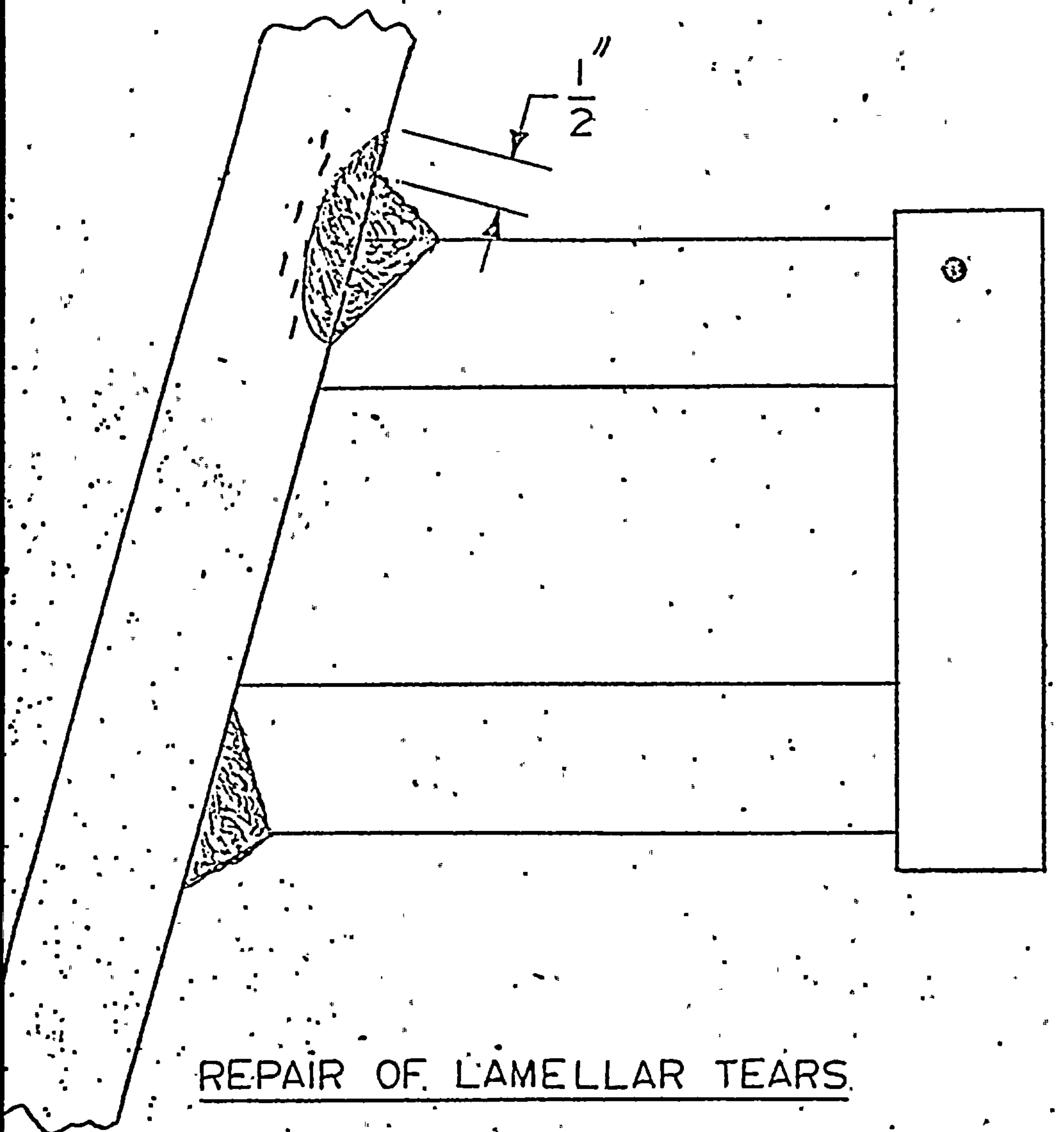
FIGURE NO. 1



ORIGINAL LAMELLAR TEARS

FIGURE NO. 2

A-2-F-008-1

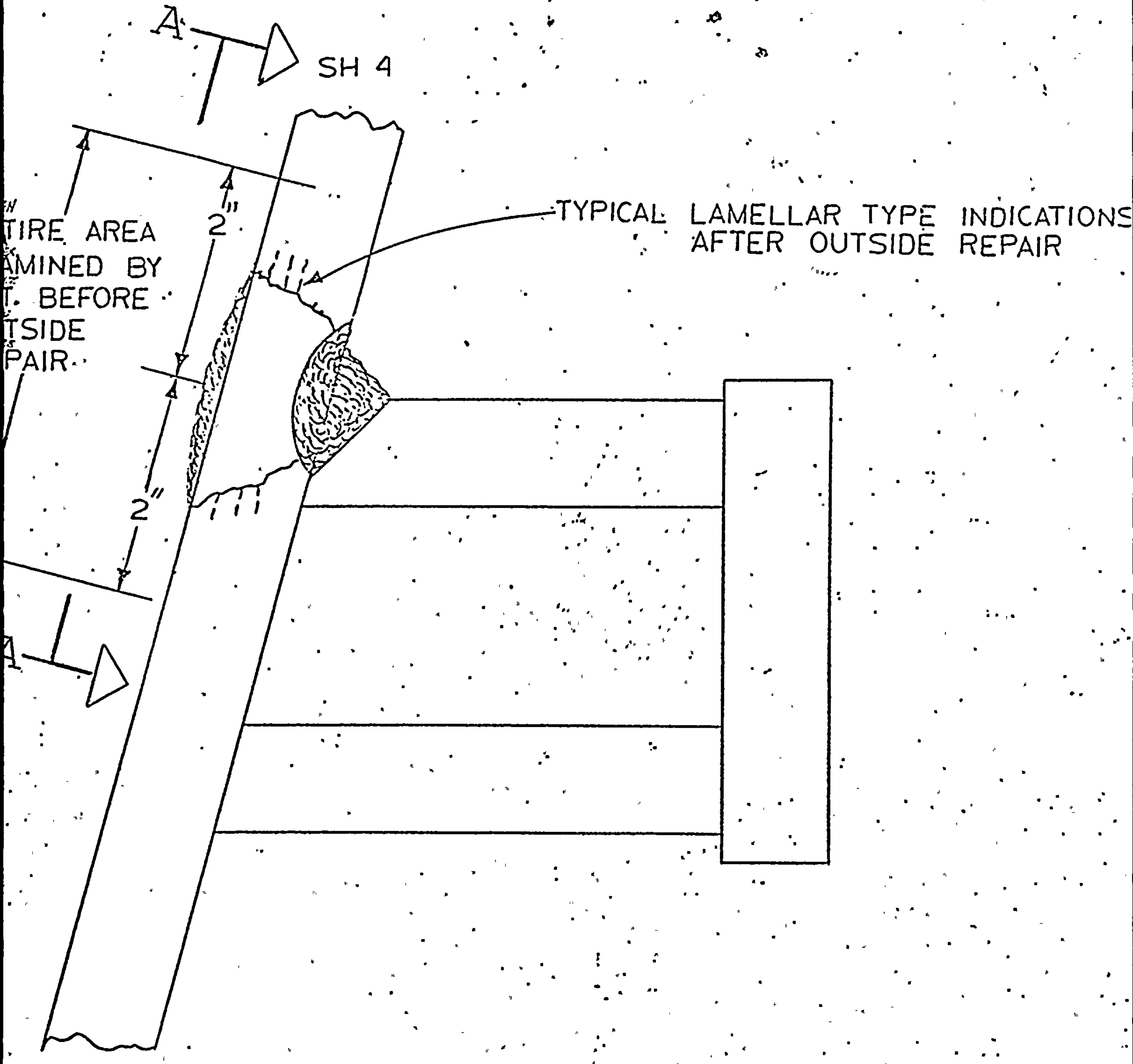


REPAIR OF LAMELLAR TEARS

SOME REPAIRED AREAS WERE FREE OF INDICATIONS WHEN EXAMINED ULTRASONICALLY

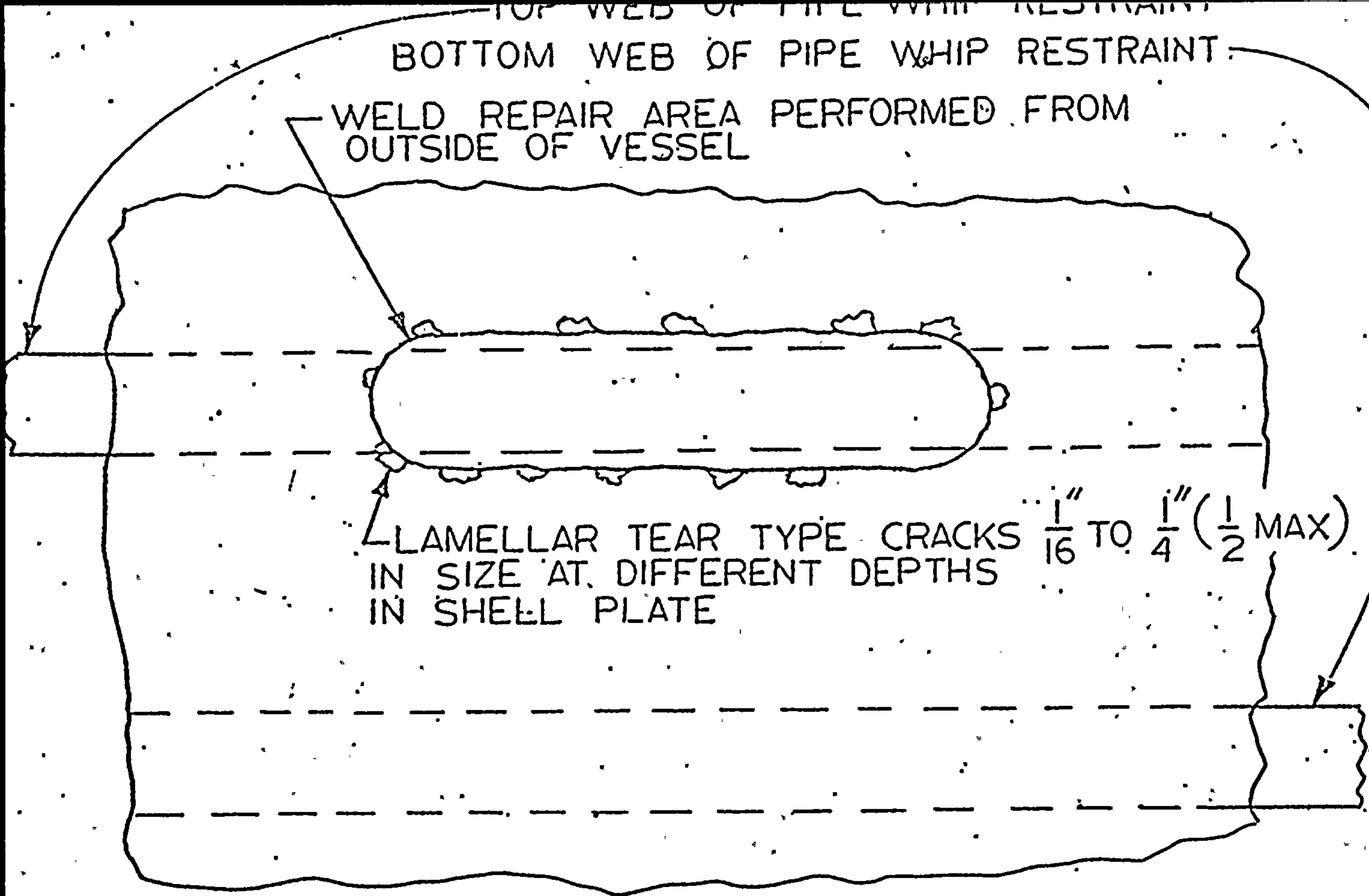
SOME REPAIRED AREAS HAD INDICATIONS AS NOTED ABOVE

FIGURE NO. 3



WELD REPAIR FROM OUTSIDE TO REMOVE INDICATIONS BEHIND INITIAL REPAIR AREA

FIGURE NO. 4



VIEW A—A (FIG. 4 REF)

INDICATIONS ARE ALL AROUND THE PERIPHERY OF REPAIR AREA WITH LENGTHS OF THE INDICATIONS EXTENDING THE SAME DISTANCE FROM THE EDGE OF THE WELD ON BOTH THE SIDES AND ENDS OF THE REPAIR AREA

FIGURE NO. 5

M. E. Wa[illegible]
M. Schulz - Richland

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MAY 5 . 1975
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RICHLAND

April 18, 1975

PDMBR-213-75-20
Contract 12764

Burns and Roe, Inc.
320 Fulton Avenue
Hempstead, New York 11550

Attention: Mr. J. J. Verderber,
Project Engineering Manager

Reference: 1. Letter, Burns and Roe to PDM, BRPDM-213-75-042, dated April 15, 1975.

2. Letter, PDM to Burns and Roe, PDMBR-213-75-19, dated April 3, 1975.

Gentlemen:

This letter contains the response to your questions raised in Reference 1. The responses are itemized in the same order as in Reference 1.

1. A revised weld repair procedure (Revision G) has included a reference to the UT procedure and requires a report of the defect sizes. The repair procedure is enclosed.

Items 2 and 3 will be discussed together.

2.&3. Reference 2. states that the 2 1/2" ring flange was fit and welded into a ring. PDM agrees that segments were raised into position, but prior to welding to the shell, the 2 1/2" flange welds were made for all the segments except the last one. The last segment was fit into its final location concurrently with fitting the shell to the ring. The ring to shell fit-up was accomplished by starting at one point and moving around the vessel fitting the shell to the ring. As one area was properly fit, a new area of fit-up was started always progressing in the same direction until a given arc of misfit was acceptable.

WNP NO. 2	
HALE	
LAVIERE	
[illegible]	
DESIGN	
CELIUS	
CARRINGTON	
E HANASCH	
[illegible]	
Dr. Jansasd	

PDMBR-213-75-90 April 18, 1975
Mr. J. J. Vorderbar

This procedure was followed until the last segment was fit into place. It was during this time that the jacks were used to fit and tack weld the shell to the ring. As stated in Reference 2., the web splice plates were not in place during the fitting operation and therefore the webs were interrupted at the intersection of each support ring segment.

The final two 2 1/2" flange welds were made concurrently with making the welds of the support ring to shell.

It is impossible at this time to know where the jacks were located during the fitting operation. Since the shell was essentially fit to the ring in one continuous operation, the only end conditions existent were those of intermittent webs and the tack welds that were made to the shell during fit-up.

In compliance with your request, I have reduced the maximum arc of misfit from 90° to 45° for the purpose of estimating maximum jack loads. The results of these calculations are shown on attached pages numbered A1 and A2. Another calculation considering a 1" gap over a 10' chord is presented on calculation pages A2 and A3. Calculation sheet A3 also presents the weld stress that would develop from the maximum load as determined from the above two cases. These calculations indicate a jack load of 47 kips for the 1" mid point gap in a 10' chord and 24 kips for the 45° arc with a 3" mid point gap. 25 kips?

4. 1) Regarding the dead load of 1081.7 kips, the original support ring calculations used the accumulated dead load above the base of the cone. This load was extracted from the initial weights as computed early in the program. The final calculated dead load as presented in Reference 2. was derived from the same initial weight calculations with some adjustments made to distribute the penetration dead loads, etc. as explained on Page IV.2.1.21 of the Stress Report. This load includes all the shell structure in Cone 4 and above and approximately 15% of the penetration dead

PDMBR-213-75-20 April 18, 1975
Mr. J. J. Verderber

loads, 50% of the seismic lug weight and 50% of the beam seat dead loads.

2) The AX-2 results are slightly different from the original results due to the choice of shell section investigated. The original choice of shell has a somewhat higher (1%) membrane stress, but the final choice of shell segment has higher secondary bending stresses and thus was used in the calculations. The same analysis was used for both choices.

3) All the BOSOR extreme fiber shell stresses have been adjusted by the ratio of $(1.5/1.4375)^2$ because this shell program presents only the extreme fiber stresses. The tabulated membrane stresses for BOSOR are calculated from the average of the adjusted extreme fiber stresses. Therefore, the conversion for the membrane stress has been accomplished and in fact is conservatively high.

4) Burns and Roe is correct concerning its statement that the maximum shear stress occurs at the neutral axis and that the stress is VQ/It'. You will notice that $\tau = V/\pi Rt$ is not the average stress but that if $Q = (\pi Rt)\,(2R/\pi)$, $I = \pi R^3 t$ and $t' = 2t$, then $VQ/It' = V/\pi Rt$, where (πRt) is equal to the half area of the shell and $(2R/\pi)$ is equal to $\bar{y}$ for the half area. The above is based on thin shell or line approximation theory. Cancelling and collecting terms, $\tau = V/\pi Rt$.

5) The calculations for weld point 3, Case B, were made using the membrane stress rather than the membrane load of 1082-lb/in. The revised calculations are attached (Page IV.5.3.294) and will be submitted in a stress report resubmittal.

PDMBR-213-75-20
Mr. J. J. Vorderbar

April 18, 1975

The above responds to all the questions contained in your letter of April 15, 1975.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

JHS for

J. H. Adams, Chief Engineer

JHA/gt

Encl.

REPAIR OF WELD AT PIPE WHIP SUPPORT TO SHELL

Rev. C [illegible]
Rev. D 3-18-75 (
Rev. E 3-21-75 (
Rev. F 3-27-75 (
Rev. G 4-16-75 (

(1) Heat shell plate. Place electric heater at opposite side of top and bottom annular plate at location of repair. This heater should extend at least 5'-0 circumferentially beyond either side of the repair area. See Note 1 below.

(2) Place electric or gas heater on top and bottom annular plate and face plate. This heater should extend at least 5'-0 circumferentially beyond either side of repair area. See Note 1 belo

(3) Preheat Item (2) to 300°F Min., Preheat Item (1) to 200°F Min.

NOTE: The differential temperature between 300°F in Item 2 and 200°F in Item 1 can only be maintained as gouging increases in the weld connecting the annular plate to the shell. It is required primarily in the last 1/4" to 1/2" to prevent crack propagation.

(4) Maintain preheat differential (See NOTE in 3 above) and gouge out defect (Gouge from end to center) in shell and annular plate as shown in Figure 1. Gouge web plate to at least the bevel shown in Detail C of E52. Gouge to sound parent metal at least 6" circumferentially beyond defects larger than 4 feet and 2 inches circumferentially for defects smaller than 4 feet.

(5) Disc grind gouged area to clean surface.

(6) MT - Disc ground area.

(7) Maintaining preheat as specified in Item (3), weld overlay on shell plate to complete weld to the original plate surface. MT every layer. Grind flush. See Figure 2. UT*for soundness in parent metal (PM) after filling PM cavity prior to making bevel weld. Shell plate temperature may be dropped to 100°F during UT. Box girder may be dropped to 150° to 200°F during UT. Maintain as closely as possible an interpass of 300°F Max. at the weld.

NOTE: Weld using stringer beads and Joint Procedure, 70-71A. Use 5/32"Ø Max. electrodes for out-of-position welds and 3/16"Ø Max. for flat and horizontal fillet welds. Use PS-69-97 for overhead repair, 5/32"Ø Max. rods.

(8) Complete welding of annular plate to shell plate. MT - every 1/4" and final cover. (See Figure 2) See Note in Items 3 and 7 above, Except in Item 3, the preheat and interpass temperature differential applies to the first 1/4" and 1/2" of weld deposit.

(9) After welding is completed, insulate the heated area and hold temperature of 350°F to 400°F for at least 2 hours and slow cool.

NOTE 1: For defects 18" or less in length, only 18" circumferentially beyond either side of the repair area needs to be heated.

ATTACHMENT TO DVR HA2, HA3, and HA4

REPAIR OF WELD AT PIPE WHIP SUPPORT TO SHELL

(10) MT after area has cooled to ambient temperature.

(11) UT after cooldown to ambient temperature.

(12) UT after pneumatic test.

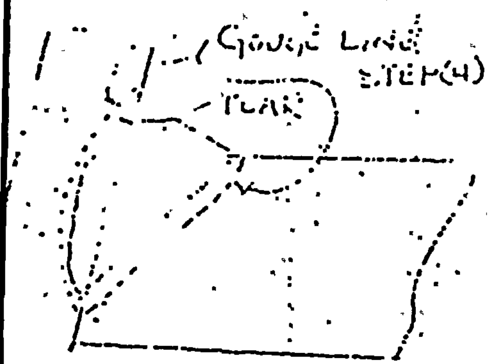


FIGURE 1

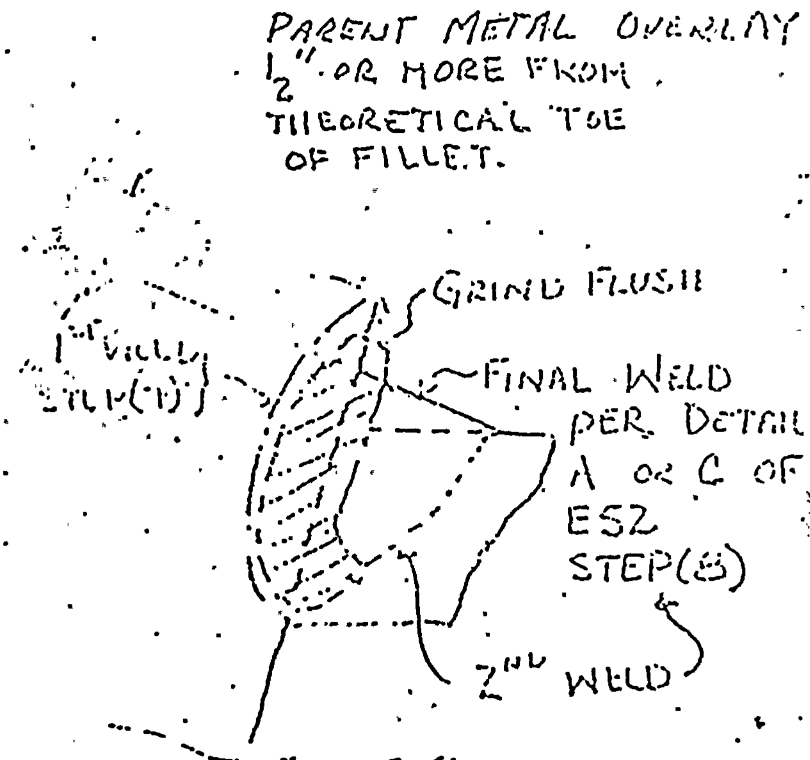


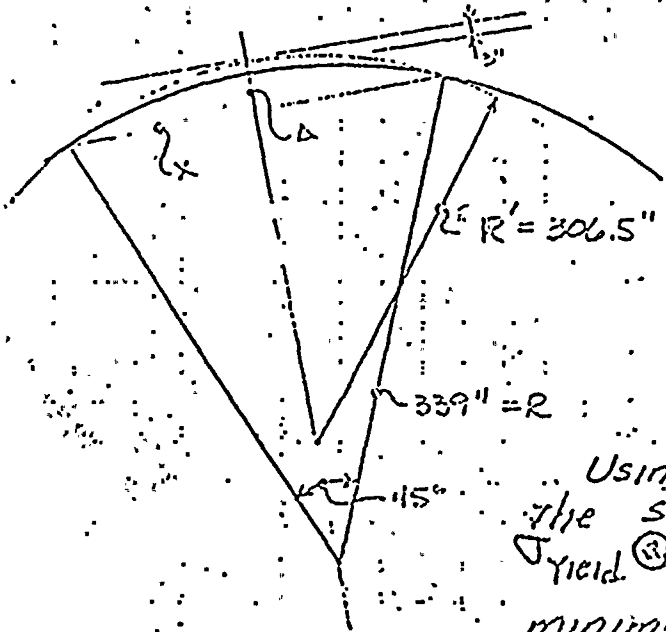
FIGURE 2

UT: Refer to UT testing procedure for sensitivity. A report of recordable DB/Areas of defect size shall be made for each UT performed.

PREPARED BY/DATE:	JTS 4-18-75				SUBJECT: ---
CHECKED BY/DATE:	JH 4-18-75				ARTICLE: ---
REVISION NUMBER:					PAGE: A-1

<u>FIRST CONSIDERATION:</u>

<u>A 45° ARC WITH A 3" GAP</u>



From Method of Reference 2.

$\Delta = R - R\cos 22\frac{1}{2}^\circ = 28.8"$

$x = R \sin 22\frac{1}{2}^\circ = 129.7"$

$R' = \dfrac{28.8^2 + 129.7^2}{2(28.8)} = 306.5"$

$\%$ Field Strain $= .2126\left(1 - \dfrac{339}{306.5}\right) = -.023$

Using A Linear Relationship of the stress-strain curve with σ_{Yield} @ 0.2% offset = 6.0 ksi minimum, then at 0.023% strain the extreme fiber bending stess is (.023/.2) times 60 ksi, ie $\sigma_{bend} = 6.9$ ksi.

Using Roark, 4th Edition, Table XIII, Case 7 it is Possible to determine the Load Required to create a 6.6 ksi circumferential bending stress.

Parameters: $R = 306.5/\cos 16.0514^\circ = 319.0$

$t = 1.5$

$A = 25.5^2(\pi)$, where $25\frac{1}{2}"$ is the approximate dimension from the ℄ of the support ring to the top of the Jacking Frame.

$R/t = 212.7 \qquad A/R^2 = 0.020$

From the tabulated values, using the above parameters and a linear approximation @ $A/R^2 = 0.015$

$S_2'(t^2/P) = \text{Factor}_{\text{Table}} \Rightarrow S_2' = 6900 \text{ psi}$

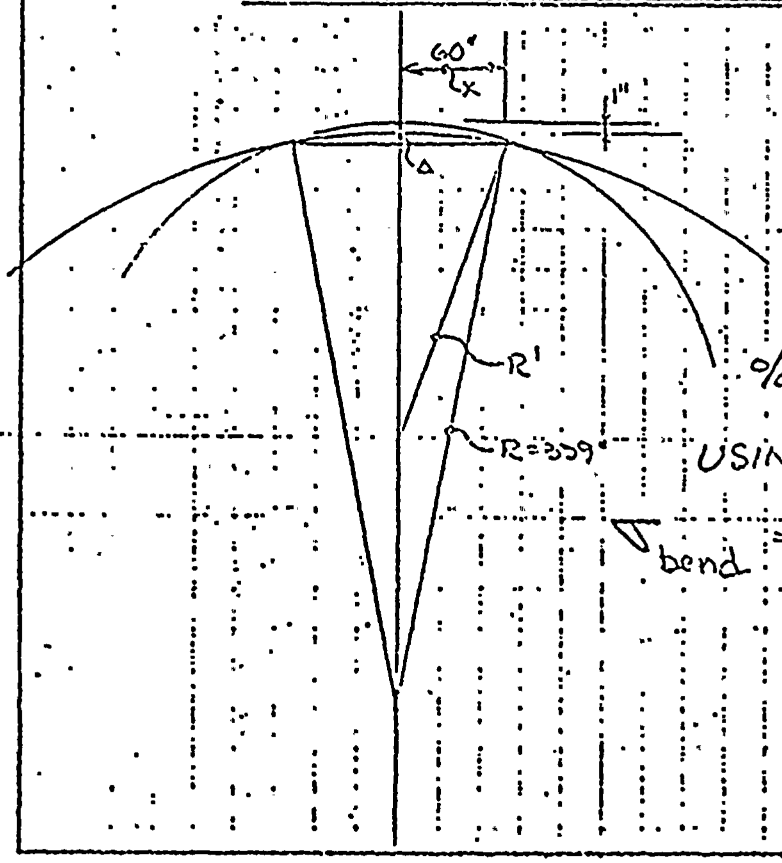
$\text{Factor} = 0.62$

Finally, $P = \dfrac{6900\,(1.5^2)}{0.62} = 25040$ pounds

$\doteq$ 12.5 TONS.

SECOND CONSIDERATION

A 10' CHORD WITH A 1" GAP



$\Delta = R - \sqrt{339^2 - 60^2} = 5.35"$

$R' = \dfrac{6.35^2 + 60^2}{2(5.35)} = 286.6"$

$\%\text{ Field Strain} = .2126\left(1 - \dfrac{339}{286.6}\right) = -0.039$

USING THE ABOVE METHOD,

$\sigma_{bend} = \dfrac{.039}{.2}(60) = 11.7 \text{ ksi}$

PREPARED BY/DATE:	JTS 4-18-75				ARTICLE: —
CHECKED BY/DATE:	JM 4-18-75				PAGE: A-3
REVISION NUMBER:					

PARAMETERS: $R = 286.6/\cos 16.054 = 298.2"$
$t = 1.5"$
$A = 25.5^2 (\pi) = 2042.8 \text{ in}^2$

$R/t = 198.8$ $\quad A/R^2 = 0.023$

From the tabulated values for $A/R^2 = 0.0256$

$$\text{FACTOR} = 0.45 + \left(\frac{300-198.8}{200}\right)(.666-.450) = 0.56$$

$$\frac{S_2' t^2}{P} = 0.56 \qquad \frac{S_2'(t^2)}{0.56} = P$$

$$\text{Finally, } P = \frac{11700(1.5)^2}{0.56} = 47009 \text{ lbs}$$

$\doteq$ 23.5 TONS

CALCULATE WELD STRESS DUE TO 47 KIP LOAD

Assume A weld length of 51 inches at the top & bottom WEB.

$$P_{WELD} = 47/102" = 0.461 \text{ K/IN.}$$

The smallest fillet weld throat for these AREAS IS 1.243".

ASSUMING THIS LOAD ACTS DIRECTLY IN TENSION

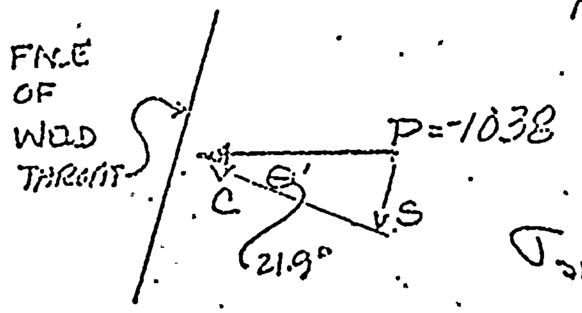
$$\sigma_{TEN} = 0.461/1.243 = .371 \text{ Ksi or}$$

371 PSI.

This stress is INSIGNIFICANT AND WHEN COMBIN WITH REF. 2 STRESSES IS STILL LESS THAN ALLOWABLE

CASE B

$$M' = 9032 + 979 + (1038 \times .75)$$
$$= 10740 \text{ in-lb/in}$$



$$C = P\cos\theta' = 963 \text{ lb/in}$$
$$S = P\sin\theta' = 387 \text{ lb/in}$$

$$\sigma_{SHEAR} = 387/1.243 = 311 \text{ psi} < 24900 \text{ psi}$$

$$\sigma_C = -\frac{963}{1.243} - \frac{10740\,(6)}{1.243^2} = -42482 < 43128$$

$$\sigma_t < \sigma_C \therefore \text{OK}$$

CASE C

$$P = 1683 \text{ lb/in} \qquad M = 1683(.75) + 9032$$
$$= 10294$$

$$T = 1683\cos\theta' = 1562$$
$$S = 1683\sin\theta' = 628$$

$$\sigma_{SHEAR} = 505 \text{ psi} < 24900 \text{ psi}$$

$$\sigma_T = \frac{1562}{1.243} + \frac{10294\,(6)}{1.243^2} = 41232 < 43128 \text{ psi}$$

CONCLUDING, THE TYPICAL WELD DESIGN FOR PT 3. IS SATISFACTORY.

AT POINT 3, A SECOND POSSIBLE GEOMETRY EXISTS; THE THROAT DIMENSION WILL BE VERIFIED & CONSIDERED SATISFACTORY IF IT IS LARGER THAN 1.243".

/e

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JUN 2 1975

WPPSS

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

WNP NO. 2

May 29, 1975

PDMBR-213-75-22
Contract 12764

Burns and Roe, Inc.
320 Fulton Avenue
Hempstead, NY 11550

Attention: Mr. J. J. Verderber,
Project Engineering Manager

Subject: Concluding Letter of Support Ring Weld Repairs

Gentlemen:

This letter is being written to describe the Lamellar tearing events as described in our meetings of May 27th and 28th.

DISCUSSION:

A periodic post-weld visual examination of the welds joining the support ring girders to the vessel shell showed Lamellar tearing to be present. To determine the extent of these defects, a highly sensitive Ultrasonic testing technique (HTL-UTP-9200) was employed based on the known discontinuity (Lamellar tearing). This examination mapped the location of the Lamellar indications as documented in NCR-00058, 00059, and 00060.

A weld repair procedure was developed to correct the Lamellar tearing. The first area to be repaired was at 0° azimuth, a weld of the top web of the upper support ring to the shell. The repair was successful. Subsequent UT (to HTL-UPT-9200) showed only acceptable indications in the repair weld.

Concluding that the repair procedure worked successfully, repairs were initiated in other areas. In performing UT examination of some repaired areas, indications to technique HTL-UTP-9200 were found behind the repair weld (toward the outside of the vessel) in the parent material.

PDMBR-213-75-22 May 29, 1975
Mr. J. J. Verderber

These indications were deemed unacceptable. UT examination of the area 2" beyond the area bounded by the previous repairs showed no indications. Repair was accomplished from the outside of the vessel shell. UT examination to HTL-UTP-9200 of the completed outside weld showed indications in a narrow band in the heat-affected zone and parent metal zone of the entire perimeter of each outside repair weld. UT of the weld metal itself was acceptable.

Not believing the indications to be Lamellar tearing and being unable to eliminate the indications during the welding process, a section of the vessel was removed and sent to USS Corporation for examination and report (see Attachment 1). In addition, microphotographs and a report were obtained from Hamill Testing Laboratory (see Attachment 2).

In summary, the following is stated:

Original Lamellar Tears were repaired by welding. Additional indications behind the repaired area (thru thickness region) were found by technique HTL-UTP-9200 necessitating repair from the outside of the vessel. Indications, known to be absent before the outside weld repair, appeared in the plate at the boundary of the repair weld. These indications were of various lengths (up to approximately 6 inches), lay from 1/4T to 3/4T from the outside surface and were from 1/8 to 1/4 inch in width.

JUSTIFICATION FOR ACCEPTANCE:

1. UT scan prior to final outside weld repair showed a band at least 2 inches on either side of the weld absent of indications.

2. Shell stresses in the through thickness direction local to the ring are at levels of 2,500 psi or less.

3. Through thickness repair weld restores the through thickness strength of the shell plate.

4. ASME Code, Section III, Paragraph NB-5130 permits laminar-type discontinuities on plate edges prepared for welding.

PDMBR-213-75-22 May 29, 1975
Mr. J. J. Verderber

5. The inclusion level in the plate was within the range expected for the grade and quality specified, and the base-plate sample met the Ultrasonic requirements of SA-435 for steel plates for pressure vessels.

6. When the plates are UT examined in accordance with ASME UT Procedure, SA-578, (Paragraph NB-2532.1), the above described indications are acceptable.

In summary, PDM believes the periphery indications are not removable and deems the vessel acceptable in accordance with the ASME Code and contract requirements.

The supplemental attachments as listed below will be sent when completed.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

J. F. Strunk

J. F. Strunk
Project Engineer

JFS/gt

Attachments (Later)

USS Report (1)
Hamill Test (2)
Rollouts of Each Web Repair Area (3)
Sample Cuts by USS and HTL (4)
Picture of Repair Area 11&12 Lower Support Ring (5)

cc: Dr. W. E. Cooper - Teledyne Materials Research
Mr. J. E. Woolsey - WPPSS

Burns and Roe, Inc.

320 Fulton Avenue * Hempstead, New York 11550 * Telephone (516) 56

TWX 510-222-4935 * Cable BUROE HEMPSTEADNY

Subject: W.O. 2808
Washington Public Power Supply System
WPPSS Nuclear Project No. 2
Contract No. 213
Repair of Containment Vessel

April 15, 1975
BRPDM-213-75-042

Pittsburgh-Des Moines Steel Company
Neville Island
Pittsburgh, PA 15225

Attention: Mr. J. Strunk

Reference: 1. Letter J. H. Adams to J. J. Verderber PDMBR-213-75-19, dated 4/3/75

2. B&R Memorandum S. Planzenbaum/J. Clapp to J. J. Verderber, dated 4/11/75 (attached)

Gentlemen:

The above referenced letter (Reference 1) contains your final engineering evaluation of the lamellar tearing problem that was found in the containment vessel at the upper pipe whip support. The Burns and Roe stress analysis review is contained in the above referenced memorandum (Reference 2), a copy of which is attached. A number of aspects of the lamellar tearing problem, however, still require clarification.

1. Please revise the weld repair procedure to define the sensitivity to be used in the ultrasonic examination so that the examination after the pneumatic test will show if any flow growth has occurred.

2. Please refer to page 2 of Reference 2. We feel the 90^{o} arc angle you assumed in your jacking frame erection calculation is unrealistic and should be revised since the ring was raised in segments.

While it may be difficult for you to ascertain the actual radial jacking load applied, we feel you should at least provide a calculated jacking load that is compatible with the calculated shell strain.

3. The sequence of the erection of the support ring described in Reference 1 is insufficiently detailed to how the pieces were assembled and how the jacks were utilized. For example, you show the fitting and welding of the flange segments into a ring as the first step; yet, our field personnel tell us the segments were raised into position before they were welded into a ring in conformance with the construction drawings. One needs to know if the jacks were used before or after the segments were welded into a ring, what the end condition was when the jacks were used, and if more than one jack was used on a segment.

4. The detailed comments resulting from the Burns and Roe stress analysis review of PDM Revision Number B, provided in Attachment A of Reference 2, must be resolved by PDM.

May we have your prompt attention to these matters.

Yours very truly,

John J. Verderber
Project Engineering Manager

JJV/HL/JC/dtl
Attachment

cc: Mr. J. E. Woolsey - WPPSS - 3 w/3
Mr. M. Schulze - PDM - Richland - 1 w/1

Telecopied to J. Strunk of PDM on 4/16/75

C. Simpson
J. Severino
K. Ronis
db

M E M O R A N D U M

BURNS and ROE, Inc. DATE: April 11, 1975

TO: J. J. Verderber

FROM: S. Flanzenbaum/J. Clapp

SUBJECT: W. O. 2808
WPPSS-NP2
Stress analysis review of Pittsburgh - Des Moines Steel Company letter PDMBR-213-75-19, with its enclosures.

Attachment A: Detailed Comments - Burns and Roe Stress Analysis Review of PDM Revision Number B.

In the enclosures to the Subject PDM letter, PDM has presented Revision Number B (Section IV, Subsection 5, Article 3, Pages 10 through 13B), which refines the stress intensity evaluation performed for the conical shell in the region of the upper pipe whip support ring (El. 542'-7¼"), as well as the support ring itself. Additionally, as part of Revision Number B, in Pages 288 through 296, PDM has presented a refined analysis of the support ring welds.

The Burns and Roe stress analysis review of the above-mentioned enclosures verify that the revised stress intensities for the conical shell, support ring, and welds meet the requirements of WPPSS Specification for Primary Containment Vessel- Contract No. 213, which includes compliance with the ASME-Section III Code for Class MC Components.

Although the Burns and Roe stress analysis review will require that PDM make certain modification to their revised stress intensities and calculated weld stresses, these modifications are of a minor nature which will result in minor changes to their stress analysis calculations. Detailed comments resulting from the Burns and Roe stress analysis review, are provided in the Attachment to this memorandum. These comments should be transmitted to PDM for their resolution.

A separate enclosure to the Subject PDM letter includes an analysis of the induced strain in the conical shell during field erection to close a 3-inch gap between the conical shell and support ring. A study of this analysis reveals that the induced strain is highly sensitive to the assumed arc angle of separation between the shell and ring. If the 90° arc angle, assumed by PDM, were halved to 45°, the induced strain would increase by a factor of 5.

PDM should provide a more detailed description of the field erection procedure which would relate to the actual arc angle of separation between shell and ring. Additionally, PDM should ascertain the actual radial jacking load applied in order to judge if it is consistent with their assumed analytical model and evaluation of induced strain in the shell.

S. Flanzenbaum/J. Clapp

S. Flanzenbaum / J. Clapp

JC/SF/nc
Attachment

ATTACHMENT A

Detailed Comments - Burns and Roe Stress Analysis Review of PDM Revision Number B.

1. The dead load placed on Cone Ring 4 has been revised (Revision B - IV.5.3. Page 12) to 1081.7 kips, and its order of magnitude appears reasonable. However, please provide a break-down of this revised load.

2. The stress output from the AX-2 Program (internal pressure condition) as shown in Revision B - IV.5.3. Page 13, indicates minor revisions from previously transmitted output (IV.5.3. Page 10). Please justify.

3. The revised stresses based on the BOSOR Program (Revision B - IV.5.3. Page 13) have all been adjusted by the ratio $(1.5/1.4375)^2$. Burns and Roe feels that this ratio is only applicable to bending stresses; and that the direct ratio of (1.5/1.4375) should be applied to the membrane stresses. Please confirm.

4. Revision B (IV.5.3. Page 12) shows the shear stress evaluated as an average shear stress. Inasmuch as the evaluation of maximum stress intensity at the outermost fiber correctly utilized a zero shear stress, the evaluation of maximum stress intensity at the neutral axis should consistently utilize the maximum shear stress (VQ/It), evaluated at the neutral axis. Please confirm.

5. The radial load indicated for Weld Point 3, Case B, Revision B (IV.5.3, Page 294) is given as 692 lb./in., instead of the correct value of 1038 lb./in. Although this will result in a higher level of weld stress, the corrected stress will still be below the allowable stress for the weld. Please confirm that the revised Case B will then prove to be the critical loading condition for Weld Point 3.

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

NEVILLE ISLAND • PITTSBURGH, PENNSYLVANIA 15225 • PHONE: (412) 331-3000

copy

April 3, 1975.

PDMBR-213-75-19
Contract 12764

Burns and Roe, Inc.
320 Fulton Avenue
Hempstead, N. Y. 11550

Attention: Mr. J. J. Verderber
Project Engineering Manager

Subject: Final Engineering Evaluation
Upper Support Ring Lamellar Tears

Gentlemen:

This letter contains the information requested by Burns and Roe at the meeting held in Pittsburgh on March 12, 1975.

The pipe whip support ring loads as given in the specification are exceedingly large for a thin shell structure to carry. In order to obtain an acceptable design, PDM requested the use of SA537 Class 2 material. SA537 material is a carbon-manganese-silicon, quenched and tempered steel for use in pressure vessels. It has a yield strength of 60 ksi min., an ultimate strength of 80 to 100 ksi, yet still maintains relatively high ductility (22% in 2") and has good weldability. It is a satisfactory material for use in containment vessels and provides the higher allowable working stress necessary in the design of the support rings. The analysis of the vessel in the area of the ring and the analysis of the ring are enclosed. The enclosed analysis pages will appear in the stress report for this area.

The erection of the support ring was accomplished as follows:

(1) Fit and weld the 2½" flange segments into a ring.

(2) Fit the $1\frac{1}{2}$" web plates to the shell and weld.

(3) Complete the splice plate welds. This operation has not been done yet.

The welding sequence was as follows:

(1) Weld the root pass of both the upper and lower web plates to the shell.

(2) Concurrently weld with one man on the top plate with semi-automatic equipment while four men located 90° apart weld the overhead manually.

(3) Complete the top plate cover welds using the manual process.

(4) Preheat was used during welding but the weld was allowed to return to ambient temperature at night.

This procedure resulted in as near a uniform rate of filling the weld groove as was practicable. A copy of the Welding Procedures and Weld Qualifications used are enclosed.

In order to do a proper job of welding the pipewhip support girder to the shell, it was necessary to maintain the gap between the girder webs and the shell at 1/16" or less. The shell was several inches out of round at the elevation of the girder. It was necessary to use a jacking frame and a jack as shown on attached Sketch 1 in order to pull the shell in to fit the girder within the required limits. Twenty, fifty and 100 ton hydraulic jacks were used to pull the shell into the required fit with the girder. The one hundred ton jack was used at only a few spots where the gap between girder and shell was several inches. The general foreman on the job feels that the full capacity of the 100 ton jack was never used since the longest jack handle used was about 20".

Burns and Roe, Inc. April 3, 1975.

Attached is calculation page 1 prepared by Jim Strunk and dated April 2, 1975. In this calculation Jim has used the maximum gap, three inches, between the girder and shell and calculated the maximum surface strain created in the shell by jacking shell and girder into conformity. In making this calculation he assumed that all of the strain occurred in the shell. The calculated strain is 0.0045%, an insignificant value.

The four welds between the shell and the webs of the two girders were inspected usually, by Magnetic Particle, and by Ultrasonics. The visual and UT inspection revealed extensive lamellar tears in the shell plate at the welds on the top and bottom webs of the top girder. The inspections revealed a $\frac{1}{4}$" x $1\frac{1}{2}$ defect in the weld on the top web of the bottom girder. This defect was judged to be a slag inclusion. UT gave twelve indications of lamellar tears in the shell at the weld on the bottom web of the bottom girder. All defects will be repaired and reinspected in accordance with the attached procedure, "Repair of Weld at Pipe Whip Support to Shell" revised on March 27, 1975.

At the meeting on March 12th a number of questions were asked concerning the lamellar tears. I will state each question and follow it with my answer.

Why did lamellar tearing occur some places and not at others?

This is like asking why does a tensile test specimen select one specific cross section to fracture rather than another. The answer, of course, is that it selects the weakest cross section at which to fail. Metallic materials are non-homogeneous materials. They have varying physical properties in all directions, but the variation in the through thickness direction is wider than in either of the other two directions. Also, the average tensile and yield strength in the through thickness direction is considerably lower than in either of the other two directions. In addition, the strains caused by welding are not uniform. They vary from place to place tending to increase as the length of completed weld increased.

What assurances are there that residual stresses will not cause additional cracks?

Let me quote from "Commentary on Highly Restrained Welded Connections" published in the AISC Engineering Journal, 3rd Quarter 1973, Vol. 10, No. 3 page 61:

> "Lamellar tearing is the separation in the parent or base material caused by "thru-thickness" strains induced by weld metal shrinkage ---. Under conditions of high restraint, localized strains due to weld metal shrinkage can be many times higher than yield point strains, whereas stresses due to design loads are only a fraction of yield point; thus the strains due to applied loads are not of primary concern in causing lamellar tearing. No cases are known of lamellar tears being initiated or propogated by design loads."

Will cracks occur where they have not yet occurred?

The above quotation indicates that lamellar tears will not occur after or propogate after the welding is completed and the part has returned to ambient temperature.

How does quenching and tempering affect the residual stresses in the plate?

When the plate is quenched the material near the two surfaces are left in a state of tension in the direction transverse to and parallel to the rolling direction; the center of the plate is left in a state of compression. When the plate is tempered at approximately 1100°F or higher, these stresses are relieved to a much lower level. After quenching, the surface stresses would be near the proportioned limit value. After tempering, the stresses would be of the order of 15 ksi. These stresses would not contribute to lamellar tearing because they are parallel to the face of the plate. Lamellar tearing results from tensile stresses normal to the surface of the plate.

The attached repair procedure should result in a sound

structure with no reoccurance of lamellar tearing.

Very truly yours,

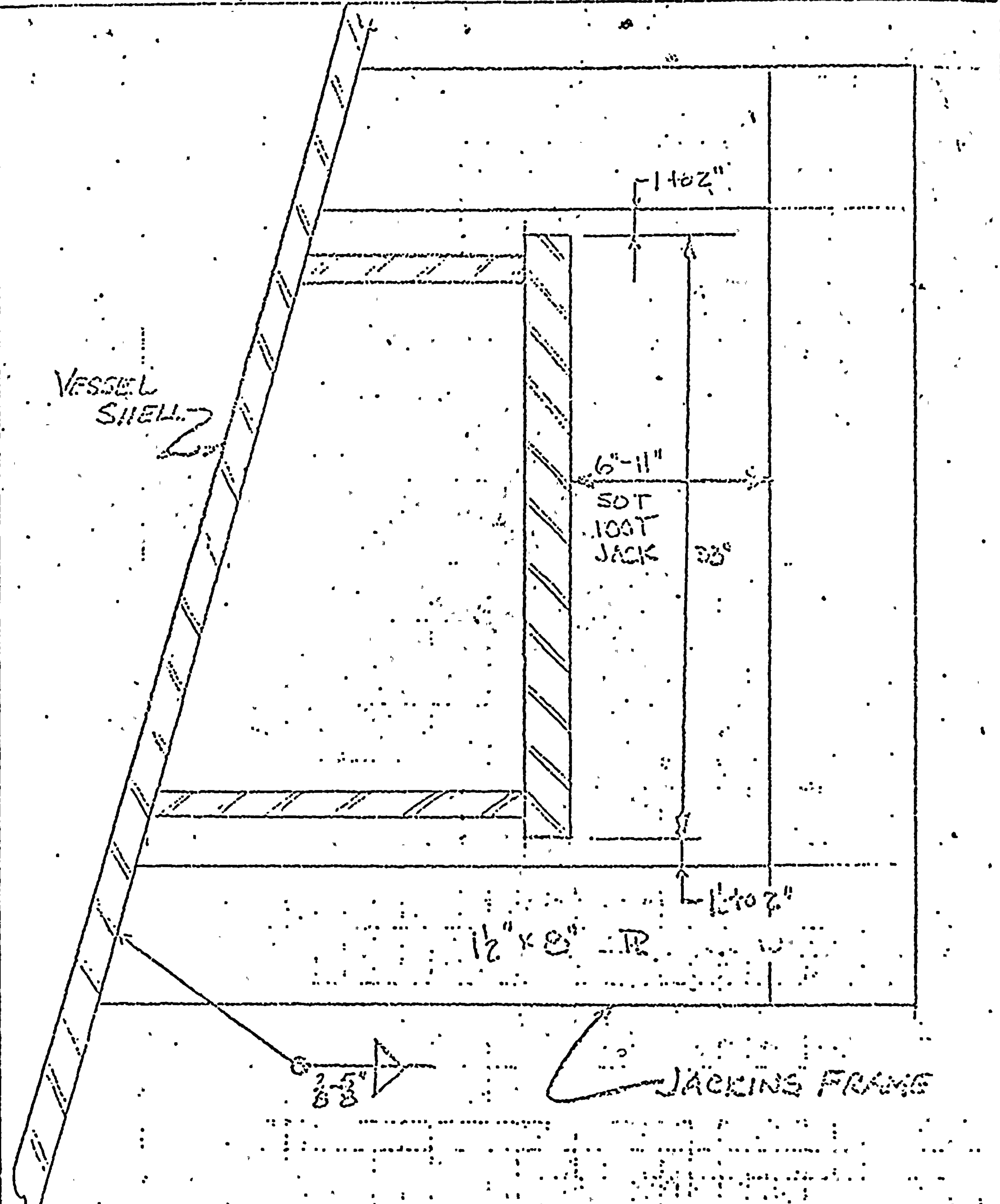
PITTSBURGH-DES MOINES STEEL COMPANY

J. H. Adams

J. H. Adams, Chief Engineer.

JHA:mfb
Enc.

cc: William Cooper
Telodyne Materials Research

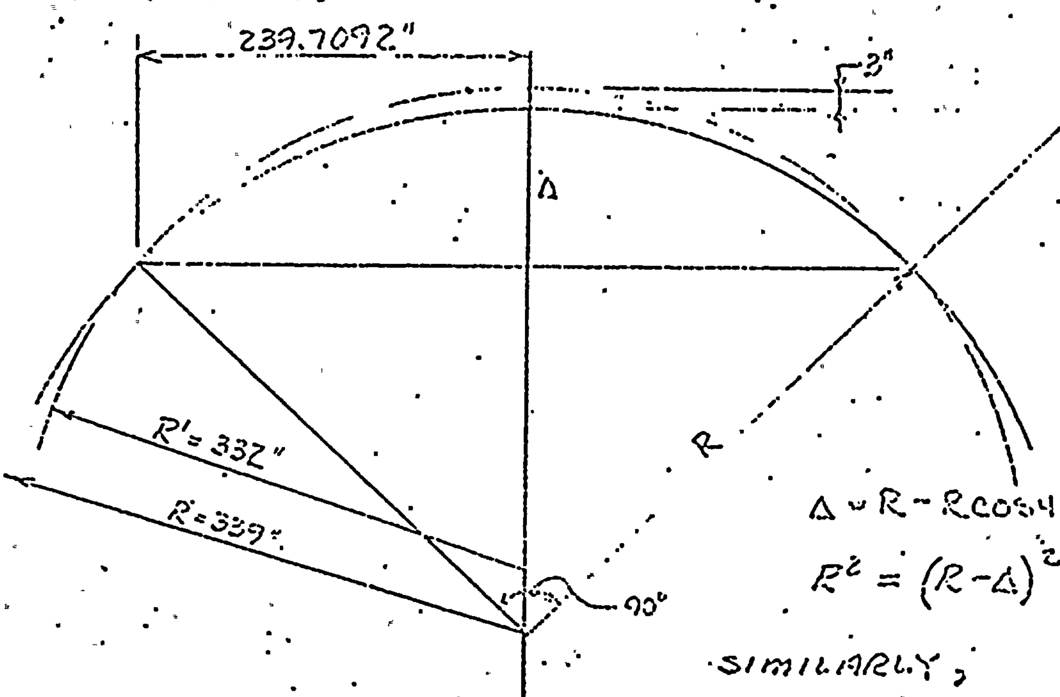


JACKING FRAME – UPPER SUPPORT RING ERECTION

REV.	SUBJECT WPPSS NUCL. PROJ. NO. 2 LOCATION RICHLAND, WASH.	CONTR. NO. 12.761
	PREPARED BY [illegible] DATE [illegible] | CHECKED BY — DATE —	PAGE NO. SK [illegible]

FIELD ERECTION CALCULATIONS

ASSUME A 3" OUT OF ROUNDNESS OVER 90° OF VESSEL.



$\Delta = R - R\cos 45° = 99.2908"$

$R^2 = (R-\Delta)^2 + 239.7092^2$

SIMILARLY,

$$R'^2 = [R' - (\Delta + 3)]^2 + 239.7092^2$$

THEN, $\cancel{R'^2} = \cancel{R'^2} - 2(102.2908)R' + 102.2908^2 + 239.7092^2$

AND $R' = 332"$

A. ORIGINAL THEORETICAL STRAIN $= \frac{50T}{R_f^*}$ WHERE R_f^* IS ADJUSTED FOR CONICAL SECTION, & $T = 1.5"$.

$$\% = {}^{75}/_{339/\cos 16.054°} = 0.2126\%$$

B. TO FIELD FIT CONE TO RING $\% = \frac{50T}{R_f^*}\left(1 - \frac{R_f^*}{R_o^*}\right)$

$$\% = 0.2126\left(1 - \frac{339/\cos 16.054}{332/\cos 16.054}\right) = -0.0045\%$$

WHERE THE MINUS SIGN INDICATES STRAIN RELIEF.

Reference - NE-4213 of ASME Section III.

STRESS INTENSITY EVALUATION

1) The COMPUTER ANALYSIS WHICH FOLLOWS COMBINES ALL THE BEAM SEAT LOADS (DL+LL+EQ(SSE)) FOR LOCATION 300° PLUS the effect OF OTHER ADJACENT BEAM Seats. IN ADDITION, THE VERTICAL AND TANGENTIAL LOADS WERE BOTH USED SIMULTANEOUSLY, CONTRARY TO THE REQUIREMENTS OF THE LOADING DRAWING SB00. THIS will MAKE THE RESULTS CONSERVATIVE.

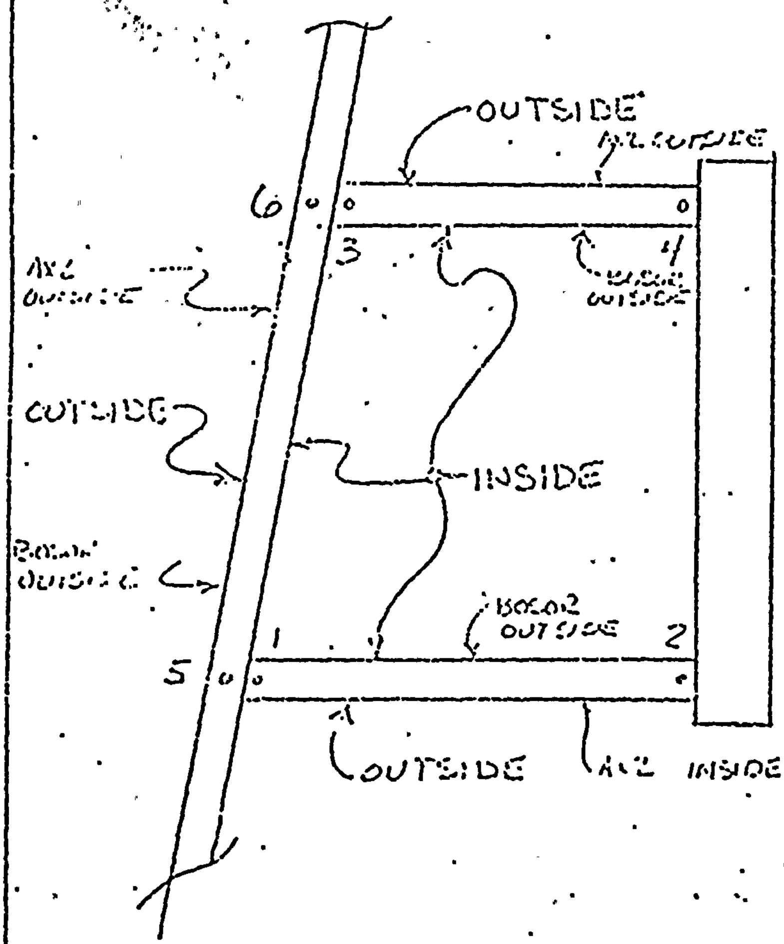
2) THE ANALYSIS IN BOSOR USED THE VESSEL ACTUAL WALL THICKNESS WITHOUT ADJUSTING FOR THE 1/16" METAL ALLOWANCE. THE FOLLOWING VESSEL SHELL CALCULATIONS WILL BE ADJUSTED TO COMPENSATE FOR THIS DEFICIENCY. THE EXTREME FIBER STRESSES WILL BE INCREASED BY THE RATIO $(1.5/1.4375)^2 = 1.089$. THE MEMBRANE STRESSES WILL BE COMPUTED FROM THE EXTREME FIBER STRESSES.

3) THE LOCA VESSEL LOADING CONDITION WITH SSE WILL BE EVALUATED AND COMPARED TO $P_L = 1.5\,S_y$. THESE STRESSES WILL ALSO BE COMPARED TO $1\frac{1}{2}\,S_m$ WHICH WILL SHOW THAT THE BEAM SEAT DESIGN WILL ALSO SATISFY THE ½ SSE EARTHQUAKE AND NORMAL BEAM SEAT LOADS.

4) IN CONJUNCTION WITH THE LOCA DESIGN, THE FOLLOWING will ALSO BE CONSIDERED: 1) VESSEL DEAD LOADS, AND 2) LOCA BELLOWS LOAD (DWG. FO [illegible]), 3) CONSIDERING THE EQ. LOADS, THE TENSILE SIDE (FOR $EQ_{\text{[illegible]}}$) WILL BE CONSIDERED. THE VESSEL DEAD LOAD WILL BE CONSIDERED ONLY AS BEING LESS EFFECTIVE

IF A 0.45 VERTICAL UP MOTION IS USED. WELD PAD LOADS WILL BE NEGLECTED.

THE SKETCH BELOW WILL INDICATE THE MOST HIGHLY STRESSED REGIONS. THE VESSEL SHELL STRESSES WILL BE INVESTIGATED FIRST. THE RING WILL NOT BE ASSUMED TO CARRY ANY VESSEL E.Q. LOADS.



COMPUTER OUTPUT CORRELATION

POINT SKETCH PG. 11	A/Z BODY	A/Z SIG	BOSOR SEGMENT	PT
1	23	20	4	1
2	23	1	4	23
3	25	20	8	15
4	25	1	8	1
5	21	1	3	31
6	26	20	3	53

FOR SA537 GR. B $S_{Y@T} = 47.92$ KSI

$S_{m}@T = 20.5$ KSI

PREPARED BY / DATE	5-21-75				ARTICLE: 5
CHECKED BY / DATE	4-1-75				PAGE: 12
REVISION NUMBER	B				

a). From Pg IV.2.1.26 OF THE STRESS Report DL = 1081.7 Kips on CONE RING 4.

b) FROM REFERENCE 1, (B&R Spec) Fig. 7&9

M_{SSE} @ EL 544 = 90×10^3 FT-K

S_{SSE} @ EL 544 = 3250 Kips

c) FROM REFERENCE 1, Fig. 5

$g_{VERT} = 0.45$.

d) THE TOTAL COMPRESSIVE BELLOWS LOAD IS: 1) 170 #/IN × 2π r, where r = 207" & 30 #/IN × 2πr, where r = 153".

therefore F_{TOT} = 250 KIPS

R = 338.95" INSIDE RADIUS WITH METAL 1/16" Allow. Removed

Then, DL(.55) + F = 844.9 Kips ↓

$\sigma_{DL+B} = 844.9 / 2\pi R t \cos 16.0514 =$

$= 844.9 / 2\pi \, 338.95 (1\tfrac{7}{16}) \cos 16.0514$

$= -287$ psi.

$\sigma_{BEND} = M / \pi R^2 t \cos 16.0514 = 2166$ psi

$\tau = S / \pi R t = 2123$ psi

PREPARED BY / DATE	JS 3-21-75				ARTICLE: 3
CHECKED BY / DATE	JM 4-1-75				PAGE: 12
REVISION NUMBER	B				

THE ABOVE STRESSES WILL BE CONSIDERED TO ACT AT POINTS 5 & 6 AS SHOWN ON PAGE 11.

THE FOLLOWING TABLE SUMMARIZES THE STRESSES FOUND FOR EACH POINT SHOWN ON PAGE 11 SKETCH. THE TABLE LISTS: 1) THE LOCAL (P_L) MEMBRANE STRESS & 2) THE LOCAL MEMBRANE + SECONDARY STRESSES AT THE EXTREME FIBERS (P_L+Q). THE TABULATED BOSOR STRESSES ARE CORRECTED FOR THE MODIFIED THICKNESS.

POINT	STRESS					
	P_L		P_L+Q (INSIDE)		P_L+Q (OUTSIDE)	
	σ_ϕ	σ_θ	σ_ϕ	σ_θ	σ_ϕ	σ_θ
1 AXZ BOS	544 ∓126	3879 ∓771	-3280 ±19091	2769 ±4490	4368 ∓19312	5049 ∓6044
2 AXZ BOS	301 ∓1467	4122 ±5392	4197 ∓6596	5269 ±3934	-3596 ±34163	2975 ±6850
3 AXZ BOS	430 ∓1122	3868 ∓5275	-2047 ∓25208	3103 ∓12251	29016 ±22965	4633 ±1102
4 AXZ BOS	273 ∓265	4024 ∓5843	2730 ±3375	4740 ∓4310	-2183 ∓3905	3309 ∓7315
5 AXZ BOS	5736 ∓1432	5436 ∓1970	15681 ±17141	8426 ±4034	-4209 ∓20125	2447 ∓7993
6 AXZ BOS	5457 ±2373	5377 ∓5678	13746 ±23234	7857 ±439	-2831 ∓18338	2596 ∓11774

THE ABOVE BOSOR STRESSES ARE VALUES WHICH WERE TAKEN FROM THE SUMMARY [illegible] ON PAGE [illegible] & MODIFIED [illegible] AS STATED IN PARA. 2 ON PAGE 10.

PITTSBURGH - DES MOINES STEEL CO. CONTRACT NO. 12764.
WPPSS HANFORD NO. 2 CONTAINMENT VESSEL

PREPARED BY / DATE 3-21-75					SECTION 3.7
CHECKED BY / DATE 4-1-75					SHEET 5
REVISION NUMBER B					ARTICLE 5
					PAGE 13A

CHECK SHELL PLATE STRESSES: PT # 5

P_L - LOCAL MEMBRANE:

CONSIDER $\sigma_{\phi\,BEND}$ AT 90° FROM THE VESSEL ℄:

$$\sigma_\phi = 5736 + 1492 + 2166 - 287 = 9107 \text{ psi}$$

$$\sigma_\theta = 5436 + 1970 = 7406 \text{ psi}$$

$\tau = 0$, if EQ. σ_{bend} IS used.

$\therefore$ SI = 9107 psi < 1½ S_y & 1½ S_m

OR: AT ℄ WHERE $\sigma_{\phi\,BEND} = 0$ & $\tau = 2123$ psi

$$\sigma_\phi = 5736 + 1492 - 287 = 6941 \text{ psi}$$

$$\sigma_\theta = 5436 + 1970 = 7406 \text{ psi}$$

$$\tau = 2123$$

$$\sigma_{1,2} = \frac{6941 + 7406}{2} \pm \sqrt{\left(\frac{6941 - 7406}{2}\right)^2 + 2123^2}$$

$\sigma_1 = 9309$ psi $\sigma_2 = 5037$ psi

$\therefore$ SI = 9309 psi < 1½ S_y & 1½ S_m

$P_L + Q$ - BY INSPECTION OF THE TABLE SHOWN ON PG. 13, IT IS OBVIOUS THAT ALL COMBINATIONS OF STRESSES ARE LESS THAN 3 S_m; $\therefore$ THE SHELL PLATE AT PT # 5 IS ADEQUATE.

CHECK SHELL PLATE STRESSES: PT #6

P_L - LOCAL MEMBRANE - See Table Pg 13.

BY INSPECTION, IT IS OBVIOUS THAT THE NET SUM OF $\sigma_{\phi i}$, σ_{θ} PLUS $\sigma_{\phi BEND}$ + τ WILL BE LESS THAN 1½ Sy & 1½ Sm. ALSO, P_L + Q WILL BE LESS THAN 3 Sm, ∴ The SHELL PL AT PT #6 IS ADEQUATE.

SUPPORT RING STRESSES: POINTS 1, 2, 3 & 4

INSPECTION OF THE TABLE OF STRESSES SHOWN ON Pg. 13 FOR POINTS 1, 2, 3 & 4 CLEARLY DEMONSTRATES THAT P_L AND P_L + Q STRESS INTENSITIES WILL BE LESS THAN THEIR RESPECTIVE ALLOWABLES FOR PIPE RUPTURE AND NORMAL DESIGN LOADS.

CONCLUDING, THE RING SUPPORT DESIGN AT ELEVATION 512'-1½ IS ADEQUATE TO CARRY BOTH THE PIPE RUPTURE LOADS AND NORMAL DESIGN LOADS.

EXAMINATION OF SUPPORT RING WELDS:

(TO SHELL & 2½" FLANGE)

FOR POINTS 1,2,3 & 4 SHOWN ON PAGE 11, THE DESIGN STRESSES, FORCES AND MOMENTS ARE TABULATED BELOW FROM DATA ON Pg. [illegible]

$P = \sigma_M \, t \qquad \sigma_M$ = membrane stress

$M = \sigma_B \, t^2/6 \qquad \sigma_B$ = Bending Stress

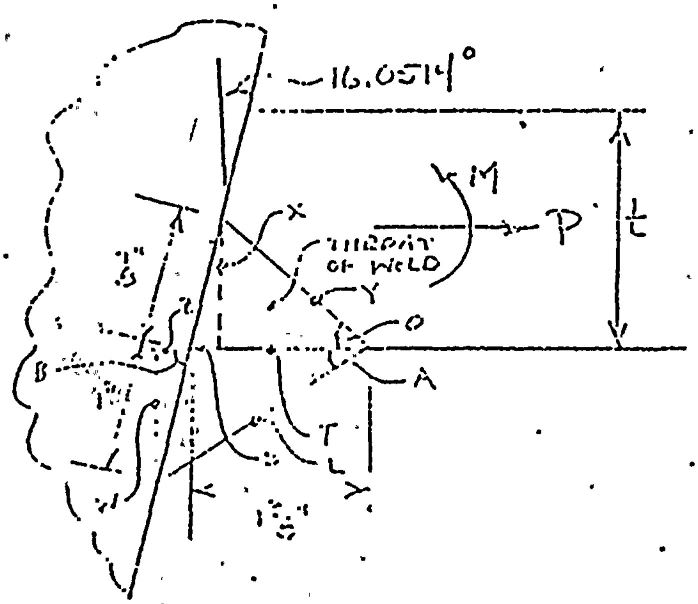
FOR CONVIENENCE AND TO BE CONSERVATIVE, THE STRESSES WILL BE SUMMED FOR RING LOADS (BOSOR) AND PRESSURE (AXZ) USING ABSOLUTE VALUES. THEREFORE,

$$\sigma_B = \underbrace{\left(\mathrm{MAX}\,|\sigma_\phi|_{(P_L+Q)} - |\sigma_\phi|_{(P_L)} \right)}_{\text{from BOSOR}} + \underbrace{\left(\mathrm{MAX}\,|\sigma_\phi|_{(P_L+Q)} - |\sigma_\phi|_{(P_L)} \right)}_{\text{FROM AXZ}}$$

$$\sigma_M = \underbrace{|\sigma_\phi|_{P_L}}_{\text{BOSOR}} + \underbrace{|\sigma_\phi|_{P_L}}_{\text{AXZ}}$$

POINT	σ_M	σ_B	P #/IN	M IN lb/IN
1	670	23040	1005.	8640
2	1768	8825	2652	3309
3	1552	26562	2328	9961
4	538	6097	807	2286

POINT 1 WELD: (PARTIAL PENETRATION)



$S = .875 \sin 16.054° = .242$
$X = .875 \cos 16.054° = .841$
$T = 1.375 - S = 1.133$
$Y = (T^2 + X^2)^{1/2} = 1.411$
$\theta = \tan^{-1} X/T = 36.580°$

$B = 90° - 16.054° = 73.946$
$Z = 1.0 \cos B = .2765$
$W = 1.0 \sin B = .96101$

$L = \sqrt{W^2 + (Z + 1.375)^2} = 1.91076$

$$\frac{1.0}{\sin A} = \frac{L}{\sin 106.054°}$$

$$A = \sin^{-1} \frac{\sin 106.054°}{L} = 30.195$$

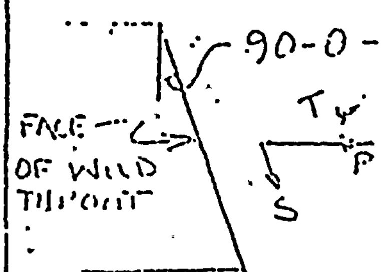
$\theta + A = 66.781°$

THROAT OF WELD:

$\therefore Y \sin(\theta + A) = \underline{1.297}$ IN

LOADS ACTING ON FACE OF THROAT:

ASSUME P transfers t/4", THEN LOADS ON FACE OF WELD ARE AS FOLLOWS:



$90 - \theta - (90 - (\theta + A)) = A = 30.195°$

$M' = M + P\frac{t}{4} = 8640 + 1005\left(\frac{1.5}{4}\right) = 9017$ IN-lb/IN

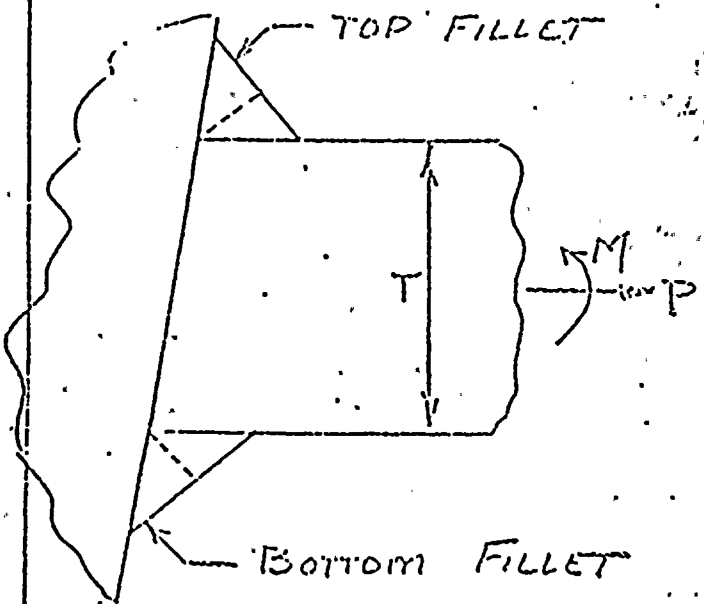
$T = P \cos 30.195° = 869$ #/IN
$S = P \sin 30.195° = 505$ #/IN

$$\sigma_{SHEAR} = S/t = 359\ psi < \frac{.9F_y}{\sqrt{3}} = 24960\ psi.$$

$$\sigma_{TENSION} = \frac{T}{THROAT} + \frac{6M}{THROAT^2} = \frac{869}{1.297} + \frac{(9017)6}{1.297^2}$$

$$= 32831\ psi < .9F_y = 43125\ psi$$

POINT 1 WELD: (Fillet AT SPLICE R.)



ASSUME EACH FILLET WELD IS LOADED BY P' WHICH IS EQUAL TO:

$$\frac{P}{2} + \frac{M}{T} = P'$$

$$P' = 503 + \frac{8640}{1.5}$$

$$= 6263\ \#/IN.$$

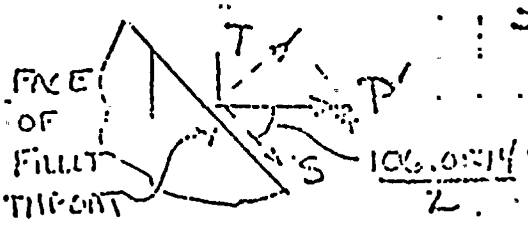
$$THROAT\ @\ TOP\ FILLET = .5\left(\cos\left(\frac{90-16.0514}{2}\right)^\circ\right)$$

$$= 0.399''$$

$$THROAT\ @\ BOTTOM\ FILLET = .5\left(\cos\left(\frac{90+16.0514}{2}\right)\right)$$

$$= 0.301''$$

STRESSES: BOTTOM FILLET



$$S = P'\cos(106.0514/2)^\circ = 3767\ \#/IN$$

$$T = P'\sin(106.0514/2)^\circ = 5004\ \#/IN$$

$$\sigma_{SHEAR} = 3767/.301 = 12515\ psi <$$

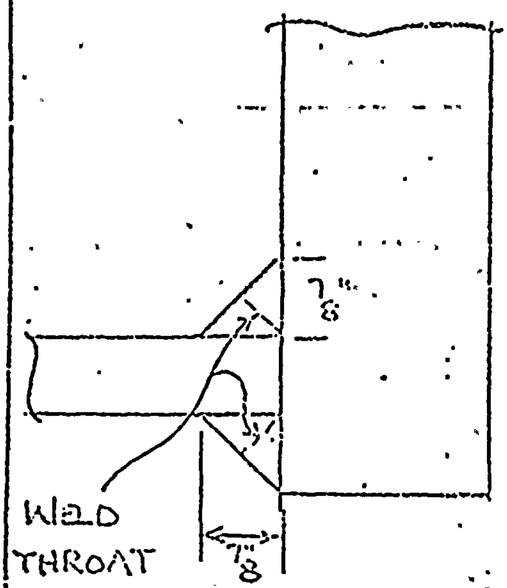
$$\sigma_{TENS} = 5004/.301 = 16625\ psi <$$

THE TOP FILLET IS ADEQUATE SINCE IT HAS A LARGER THROAT.

FINALLY, THE WELDS AT POINT 1 ARE TOTALLY ADEQUATE.

<u>POINT 2 WELD</u>: (DOUBLE FILLETS)

CONSIDER 2 - $\frac{7}{8}''$ FILLET WELDS:



$$\text{THROAT} = .875\,(\sin 45^\circ) = .619''$$

LOAD TO EACH FILLET =

$$\frac{P}{2} + \frac{M}{T} = P' = 3532\ \#/\text{IN}$$

$$S = P' \cos 45^\circ = 2498\ \#/\text{IN}$$
$$T = P' \sin 45^\circ = 2498\ \#/\text{IN}$$

$$\sigma_S = \sigma_T = \frac{S}{\text{THROAT}} = \frac{T}{\text{THROAT}}$$

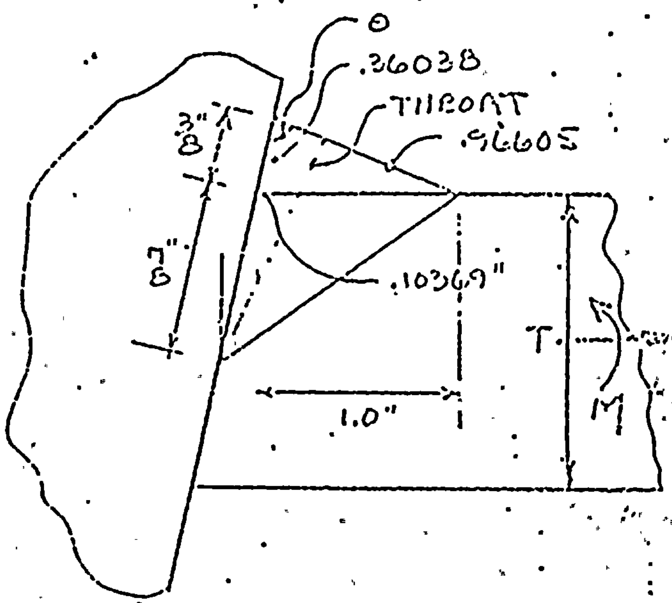
$$\sigma_{SHEAR} = \sigma_{TENSION} = 4036\ \text{PSI}$$

BOTH OF WHICH ARE LESS THAN $.9F_Y/\sqrt{3}$ & $.9F_Y/2$ RESPECTIVELY

$\therefore$ THE WELDS AT POINT 2 ARE ADEQUATE.

POINT 3 WELDS: (PARTIAL PENE. WELD)

FIRST GEOMETRY:



$\theta = 16.0514 + \tan^{-1} \frac{1-.10369}{.36038}$

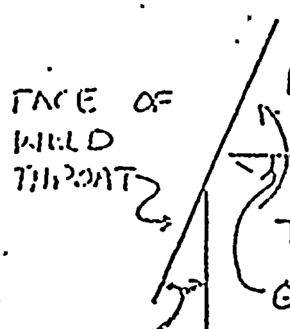
$\theta = 84.15°$

THROAT = 1.25 SIN θ

= 1.243"

ASSUME P TRANSFERS $\frac{T}{4}$",

THEN LOADS ON FACE OF WELD ARE AS FOLLOWS:



$M' = M + \frac{PT}{4} = 9961 + \frac{\overset{642}{2328}}{4}(1.5) = 10834 \frac{\text{IN-LB}}{\text{IN}}$

P = 2328 #/IN

$S = P \sin\theta' = 868$ #/IN

$T = P \cos\theta' = 2160$ #/IN

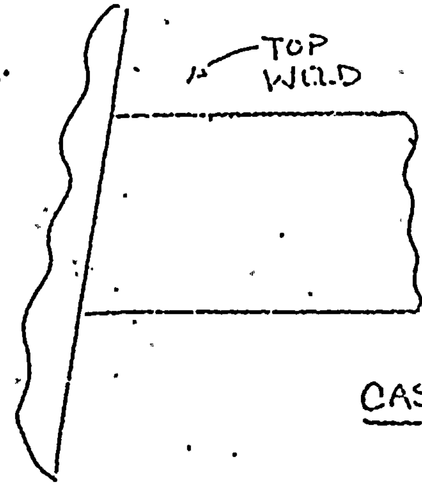
$16.0514° + 90 - 84.15$
$= 21.9° = \theta'$

$\sigma_{SHEAR} = 868/1.243 = 698$ psi $< .9F_Y/1.3$

$\sigma_{TEN} = \frac{2160}{1.243} + \frac{6(10834)}{1.243^2} = 43810$ psi

A CLOSER REVIEW OF THE LOAD COMBINATIONS MADE ON Pg 288 SHALL BE MADE TO EVALUATE WELD STRESS AT POINT 3.

FROM THE STRESS TABLE ON PAGE 15:



CASE A

$\sigma_P = 1552$
$P_T = 2328$ #/in

$\sigma_{M_{BOS}} = 24086$ psi
$M_B = 9032$ "#

$\sigma_{M_{AVE}} = 2476$ psi
$M_A = 929$ in-#/"

OR

CASE B

$\sigma_{P_C} = -692$
$P_C = -1038$ #

$\sigma_{M_{AVE}} = 2476$
$M_A = 929$

$\sigma_{M_{BOS}} = 24086$
$M_B = 9032$

OR FOR Support Ring Loads ONLY W/O PRESSURE

CASE C

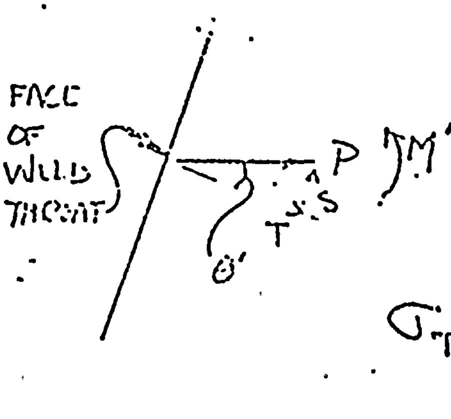
$\sigma_P = 1122$
$P_T = 1683$ #/in

$\sigma_{M_{BOS}} = 24086$
$M_B = 9032$

ASSUME P TRANSFERS T/2", THEN FOR:

CASE A:

$P = 2328$ & $M' = 9032 - 929 + 2328(.75)$
$= 9849$



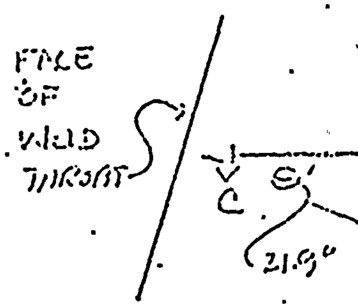
$S = P \sin\theta' = 868$ #/in
$T = P \cos\theta' = 2160$ #/in

$\sigma_{SHEAR} = 868/1.243 = 698$ PSI < 2490

$$\sigma_T = \frac{2160}{1.243} + \frac{6(9849)}{1.243^2} = 39985 \text{ PSI} < 43128 \text{ PSI}$$

CASE B

$M' = 9032 + 929 + (692 \times .75)$
$= 10480.$ "#/IN



$C = P\cos\theta' = 642$ #/IN
$S = P\sin\theta' = 255$ #/IN

$\sigma_{SHEAR} = 255/1.243 = 205$ psi < 249..

$$\sigma_C = -\frac{642}{1.243} - \frac{10480\,(6)}{1.243^2} = -41214 < 43128$$

$\sigma_t < \sigma_C$ ∴ OK

CASE C.

$P = 1683$ #/IN $\quad M = 1683(.75) + 9032$
$= 10294$

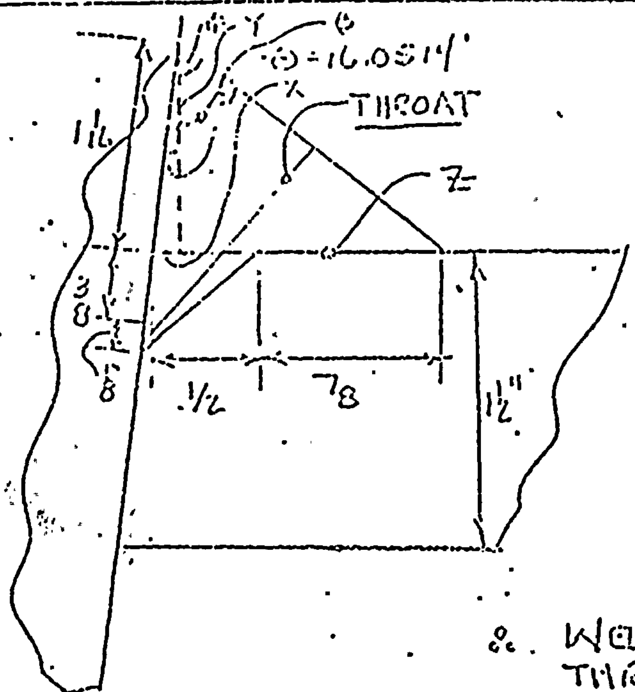
$T = 1683\cos\theta' = 1562$
$S = 1683\sin\theta' = 628$

$\sigma_{SHEAR} = 505$ psi < 24900 psi

$$\sigma_T = \frac{1562}{1.243} + \frac{10294\,(6)}{1.243^2} = 41232 < 43128$$

CONCLUDING, THE TYPICAL WELD DESIGN FOR PT 3 IS SATISFACTORY.

AT POINT 3, A SECOND POSSIBLE GEOMETRY EXISTS; THE THROAT DIMENSION WILL BE VERIFIED & CONSIDERED SATISFACTORY IF IT IS LARGER THAN 1.243".



$X = 1.0625 \times \sin\theta = .29378$
$Y = 1.0625 \times \cos\theta = 1.02108$
$Z = 1.375 - X = 1.08122$

$\phi = \tan^{-1} Z/Y = 46.6386$

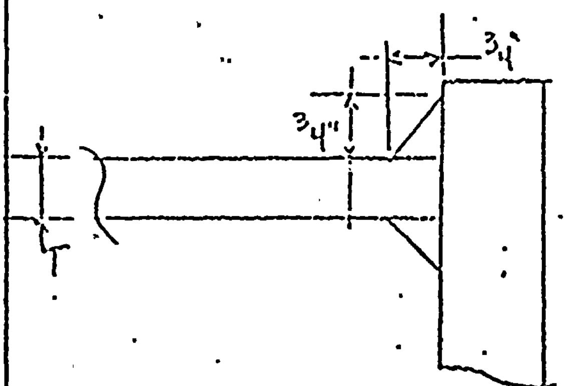
$\beta = \theta + \phi = 62.689$

$\text{THROAT} = 1\tfrac{9}{16} \cdot \sin\beta = 1.388$

$\text{THROAT}_{\text{EFFECT}} = \text{THROAT} - \tfrac{1}{8} = 1.263''$

∴ WELD IS ADEQUATE SINCE THROAT IS LARGER THAN THE THROAT CALCULATED FOR FIRST GEOMETRY ON PAGE 292.

<u>POINT 4 WELD:</u> (TYPICAL EXCEPT AT SPLICE B)



ASSUME EACH FILLET WELD IS LOADED BY P' WHICH IS EQUAL TO:

$$\frac{P}{2} + \frac{M}{T} = P'$$

$$P' = \frac{807}{2} + \frac{2286}{1.5} = 1928 \ \#/\text{IN}$$

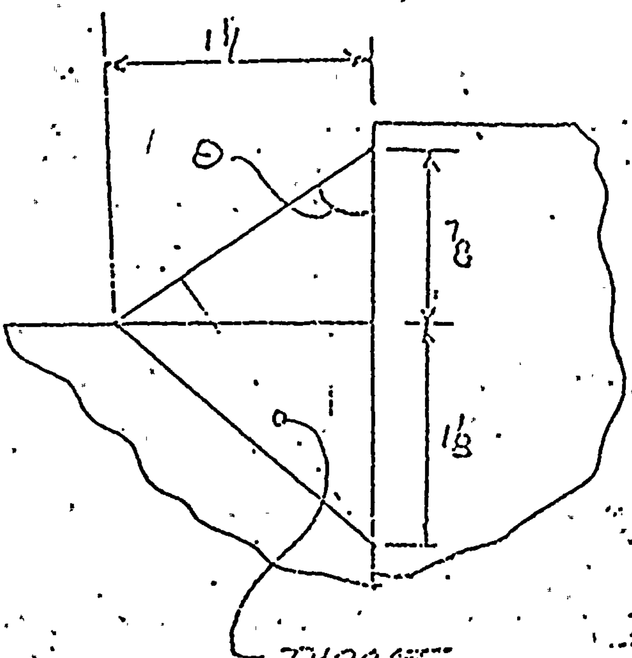
$\text{THROAT} = .75(\sin 45°) = 0.530''$

$S = P' \cos 45° = 1363 \ \#/\text{IN}$
$T = P' \sin 45° = 1363 \ \#/\text{IN}$

$$\sigma_{\text{SHEAR}} = \sigma_{\text{TEN}} = 1363/.530 = 2572 \text{ psi}$$

$< .9F_y \ \& \ .9F_y/1.5 \ \therefore \text{OK}$

POINT 4 WELD : (AT SPLICE PLATE)



$\theta = \tan^{-1} \frac{1.25}{.875}$

$\theta = 55°$

THROAT = 2.0" (SIN 55°)

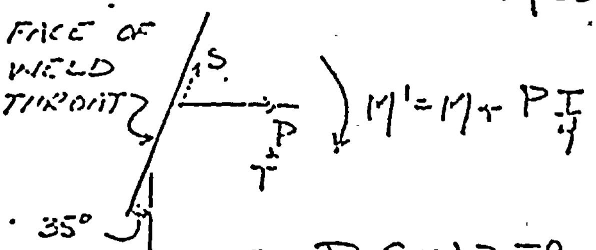
= 1.638"

ASSUME P TRANSFERS T/4";

THEN $M' = M + P\frac{T}{4}$

From Pg 288, P = 807 M = 2286

M' = 2589



S = P SIN 35° = 807 SIN 35° = 463 #/IN
T = P COS 35° = 807 COS 35° = 661 #/IN

$\sigma_{SHEAR} = 463/1.638 = 283$ PSI < 24900 psi

$\sigma_{Ten} = \frac{661}{1.638} + \frac{2589(6)}{1.638^2} = 6193 < 43128$ psi

CONCLUDING, THE WELDS OF THE UPPER SUPPORT RING AND ITS WELDS TO THE SHELL ARE ADEQUATE FOR THE SPECIFIED LOADS.

[illegible] Procedure Specification 70-72A
Burns and Roe Specification 2808-213
WPPSS Nuclear Project No. 2

[illegible] Flux Cored Arc Welding (FCAW) and Shielded Metal Arc (SMAW)
ASME Section III, Class MC.

THIS PAGE IS A RECORD OF ALL REVISIONS OF THE SPECIFICATION. EACH TIME THE SPECIFICATION IS CHANGED, ONLY THE NEW OR REVISED PAGES ARE ISSUED.

FOR CONVENIENCE, THE NATURE OF THE REVISION IS BRIEFLY NOTED UNDER REMARKS, BUT THESE REMARKS ARE NOT PART OF THE SPECIFICATION. THE REVISED PAGES ARE A PART OF THE SPECIFICATION AND SHALL BE COMPLIED WITH IN THEIR ENTIRETY.

REV	DATE	BY	PAGES	REMARKS
0	12-7-73	AVT	ALL	Initial issue.
A	2-12-75	AVT	4	Added sketch to page.

REV	ENGINEERING APPROVAL	OPERATING DEPARTMENT APPROVAL	
0	[illegible signature]	[illegible signature]	
A	[illegible signature]	[illegible signature]	

ESSENTIAL VARIABLES

This procedure specification is a qualified procedure for the construction of weldments whose essential variables fall within the limitation specified below. A different procedure specification is required for weldments whose essential variables differ from those specified below.

Base Metal - The base metal shall conform to the specifications for ASME SA537 Gr. B, which is found in materials Group P - Number 12B-SG-2.

Filler metal - The filler metal shall conform to McKay 85C3 and shall conform to the applicable requirements of ASME SFA5.20 for composite electrodes in Group Number F-6 and ASME SFA5.5 Classification E8018C3 for ferrous filler metal in Group Number F-4. The chemical composition of the weld deposit shall fall within the following limits: C - .05, Mn - .90, Si - .55, Ni - .40, Mo - .55.

Shielding Gas - The gas shall be weld grade CO_2 used at a flow rate of 60 CFH.

Position - The welding shall be done in the horizontal and flat positions.

Preheat and Interpass Temperature - Is required during fabrication and/or erection in conformance with the following:

Thickness	Preheat	Interpass
1" and Under	100°F Minimum	250°F Max.
Over 1 to 1 1/2"	200°F Minimum	350°F Max.
Over 1 1/2"	250°F Minimum	400°F Max.

The qualification test for this procedure specification shall be performed with a preheat of 200°F.

No welding of any kind shall be done when the temperature of the base metal is lower than 0°F. At temperatures between 0°F and 60°F, the surface of all areas within 3 inches of the point where the weld is to be started shall be preheated to a minimum of 60°F or as shown above before welding is started.

Base Metal Thickness - This joint is qualified for use on thicknesses from 3/16" to 1½.

Backing Strips - None permitted.

Welding Procedure - The welds shall be made by multiple passes.

Welding Process - The welding shall be done by the Flux Cored Arc Welding Process (FCAW) using semi-automatic machine equipment. A consumable electrode as specified in ASME SFA5.20, Class McKay 85-C3 shall be used. The shielded metal arc welding process (SMAW) using manual equipment shall be used.

Electrical Characteristics - The current used shall be DC with reverse polarity. A permissible of variable of 15% above or below the amperages and/or voltages specified on the PS-70-72 A joint sketch shall be allowed.

Heat Treatment: NONE

NON ESSENTIAL VARIABLES

The following paragraphs describe details which are not Essential Variables. Changes in these details may be made without setting up a new Procedure Qualification provided they are recorded as revisions.

Preparation of Base Material - The edges or surfaces of the parts to be joined by welding shall be prepared by shearing, machining, chipping, burning, or grinding as shown on PS-70-72A joint sketch (Page 4) and shall be cleaned of all oil, grease, paint, dirt, rust, scale, moisture or other foreign material that may adversely affect the quality of welds, prior to welding. Weld area shall be cleaned by grinding, blasting, wire brushing, etc.

Joint Welding Procedure - In addition to the Essential Variables listed under "Welding Procedure", the following non-essential variables shall be followed.

The bead technique shall be as shown on PS-70-72A joint sketch (Page 4). Number of beads, if the joint dimension is increased or decreased, shall be proportional to the area following bead size above.

Appearance of Welding Layers - The welding current and manner of depositing the weld metal shall be such that there shall be practically no undercutting on the side walls of the welding groove or the adjoining base material.

Cleaning - All slag or residue remaining on any bead of welding shall be removed before laying down the next successive bead. Excessive weld spatter to be removed before depositing the next layer.

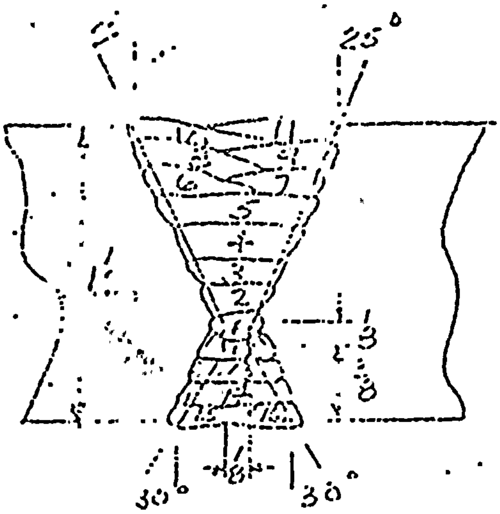
Defects - Any cracks or blow holes that appear on the surface of any bead of welding shall be removed by chipping, grinding, or gouging before depositing the next successive bead of welding.

Peening - There shall be no peening excepting for removal of adhering slag using a de-slagging gun.

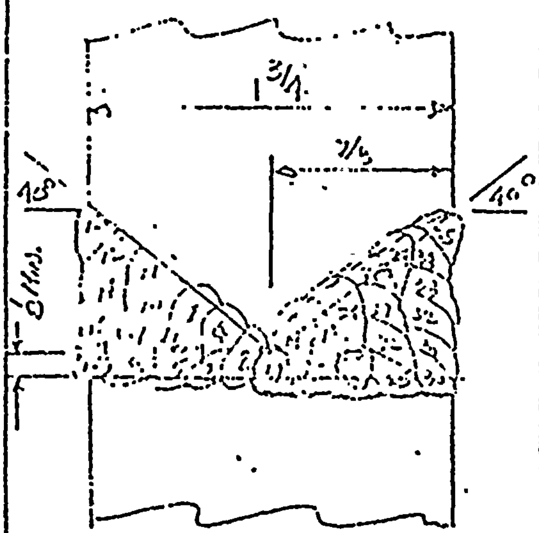
Treatment of Underside of Groove - The root side of the groove shall be gouged by arc air gouging, chipping, or as required by the qualification procedure. Carbon arc air gouged surfaces containing oxidized material shall be ground to remove the oxidized material before proceeding with the welding. All penetration butt welds shall be prepared to clean sound metal as called for on the welding procedure qualification record.

PROCEDURE SPECIFICATION 70-72A

SMAW and FCAW — Flat Position

JOINT PREP.	THK.	PASS	DIA.	TYPE	AMPS	VOLTS
	1 1/2	1-2	5/32	E8018-C3	170-180	23-25
		3	3/16	E8018-C3	210-220	24-26
		4-16	3/32	85C-3	300-325	28-30

SMAW & FCAW — Horiz. Position

JOINT PREP.	THK.	PASS	DIA.	TYPE	AMPS	VOLTS
		1	5/32	E8018 C3	170-180	23-25
		2-11	3/32	85C-3	FCAW 300-325	28-30
	1-3/4	12-16	3/16	E8018 C3	SMAW 200-210	24-26
		17-29	3/32	85C-3	FCAW 300-325	28-30
		30-35	3/16	E8018 C3	SMAW 200-210	24-26

RECOMMENDED [illegible] Q-1 MANUFACTURER'S RECORD OF WELDING PROCEDURE QUALIFICATION TESTS

Specification No. 70-72A Date 11-6-70

Welding Process SMAW & FCAW Manual or Machine Manual & Semi-Auto

Material Specification A537 Cl. B. Q & T to Same of P-No. 12 Sub Gr. 2 to P-No. 12 Sub Gr. 2

Thickness (if pipe, diameter and wall thickness) 1 3/4

Thickness Range this test qualifies 3/16 to 1 1/2

Filler Metal Group No. F-4(E8018C3) F6(FCAW)

Weld Metal Analysis No. A- (SMAW) C .05-.12, Mn .75-1.2, Si .35-.60, Ni 1.2-2.5 Typ. Weld Metal Analysis Undiluted (FCAW) C .05, Mn .90, Si .55, Ni .90

FLUX OR ATMOSPHERE

Flux Trade Name or Composition -

Inert Gas Composition -

Trade Name - Flow Rate -

Is Backing Strip used? No

Preheat Temperature 200°F

Interpass Temperature Range 200°F to 400°F

Postheat Treatment No

WELDING PROCEDURE

Single or Multiple Pass Multiple

Single or Multiple Arc Single

Position of Groove Horiz. 2G (See Pars. & Figs. Q-2 & Q-3, or QN-2 & QN-3)
(Flat, horizontal, vertical, or overhead; if vertical, state whether upward or downward)

FOR INFORMATION ONLY

Filler Wire-Diameter 5/32Ø-3/16Ø (Manual) 3/32 (FCAW)

WELDING TECHNIQUES

Trade Name McKay E8018C3&Speed Alloy 85C-3 Joint Dimensions Accord with Attached Sketch

Type of Backing None amps 170-325 volts 23-30 inches per min. "

Forehand or Backhand Forehand Current DC Polarity Reverse

REDUCED SECTION TENSILE TEST (Figs. Q-6 and QN-6)

Specimen No.	Dimensions		Area	Ultimate Total Load, lb.	Ultimate Unit Stress, psi	Character of Failure and Location
	Width	Thickness				
1	.980	1.656	1.623	143,750	88,600	Base Metal
2	.966	1.632	1.577	143,750	91,150	Base Metal & Weld Metal

GUIDED BEND TESTS (Figs. Q-7.1, Q-7.2, QN-7.1, QN-7.2, QN-7.3)

Type and Figure No.	Result	Type and Figure No.	Result
Q7.1 Side	Passed Passed	Side Q7.1	Passed Passed
Q7.1 Side	Passed Passed	Side Q7.1	Passed Passed

Results of Filletweld Tests, Fig. Q-9(c) N/A

Welder's Name J. Mondine Clock No. 012 Stamp No. J. M.

Who by virtue of these tests meets welder performance requirements.

Test Conducted by PDM Steel Co. Laboratory—Test No. 70-72A

per L. Colarossi

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

CHARPY V-NOTCH IMPACTS
10mm X 10 mm @ -40°F

	WELD	LAT. EXP. WELD	HAZ	LAT. EXP. HAZ
1.	50	.037	73	.051
2.	48	.039	78	.052
3.	48	.038	30	.023

Signed P. D. M. Steel Co.
(Manufacturer)

By [signature]

DIRECTOR OF RESEARCH

SPECIFICATION: Procedure Specification 70-71A
Burns and Roe Specification No. 2808-213
WPPSS Nuclear Project No. 2

DESCRIPTION: Shielded Metal Arc Welding (SMAW)
ASME Section III, Class MC, 1 and 2

THIS PAGE IS A RECORD OF ALL REVISIONS OF THE SPECIFICATION. EACH TIME THE SPECIFICATION IS CHANGED, ONLY THE NEW OR REVISED PAGES ARE ISSUED.

FOR CONVENIENCE, THE NATURE OF THE REVISION IS BRIEFLY NOTED UNDER REMARKS. BUT THESE REMARKS ARE NOT PART OF THE SPECIFICATION. THE REVISED PAGES ARE A PART OF THE SPECIFICATION AND SHALL BE COMPLIED WITH IN THEIR ENTIRETY.

REV	DATE	BY	PAGES	REMARKS
0	9-10-73	AVT	ALL	Initial Issue
A	9-27-74	JFS	1	Added P-1 material welds under base material essential variables.

REV	ENGINEERING APPROVAL	OPERATING DEPARTMENT APPROVAL	
0	[signature]	[signature]	
A	[signature]	[signature]	

NOTATIONS IN THIS COLUMN INDICATE WHERE CHANGES HAVE BEEN MADE.

ESSENTIAL VARIABLES

This procedure specification is a qualified procedure for the construction of weldments whose essential variables fall within the limitation specified below. A different procedure specification is required for weldments whose essential variables differ from those specified below.

Base Metal - The base metal shall conform to the specifications for ASME SA537 Gr. B, quenched and tempered, which is found in material Group P - Number 12B-SG-2. This procedure also covers welds of base materials above to Group P-1 materials or P-1 to P-1 material welds
A Filler Metal - The filler metal shall conform to ASME Filler Metal Specification ASME SFA5.5 Classification E8018-C3 for ferrous filler metal in Group Number F-4. The chemical composition of the weld deposit shall fall within the following composition limits: C - .12 max., Mn - 0.40 to 1.25, Si - 0.80 min, Ni - 0.80 to 1.10.

Position - The welding shall be done in the horizontal and flat positions.

Preheat and Interpass Temperature - Is required during fabrication and/or erection in conformance with the following:

Thickness	Preheat	Interpass
1" and Under	100°F Minimum	250°F Max.
Over 1 to 1 1/2"	200°F Minimum	350°F Max.
Over 1 1/2"	250°F Minimum	400°F Max.

The qualification test for this procedure specification shall be performed with a preheat of 200°F.

No welding of any kind shall be done when the temperature of the base metal is lower than 0°F. At temperatures between 0°F and 60°F, the surface of all areas within 3 inches of the point where the weld is to be started shall be preheated to a minimum of 60°F or as shown above before welding is started.

Heat Treatment - None is required.

Base Metal Thickness - This joint is qualified for use on material thicknesses from 3/16" to 1 1/2".

Backing Strips - None allowed.

Welding Procedure - The welds shall be made by multiple passes.

Welding Process - The welding shall be done by the Shielded Metal Arc Welding Process (SMAW) using manual equipment.

Electrical Characteristics - The current used shall be DC with reverse polarity (Base Material shall be on the negative side of the line). A permissible variation of 15% above or below the amperage and/or voltages specified in the PS-70-71A joint sketch (Page 4) shall be allowed.

NOTATIONS IN THIS COLUMN INDICATE WHERE CHANGES HAVE BEEN MADE.

NON ESSENTIAL VARIABLES

The following paragraphs describe details which are not Essential Variables. Changes in these details may be made without setting up a new Procedure Qualification provided they are recorded as revisions.

Preparation of Base Material - The edges or surfaces of the parts to be joined by welding shall be prepared by shearing, machining, chipping, burning, or grinding as shown in the PS-70-71A joint sketch (Page 4) and shall be cleaned of all oil, grease, paint, dirt, rust, scale, moisture or other foreign material that may adversely affect the quality of welds, prior to welding. Weld area shall be cleaned by grinding, blasting, wire brushing, etc.

Joint Welding Procedure - In addition to the Essential Variables listed under "Welding Procedure", the following non-essential variables shall be followed.

The bead technique shall be as shown in the PS-70-71A joint sketch (Page 4). Weaving of the weld beads shall be held to about 2 1/2 times the electrode diameter with layer thickness of deposited metal about 1/8 of an inch. Number of beads, if the joint dimension is increased or decreased, shall be proportional to the area following bead size above.

Appearance of Welding Layers - The welding current and manner of depositing the weld metal shall be such that there shall be practically no undercutting on the side walls of the welding groove or the adjoining base material.

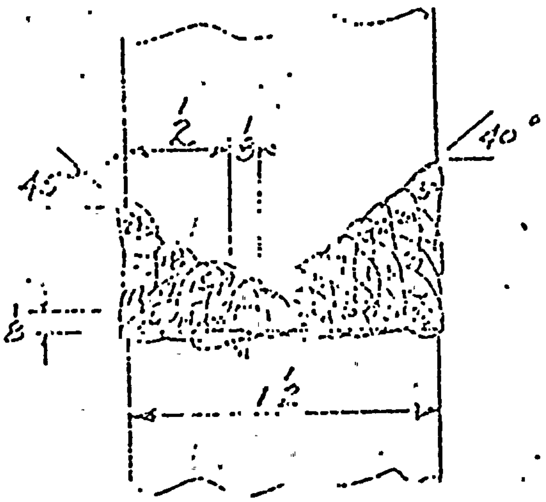
Cleaning - All slag or residue remaining on any bead of welding shall be removed before laying down the next successive bead. Excessive weld spatter is to be removed before depositing the next layer.

Defects - Any cracks or blow holes that appear on the surface of any bead of welding shall be removed by chipping, grinding or gouging before depositing the next successive bead of welding.

Treatment of Underside of Groove - The root side of the groove shall be gouged by arc air gouging, chipping, or as required by the qualification procedure. Carbon arc air gouged surfaces containing oxidized material shall be ground to remove the oxidized material before proceeding with the welding. All full penetration butt welds shall be prepared to clean sound metal.

NOTATIONS IN THIS COLUMN INDICATE WHERE CHANGES HAVE BEEN MADE

PROCEDURE SPECIFICATION 70-71A



Thk.	Pass	Amps	Volts	Size
1 1/2	1-3	170-180	23-25	5/32
	4-7	210-220	24-26	3/16
	8-10	270-280	24-26	7/32
	11-15	170-180	23-25	5/32
	16-21	210-220	24-26	3/16
	22-29	270-280	24-26	7/32
	30	200-210	24-26	3/16

SUBJECT Joint Sketch				CONTR. NO. 1276
PREPARED BY AVT	DATE 1-10-73	CHECKED BY MC	DATE 1-6-73	PAGE NO. 4 of 4

RECOMMENDED FORM Q-1 MANUFACTURER'S RECORD OF WELDING PROCEDURE QUALIFICATION TESTS

Specification No. 70-71A Date *11-6-70
Welding Process SMAW Manual or Machine Manual
Material Specification A537 Gr. B Q & T to Same of P-No. 12 Sub Gr. 2 to P-No. 12 Sub Gr. 2
Thickness (if pipe, diameter and wall thickness) 1 3/4
Thickness Range this test qualifies 3/16 to 1 1/2
Filler Metal Group No. F- 4
Weld Metal Analysis C - .12 Max, Mn - 0.40 to 1.25, Si - 0.80 Max, Ni - 0.80 to 1.10
For oxyacetylene welding—State if Filler Metal is silicon or aluminum killed.

FLUX OR ATMOSPHERE

Flux Trade Name or Composition -
Inert Gas Composition -
Trade Name - Flow Rate -
Is Backing Strip used? No
Preheat Temperature 200°F
Interpass Temperature Range 200°F to 400°F
Postheat Treatment No

WELDING PROCEDURE

Single or Multiple Pass Multiple
Single or Multiple Arc Single
Position of Groove Horiz. 2G (See Pars. & Figs. Q-2 & Q-3, or QN-2 & QN-3)
(Flat, horizontal, vertical, or overhead; if vertical, state whether upward or downward)

SFA5.5 -

FOR INFORMATION ONLY

Filler Wire—Diameter 5/32Ø-3/16Ø-7/32Ø
Trade Name McKay E8018 C3
Type of Backing None
Forehand or Backhand Forehand

WELDING TECHNIQUES

Joint Dimensions Accord with Attached Sketch
amps 170-230 volts 23-26 inches per min. "
Current DC Polarity Reverse

REDUCED SECTION TENSILE TEST (Figs. Q-6 and QN-6)

Specimen No.	Dimensions Width	Dimensions Thickness	Area	Ultimate Total Load, lb.	Ultimate Unit Stress, psi	Character of Failure and Location
1	.976	1.662	1.662	1?1,000	86,950	Base Metal
2	.984	1.635	1.609	139,750	86,850	Base Metal

GUIDED BEND TESTS (Figs. Q-7.1, Q-7.2, QN-7.1, QN-7.2, QN-7.3)

Type and Figure No.	Result	Type and Figure No.	Result
Q7.1 Side	Passed Passed	Q7.1 Side	Passed Passed
Q7.1 Side	Passed Passed	Q7.1 Side	Passed Passed

Results of Filletweld Tests, Fig. Q-9(c) - - - -
Welder's Name J. Mondine Clock No. 012 Stamp No. J. M.
Who by virtue of these tests meets welder performance requirements.
Test Conducted by P.D.M. Steel Co. Laboratory—Test No. 70-71A
per L. Colarossi

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

CHARPY V-NOTCH IMPACTS
8mmX 10 mm @ - 40°F

	WELD	Lat. Exp. Weld	HAZ	Lat. Exp. HAZ
1.	93	.071	45	.038
2.	90	.073	88	.065
3.	90	.067	56	.047

Signed P. D. M. Steel Co.
(Manufacturer)
By [signature]
DIRECTOR OF RESEARCH

* Ht. #A6064
Slab #0B

Burns and Roe Specification 69-97
Burns and Roe Specification No. 2808-213
WPPSS Nuclear Project No. 2

Shielded Metal Arc Welding (SMAW)
ASME Section III, Class 1, 2 and MC

THIS PAGE IS A RECORD OF ALL REVISIONS OF THE SPECIFICATION. EACH TIME THE SPECIFICATION IS CHANGED, ONLY THE NEW OR REVISED PAGES ARE ISSUED.

FOR CONVENIENCE, THE NATURE OF THE REVISION IS BRIEFLY NOTED UNDER REMARKS. BUT THESE REMARKS ARE NOT PART OF THE SPECIFICATION. THE REVISED PAGES ARE A PART OF THE SPECIFICATION AND SHALL BE COMPLIED WITH IN THEIR ENTIRETY.

REV	DATE	BY	PAGES	REMARKS
0	6/25/73	JFS	ALL	Initial Issue
A	9/24/73	AVT	1	Revised preheat, first paragraph and added Code requirement.
			3	Added Code requirement.
			5&6	Initialed "Checked by" block.
			Q1	Removed range from preheat temperature range. Revised preheat and interpass range. Removed reference to P.M. in Charpy Table.
B	11-8-73	AVT	Cover and Pages 1 to 4	Added Class 1 and 2.
			Q1	Added lateral expansion.

REV	ENGINEERING APPROVAL	OPERATING DEPARTMENT APPROVAL	
0	L. Coleman	[illegible]	
A	L. Coleman	[illegible]	
B	T. Coleman	[illegible]	

NOTATIONS IN THIS COLUMN INDICATE WHERE CHANGES HAVE BEEN MADE.

ESSENTIAL VARIABLES

A This procedure specification is a qualified procedure for the construction of weldments whose essential variables fall within the limitation specified below. A different procedure specification is required for weldments whose essential variables differ from those specified below.

Base Metal - The base metal shall conform to the specifications for ASME SA537 Gr. B which is found in materials Group P - Number 12B, Subgroup 2. This procedure also covers welds of base material above to Group P - Number 1 materials.

Filler Metal - The filler metal shall conform to ASME Filler Metal Specification ASME FSA5.5 Classification E8018 for ferrous filler metal in Group Number F-4. The chemical composition of the weld deposit shall be within the following composition limits: C - .12 max., Mn - 0.40 to 1.25, Si - 0.80 max., Ni - 0.80 to 1.10.

Position - The welding shall be done in the vertical, overhead and flat positions.

A Preheat and Interpass Temperature - Is required during fabrication and/or erection in conformance with the following:

	Thickness	Preheat	Interpass
A	3/4" and Under	60°F Minimum	250°F Max.

A The qualification test for this procedure specification shall be performed with a preheat of 50°F.

No welding of any kind shall be done when the temperature of the base metal is lower than 0°F. At temperatures between 0°F and 60°F, the surface of all areas within 3 inches of the point where the weld is to be started shall be preheated to a minimum of 60°F or as shown above before welding is started.

Base Metal Thickness - This joint is qualified for use on material thicknesses from 3/16" to 3/4".

A Backing Strips - None allowed for this procedure, ASME Code Section IX Paragraph V-7 permits use of backing strip for qualification.

Welding Procedure - The welds shall be made by multiple passes.

Welding Process - The welding shall be done by the Shielded Metal Arc Welding Process (SMAW) using manual equipment.

Electrical Characteristics - The current used shall be DC with reverse polarity (Base Material shall be on the negative side of the line). A permissible variation of 15% above or below the amperage and/or voltages specified in the PS-69-97 joint sketches (Pg. 5 through 6) shall be allowed. For vertical position welding, a permissible variation of ±25% in the specified amperage or voltage is allowed for downhill welding on the root and cover passes of the joint.

Heat Treatment - None

NOTATIONS IN THIS COLUMN INDICATE WHERE CHANGES HAVE BEEN MADE

NON ESSENTIAL VARIABLES

The following paragraphs describe details which are not Essential Variables. Changes in these details may be made without setting up a new Procedure Qualification provided they are recorded as revisions.

Preparation of Base Material - The edges or surfaces of the parts to be joined by welding shall be prepared by shearing, machining, chipping, burning, or grinding as shown in the PS-69-97 joint sketches (Pg. 5 through 6) and shall be cleaned of all oil, grease, paint, dirt, rust, scale, moisture or other foreign material that may adversely affect the quality of welds, prior to welding. Weld area shall be cleaned by grinding, blasting, wire brushing, etc.

Joint Welding Procedure - In addition to the Essential Variables listed under "Welding Procedure", the following non-essential variables shall be followed.

The bead technique shall be as shown in the PS-69-97 joint sketc (Pg. 5 through 6). Weaving of the weld beads shall be held to about 2 1/2 times the electrode diameter with layer thickness of deposited metal about 1/8 of an inch. Number of beads, if the joint dimension is increased or decreased, shall be proportional to the area following bead size above. All welds in the vertical position shall be made with an upward progression, A cept that the cover pass may be up or down. The root pass may also run either up or down when the root pass is removed to sound metal.

Appearance of Welding Layers - The welding current and manner of depositing the weld metal shall be such that there shall be practically no undercutting on the side walls of the welding groove or the adjoining base material.

Cleaning - All slag or residue remaining on any bead of welding shall be removed before laying down the next successive bead. Excessive weld spatter is to be removed before depositing the next layer.

Defects - Any cracks or blow holes that appear on the surface of any bead of welding shall be removed by chipping, grinding or gouging before depositing the next successive bead of welding.

Peening - There shall be no peening excepting for removal of adhering slag using a de-slagging gun.

Treatment of Underside of Groove - The root side of the groove shall be gouged by arc air gouging, chipping, or as required by the qualification procedure. Carbon arc air gouged surfaces containing oxidized material shall be ground to remove the

NOTATIONS IN THIS COLUMN INDICATE WHERE CHANGES HAVE BEEN MADE.

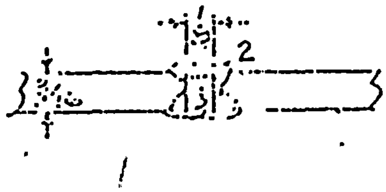
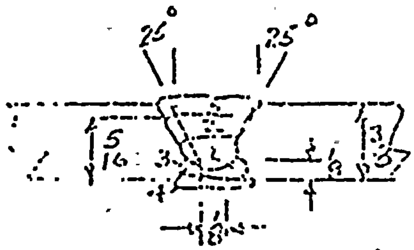
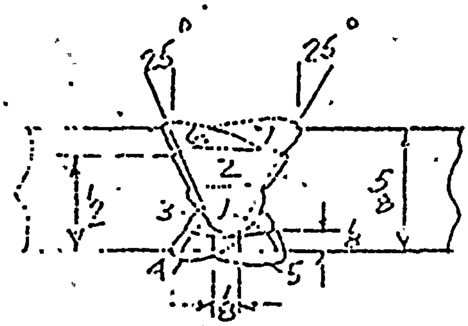
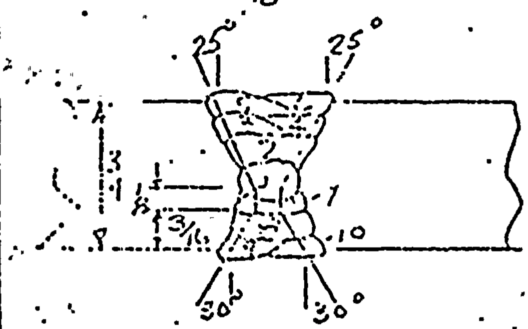
B

oxidized material before proceeding with the welding. All full penetration butt welds shall be prepared to clean sound metal.

NOTATIONS IN THIS COLUMN INDICATE WHERE CHANGES HAVE BEEN MADE

PROCEDURE SPECIFICATION 69-97

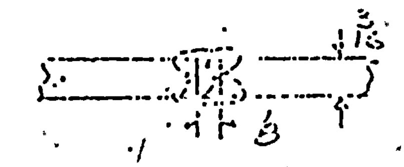
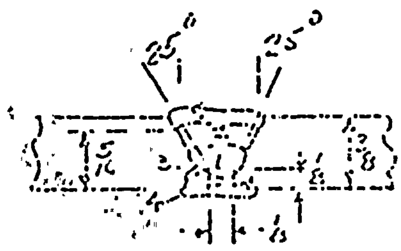
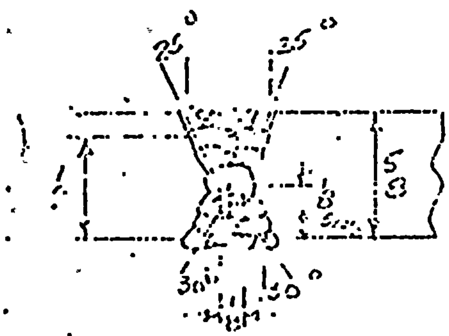
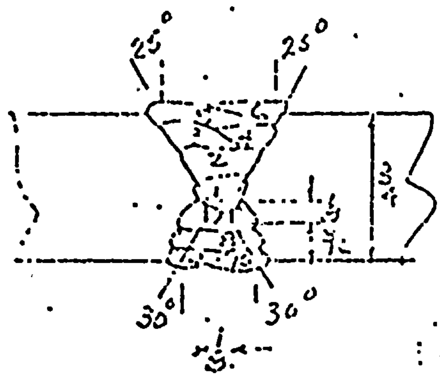
S.M.A.W. FLAT AND OVERHEAD E8018-C3

	Thk.	Pass	Amp	Volts	Size
	3/16	1-3	125-130	22-24	1/8
	5/16	1-4	125-130	22-24	1/8
	3/8	1-4 5	125-130 165-170	22-24 23-25	1/8 5/32
	1/2	1-2 3-5	165-170 125-130	23-25 22-24	5/32 1/8
	5/8	1-2 3-5 5-8	165-170 125-130 165-170	23-25 22-24 23-25	5/32 1/8 5/32
	3/4	1-6 7-8 9-10	165-170 125-130 165-170	23-25 22-24 23-25	5/32 1/8 5/32

SUBJECT	LOCATION	CONTR. NO. 12764
PREPARED BY AVT DATE 9-26-73	CHECKED BY NS DATE [illegible]	PAGE NO.

PROCEDURE SPECIFICATION 69-97

S.M.A.W. | VERTICAL | E8018-C3 ELECTRODE

	Thk.	Pass	Amp.	Volts	Size
	3/16	1-2	125-130	22-24	1/8
	5/16	1-4	125-130	22-24	1/8
	3/8	1-5	125-130	22-24	1/8
	1/2	1-5	125-130	22-24	1/8
	5/8	1-9	125-130	22-24	1/8
	3/4	1-10	125-130	22-24	1/8

SUBJECT Joint Sketch	LOCATION	CONTR. NO. 12764
PREPARED BY AVT DATE [illegible]	CHECKED BY [illegible] DATE [illegible]	PAGE NO.

RECOMMENDED FORM Q-1 MANUFACTURER'S RECORD OF WELDING PROCEDURE QUALIFICATION TESTS

Specification No. 69-97 Date 5-6-71
Welding Process SMAW Manual or Machine Manual
Material Specification SA537Gr. B to SA537Gr. B of P-No. 12B GG-2 to P-No. 12B GG-2
Thickness (if pipe, diameter and wall thickness) 3/4
Thickness Range this test qualifies 3/16 to 3/4
Filler Metal Group No. F-4

FLUX OR ATMOSPHERE

Weld Metal Analysis C - .12 max., Mn - 0.40 to 1.25, Si - 0.80 max Ni - 0.80 to 1.10
For oxyacetylene welding—State if Filler Metal is silicon or aluminum killed.

Flux Trade Name or Composition -
Inert Gas Composition -
Trade Name - Flow Rate -
Is Backing Strip used? Yes
Preheat Temperature 50°F
Interpass Temperature Range 50°F to 250°F
Postheat Treatment None

A

WELDING PROCEDURE

Single or Multiple Pass Multiple
Single or Multiple Arc Single
Position of Groove Horiz. Fixed 5G (See Pars. & Figs. Q-2 & Q-3, or QN-2 & QN-3)
(Flat, horizontal, vertical, or overhead, if vertical, state whether upward or downward)

SFA 5.5

FOR INFORMATION ONLY

Filler Wire—Diameter 1/8 - 5/32
Trade Name McKay E8018 C3
Type of Backing SA537 Gr. B
Forehand or Backhand -

WELDING TECHNIQUES

Joint Dimensions Accord with Attached Sketch
Amps 125-1 Volts 22-2 Inches per min. "
Current DC Polarity Reverse

REDUCED SECTION TENSILE TEST (Figs. Q-6 and QN-6)

Specimen No.	Dimensions Width	Dimensions Thickness	Area	Ultimate Total Load, lb.	Ultimate Unit Stress, psi	Character of Failure and Location
1	.760	.667	.506	43,500	85,968	PASSED
2	.751	.685	.514	45,200	87,937	PASSED

GUIDED BEND TESTS (Figs. Q-7.1, Q-7.2, QN-7.1, QN-7.2, QN-7.3)

Type and Figure No.	Result	Type and Figure No.	Result
Side Q7.1	PASSED	Side Q7.1	PASSED
Side Q7.1	PASSED	Side Q7.1	PASSED

Results of Filletweld Tests, Fig. Q-9(c) -
Welder's Name J. Cianciarulo, Jr. Clock No. 436 Stamp No. JC
Who by virtue of these tests meets welder performance requirements.
Test Conducted by Pitts. Des Moines St Laboratory—Test No. 69-97
per ... Colarossi

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

CHARPY V-NOTCH IMPACTS
5mm X 10 mm @ - ...°F

	WELD	LAT. EXP.	HAZ	LAT. EXP.
1.	101	.079	75	.057
2.	104	.082	46	.042
3.	102	.080	58	.043

A
B

Signed PITTSBURGH-DES MOINES STEEL CO.
(Manufacturer)
By [signature]
MANAGER OF RESEARCH

ATTACHMENT TO DVR HA2 and HA3

Rev. A 1-29-75
Rev. B 3-7-75
Rev. C 3-12-75
Rev. D 3-18-75
Rev. E 3-21-75
Rev. F 3-27-75

REPAIR OF WELD AT PIPE WHIP SUPPORT TO SHELL

(1) Heat shell plate. Place electric heater at opposite side of top and bottom annular plate at location of repair. This heater should extend at least 5'-0 circumferentially beyond either side of the repair area.

(2) Place electric or gas heater on top and bottom annular plate and face plate. This heater should extend at least 5'-0 circumferentially beyond either side of repair area.

(3) Preheat Item (2) to 300°F Min., Preheat Item (1) to 200°F Min.

NOTE: The differential temperature between 300°F in Item 2 and 200°F in Item 1 can only be maintained as gouging increase in the weld connecting the annular plate to the shell. It is required primarily in the last 1/4" to 1/2" to prevent crack propagation.

(4) Maintain preheat differential (See NOTE in 3 above) and gouge out defect (Gouge from end to center) in shell and annular plate as shown in Figure 1. Gouge web plate to at least the bevel shown in Detail C of E52. Gouge to sound parent metal at least 6" circumferentially beyond defects larger than 4 feet and 2 inches circumferentially for defects smaller than 4 feet.

(5) Disc grind gouged area to clean surface.

(6) MT - Disc ground area.

(7) Maintaining preheat as specified in Item (3), weld overlay on shell plate to complete weld to the original plate surface. MT every layer. Grind flush. See Figure 2. UT for soundness in parent metal (PM) after filling PM cavity prior to making bevel weld. Shell plate temperature may be dropped to 100°F during UT. Box girder may be dropped to 150° to 200°F during UT. Maintain as closely as possible an interpass of 300°F Max. at the weld.

NOTE: Weld using stringer beads and Joint Procedure, 70-71A. Use 5/32"Ø Max. electrodes for out-of-position welds and 3/16"Ø Max. for flat and horizontal fillet welds.
F Use PS-69-97 for overhead repair, 5/32"Ø Max. rods.

(8) Complete welding of annular plate to shell plate. MT - every 1/4" and final cover. (See Figure 2) See Note in Items 3 and 7 above, Except in Item 3, the preheat and interpass temperature differential applies to the first 1/4" and 1/2" of weld deposit.

(9) After welding is completed, insulate the heated area and hold temperature of 350°F to 400°F for at least 2 hours and slow cool.

ATTACHMENT TO DVR HA2 and HA3

REPAIR OF WELD AT PIPE WHIP SUPPORT TO SHELL

(10) MT after area has cooled to ambient temperature.

(11) UT after cooldown to ambient temperature.

(12) UT after pneumatic test.

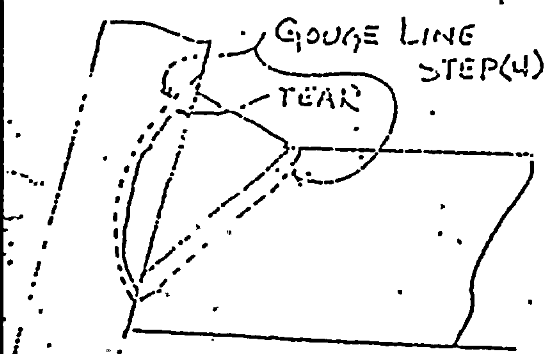


FIGURE 1

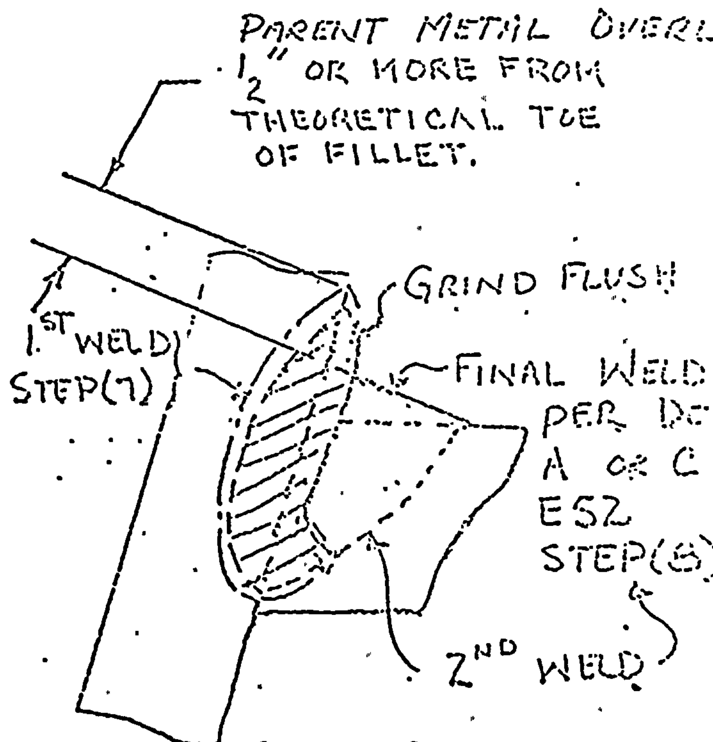


FIGURE 2

TELEDYNE
MATERIALS RESEARCH
303 BEAR HILL ROAD
WALTHAM, MASSACHUSETTS 02154
(617) 890-3350 TWX (710) 324-7503

March 18, 1974
TR-2059(a)

Mr. J. J. Byrnes
Manager of Projects
Burns and Roe, Inc.
320 Fulton Avenue
Hempstead, NY 11550

Subject: Progress Report - Lamellar Tearing Experienced on the Containment Vessel - WPPSS Nuclear Project No. 2.

Dear Mr. Byrnes:

The letter report includes a general review of the lamellar tearing problem and a discussion of the proposed repair procedure on the subject vessel. This letter is based upon my review of the NCR and associated documents, meetings with Burns and Roe, Inc. (B & R) and B & R and Pittsburgh - Des Moines Steel Company (PDM), subsequent telecons with WPPSS and B & R personnel and with others identified in the following, and a review of recent literature during the period March 10 through the present.

A. Lamellar Tearing as a General Problem

The best available summary statement that we have found with respect to lamellar tearing is that prepared in June 1974 by the ASME Code Task Group on Lamellar Tearing.

"Lamellar tearing is the separation in the parent or base material caused by thru-thickness strains induced by weld metal shrinkage. Lamellar tearing should not be confused with laminations in plate material.

"Steel may be counted upon to deform locally parallel and transverse to the rolling direction and, if deformed enough, to bring about a redistribution of the forces in such a way that the localized highly stressed areas refuse to accept additional load and call upon surrounding material to share in the load transfer. In the thru-thickness

TELEDYNE MATERIALS RESEARCH

direction, strains in excess of the yield point may cause decohesion and lead to a lamellar tear.

"A lamellar tear occurs only in the base metal and while it may originate close to the toe or root of a weld, often the tear may originate well outside the HAZ and may not propagate to the surface. The cross-section of a lamellar tear is step-like, with longitudinal terraces that are markedly longer than the transverse portions. The fracture has a fibrous appearance and this characteristic, along with the terraced profile and location within the base material away from the weld fusion line, is the best way of distinguishing the lamellar tear from HAZ cracks caused by hydrogen.

"Under conditions of high restraint, localized strains due to weld metal shrinkage can be many times higher than yield points strains, whereas stresses due to design loads are only a fraction of yield point; thus the strains due to applied loads are not of primary concern in causing lamellar tearing. No cases are known of lamellar tears being initiated by design loads.

"Investigation by the Task Group revealed lamellar tearing to be a complex phenomenon involving several variables. Treatment of any singular variable without consideration of other effects would be of little value. The initiation or suscepability to lamellar tearing is related to material properties, nonmetallic inclusion content, weld joint design and welding practice."

This Task Group, which reports to the Subgroup on Fabrication and Examination of the Subcommittee on Nuclear Power, has the objective "to develop recommendations to prevent lamellar tearing in restrained welded joints, with the present investigation limited to carbon and low alloy steels." Although the Task Group has approved some suggested changes for Code Subsection NF, Component Supports, no higher - level action has been taken. This aspect was chosen for initial efforts because of the absence of required non-

destructive examination of such supports and the extent of tearing which has been experienced.

The lamellar tearing problem has become a common one in recent years, possibly because of improved examination techniques. Most of the present research, US and foreign, is directed at identifying the basic mechanisms involved and to the development of mechanical or nondestructive test techniques for establishing the susceptibility to tearing of a given material. Beyond the facts that the tearing initiates at non-metallic inclusions and propagates by microvoid coalescence at temperatures of about 400°F as a result of strains caused by weld shrinkage, there is little agreement as to either the mechanism or how to measure susceptibility. Cleavage is not involved.

Considerable amounts of guidance as to geometry, material and weld procedure, are available, but are subject to economic arguments. When nondestructive examination techniques are applied to establish whether or not tearing has occurred in susceptible structures, there is opinion that repair may be preferable to prevention. When excessive amounts of repair are required, prevention comes to the fore. It is clear that repair efforts which simply follow the original welding procedures will only cause additional cracking, so that repair procedures must reflect corrective techniques.

B. <u>The WPPSS-2 Application</u>

Nondestructive examination of the containment vessel has indicated the presence of lamellar tearing in the shell plate beneath the welds attaching the upper pipe whip support ring. The questions to be discussed here are the technical acceptability of the proposed procedure for repairing those lamellar tears which have been experienced and the Code acceptability of the proposed repair. Before doing this, the proposed repair procedure will be discussed.

1. <u>Repair Procedure</u>

The present draft of the repair procedure in my possession is Revision B, 3-7-75, of Attachment to DVR HAZ and HA3, Repair of Weld at Pipe Whip

Support to Shell. In brief, this procedure involves:

a. Preheating.
b. Removal of the defect by gouging and grinding, with NDT check on removal.
c. Buttering of the shell plate to restore the original thickness and UT examination of the plate.
d. Performance of the attachment weld with intermittent MT examination.
e. Soaking and cooling.
f. MT and UT at ambient.
g. Pneumatic test and UT.

By telecon with Mr. Lunt of March 14, 1975, I requested that this repair procedure be modified to include:

a. Extending the buttered region on the shell plate to a distance 1/2" further from the weld root than the planed height of the attachment weld to assure that the attachment weld was not made to the base plate.
b. Extending the clean out of the defect six inches circumferentially beyond the indicated ends of the cracks, with the buttering extending into this area, to assure that the attachment weld was not made to the base plate near the end of a previous crack.

It is my understanding that PDM and B & R have accepted these revisions and that they will be implemented.

The remaining question is the sequence to be followed in making the repair. PDM field personnel have expressed concern over the original concept of a sequence in the order of:

a. Remove all defect areas.
b. Repair all shell plates.
c. Perform the attachment welds.

TELEDYNE MATERIALS RESEARCH

As an alternate, the field forces have recommended that this sequence be split, so that all three steps have been completed on the two large cracks at the top of the ring before starting the sequence of the bottom of the ring. Mr. Lunt (B &R) and I discussed this proposal on March 14, 1975 and agreed that this sequence would be satisfactory.

2. Technical Acceptability

Although some of the scientific aspects of lamellar tearing are still being debated, the practical circumstances which result in lamellar tearing and the methods for repair are well understood based on past experience. In the present case:

a. The presence of tearing has been identified and the extent determined by UT, the best available technique.

b. The defect removal procedures are conventional and are confirmed by surface examination.

c. The plate repair procedures are conventional and are confirmed by UT. Of most importance, the consequence of the repair is a weld layer on the plate which is just the "groove - and - butter" technique most often recommended for avoidance or repair of the phenomina.

d. Application of the attachment weld, particularly the dimensions of the weld, should be subject to more attention than when originally performed.

e. UT of the repaired area after repair and of the entire circumference after pneumatic testing will confirm the absence of additional lamellar tearing.

f. Completing the repair on top of the beam proceeding with the bottom, in addition to resolving the practical problem of support, will provide a check-out of the procedure.

It is our opinion that the proposed repair procedure is technically acceptable and offers the best way to minimize schedule delays. There appear to be no viable alternatives to the method proposed by PDM.

3. Code Acceptability

Mr. R. M. Gibson, of Factory Mutual Research which is part of PDM's Authorized Inspection Agency Factory Mutual System, in his letter to PDM dated Feb. 11, 1975, states that "the repair does not conflict with the Code under which the vessel is being built." However, in an earlier sentence Mr. Gibson implies that the repair does not meet the intent of the Code. The latter statement has caused some concern since none of the parties involved wish to take advantage of specific words and end up violating intent."

In preparation for a discussion with Mr. Gibson of his concern, I discussed the matter with:

a. Mr. L. J. Chockie, a member of the Main Committee and of the Subcommittee on Nuclear Power and until this month Chairman of the Subgroup on Fabrication and Examination to which the Task Group on Lamellar Tearing reports.
b. Mr. R. F. Reedy, Vice-Chairman of the Subcommittee on Nuclear Power and Chairman of the Subgroup on Containment.

These gentlemen share my opinion that the subject repair is consistent with the intent of the Code. I discussed the concern with Mr. Gibson on the afternoon of March 18, 1975 and he indicated that the phrase concerning intent could probably be deleted from his letter. However, further discussions may be required.

Very truly yours,

TELEDYNE MATERIALS RESEARCH

W. E. Cooper

William E. Cooper
Senior Vice President &
Technical Director

WEC:raj

TELEDYNE
MATERIALS RESEARCH

303 BEAR HILL ROAD

WALTHAM, MASSACHUSETTS 02154

(617) 890-3350 TWX (710) 324-7506

April 11, 1975
TR-2059(b)

Mr. J. J. Byrnes
Manager of Projects
Burns and Roe, Inc.
320 Fulton Avenue
Hempstead, NY 11550

Subject: Progress Report - Lamellar Tearing Experienced on the Containment Vessel-WPPSS Nuclear Project No. 2.

Dear Mr. Byrnes:

Our first letter report dated March 18, 1975, described the lamellar tearing problem, the draft of the repair procedure, and the technical and Code acceptability of the proposed repair. Since that date we have been involved with respect to:

1. The repair weld procedure, which has been modified, in accordance with our recommendations and other developments, and is now Revision F.

2. The question related to Code intent, which has been eliminated by the March 20, 1975 letter from Factory Mutual Research (R. M. Gibson) to PDM (J. Strunk).

3. Review of the April 3, 1975 letter from PDM (J. H. Adams) to Burns and Roe (J. J. Verderber) providing their final engineering evaluation.

Since the first two items are self-explanatory, this letter report provides our conclusions with respect to the PDM final engineering evaluation.

1. <u>PDM Conclusion (pp 4-5)</u>

PDM concludes that the repair procedure being used "should result in a sound structure with no reoccurrence of lamellar tearing". TMR's letter of March 19, 1975 stated that "it is our opinion that the proposed repair procedure is technically acceptable". During the subsequent time period we have not revised our opinion. In particular, we believe that the performance of the repair in accordance with the procedures provided by PDM will restore the containment vessel to the state intended during initial construction.

2. Applied Stresses

We have reviewed the general methods applied by PDM in the design and analysis of the structure and the summary computations provided to us by PDM consisting of Section IV, Subsection 5, Article 3 Pages 10-13B and 288-296. These have been reviewed under the assumption that the Design Specification has been properly interpreted by PDM, which is subject to approval by others per ASME NA-3260, and in sufficient detail to assure us that the interpretation of the computed results is adequate.

Pages 10-13B consider the stresses induced in the shell of the containment vessel as a result of the specified loading conditions. We have supplemented the computations provided to us with a telephone conversation with PDM (J Strunk) on March 8, 1975 for the purpose of further clarification. We concur with the PDM conclusion that the shell stresses are within Code limits. It is pertinent to note that the local membrane stress intensity of 9.3 ksi is less than 1/3rd of the allowable value and that the primary-plus-secondary stress intensity is less than 2/3rds of the allowable value.

Pages 288-296 consider the stresses in the support ring attachment welds. We would first note that the allowable primary-plus-secondary stress imposed by the Design Specification is 90% of the yield strength of the material, or 43.1 ksi. This compares to a Code allowable $3S_m$ value of 61.5 ksi for the OBE Condition. Therefore, there is considerable conservatism in the design criterion used. All of the welds meet this limit, with the most highly stressed weld, that for the attachment of the top plate, having a stress of 41.2 ksi.

Of more importance with respect to the aspect of lamellar tearing is the "through-thickness" tension applied to the shell plate by the operating conditions. The maximum value of this stress is 1.6 ksi, an almost negligible value.

3. Residual Stresses

There are residual stresses in the attachment welds and in the adjacent plate as a result of initial forming, jacking to assure weld alignment, and welding. The Code does not require consideration of such stresses when the margin between operating temperature and the transition temperature meets Code requirements. Therefore, residual stresses have not been explicitly treated in the design or evaluation.

TELEDYNE MATERIALS RESEARCH

9.017

Despite the insignificance of such stresses, we must comment on the discussion of this aspect near the bottom of page 4 of the PDM letter. The data given by O. J. Horger on pages 480 and 484 of the Handbook for Experimental Stress Analysis are the most appropriate data we have located. These data indicate that after quenching, but before tempering, the residual stress will be about 100 ksi compressive on the surface, 60 ksi tension at the center, with the through-thickness residual stress being zero at the surface and having a maximum tensile value of about 8 ksi. Tempering at 110°F reduces the 100 ksi to about 20 ksi compressive at the surface. Data are not given for other directions or locations, but tempering will also considerably reduce these values.

1100

It is our opinion that these residual stresses will not be of significance to subsequent service, and particularly that lamellar cracking will not occur after completion of the repair procedure.

Very truly yours,

TELEDYNE MATERIALS RESEARCH

W. E. Cooper

William E. Cooper
Senior Vice President &
Technical Director

WEC:raj

JUN 5 1975

MATERIALS RESEARCH
303 BEAR HILL ROAD
WALTHAM, MASSACHUSETTS 02154
(617) 890-3350 TWX (710) 324 7563

May 28, 1975
~~TR-2059(c)~~

WNP NO. 2									
X HALE	L LARRIERE	OE TRAPP	GE DLEGAN	GL GLIMAUS	J HARRINGTON	SITE MANAGER			

Mr. J. J. Byrnes
Manager of Projects
Burns & Roe, Inc.
320 Fulton Avenue
Hempstead, NY 11550

Subject: Repair of Lamellar Tearing Experienced on the Containment Vessel - WPPSS Nuclear Project No. 2.

Dear Mr. Byrnes:

A meeting was held at TMR on May 28, 1975 for the purposes of reviewing the results of the subject repair operation, including a discussion of the nature and significance of certain ultrasonic discontinuities present after completion of the planned repair. The meeting was attended by WPPSS, Burns and Roe, PDM and TMR personnel.

In addition to the oral presentation and discussion, the following documents were available:

1. Draft Summary by PDM.
2. Factory Mutual Research (R. M. Gibson) letter to PDM (J. F. Strunk), May 19, 1975.
3. United States Steel (B. F. Williams) letter to PDM (A. M. Wiese), May 15, 1975 with attached evaluation bulletin.
4. Hamill Testing Laboratory Report #004 (C. R. Vigne) to PDM, May 14, 1975.

PRESENT STATUS

The discussion summarized the present status of the WPPSS-2 containment vessel as follows:

1. The planned repair has been completed without reinitiation of the lamellar tears which established the need for repair.
2. Following completion of the subsequent additional repair discussed below, ultrasonic examination to Section III procedures, particularly sensitivity, did not reveal any indications in excess of the applicable Section III acceptance criteria for base metal or weld metal.

3. Following completion of the planned repair, an ultrasonic examination was performed at additional (+ 20dB) gain, similar to that applied in establishing the material to be removed for the planned repair. This examination revealed small UT discontinuities in the base metal between the outer surface of the vessel and the repair weld. It was decided to remove the suspect material, working from the outer surface, and to weld repair these regions. Following completion of this additional repair, the high-gain UT examination was repeated. The result was that additional discontinuities were identified around the periphery of each of these outer surface repairs in base material which had been examined previously and in which there were no such discontinuities. These indications lie in the plane of the plate, are 1/4 T to 3/4 T from the outer surface, and extend away from the weld for a distance generally between 1/8" and 1/4" and no more than 1/2". A portion of the plate was removed and subjected to metallographic examination by US Steel and Hamill. PDM will prepare a summary report on this aspect.

4. If these new discontinuities are deemed to be of negligible structural significance, the pneumatic test would be conducted and an additional high-gain UT examination performed in accordance with presently established plans. Assuming that no significant change in the UT results was experienced, the repair would be considered to have been accomplished.

DISCUSSION

Item 3 of the above listing was the main topic for discussion at the meeting. The technical details will be documented elsewhere and are not repeated here. As a summary of the discussion:

1. The inclusion level of the plate is not abnormal, as indicated by macroscopic and microscopic (100X) metallography and by ultrasonic transmissibility. There are short, isolated non-metallic inclusions on several planes with no indication of gross segregation and laminar discontinuity.

2. The indications lie in the plane of the plate, and are short and at several depths. Microscopic examination reveals ovalization of the initially planar discontinuities and cracking between some of the closely adjacent inclusions. In that sense the cracking is of a lamellar type. The overall pattern seems to be the result of both heat and shrinkage stress causing a broadening and connecting of the original inclusions with resulting amplification of the UT signal into the reportable range.

3. The presence of these new discontinuities at the periphery of all repairs made from the outer surface indicates that this particular type of discontinuity is not repairable, since further attempts at repair would just establish new discontinuities at the new repair periphery.

4. The discontinuities are in the central region of the plate, where the bending stresses which are of most significance are smaller than at the surface, and the discontinuities are bordered on one side by weld metal, providing shear continuity.

5. Changes in the ultrasonic pattern from the present to the time following the pneumatic test are to be expected as a result of the natural variables of the UT test, but are not expected to be significant. Specifically, the indicated size would not be expected to vary by more than about 1/4".

CONCLUSIONS

Based upon the above discussion, and assuming that subsequent documentation does not result in new information, it is our opinion that the new UT discontinuities are of negligible structural significance. Therefore, we would recommend acceptance of the PDM recommendation to proceed with pneumatic testing and subsequent UT examination in accordance with previously established procedures. Assuming successful completion of these steps, we would consider the repair to have been satisfactorily completed.

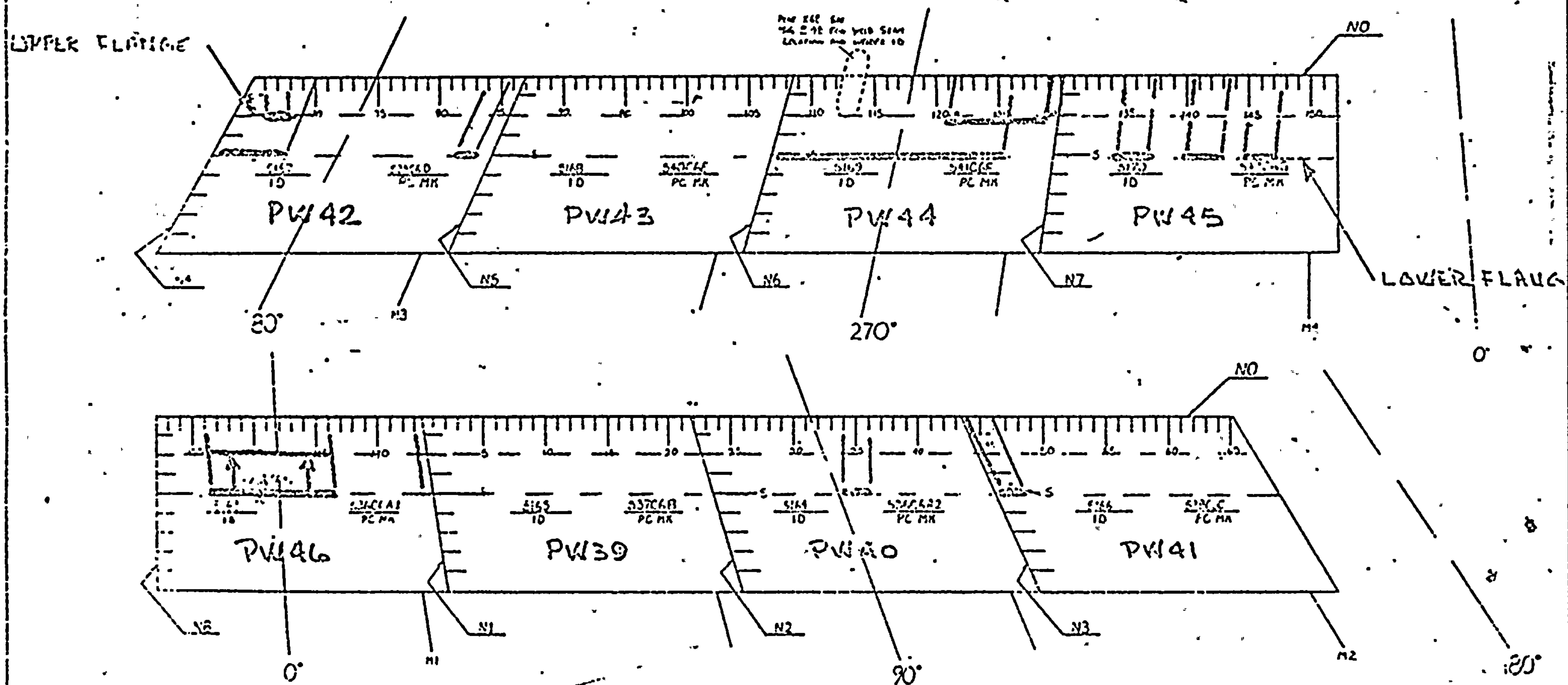
Very truly yours,

TELEDYNE MATERIALS RESEARCH

W. E. Cooper

William E. Cooper
Senior Vice President &
Technical Director

WEC:raj



UPPER PIPE WHIP SUPPORT

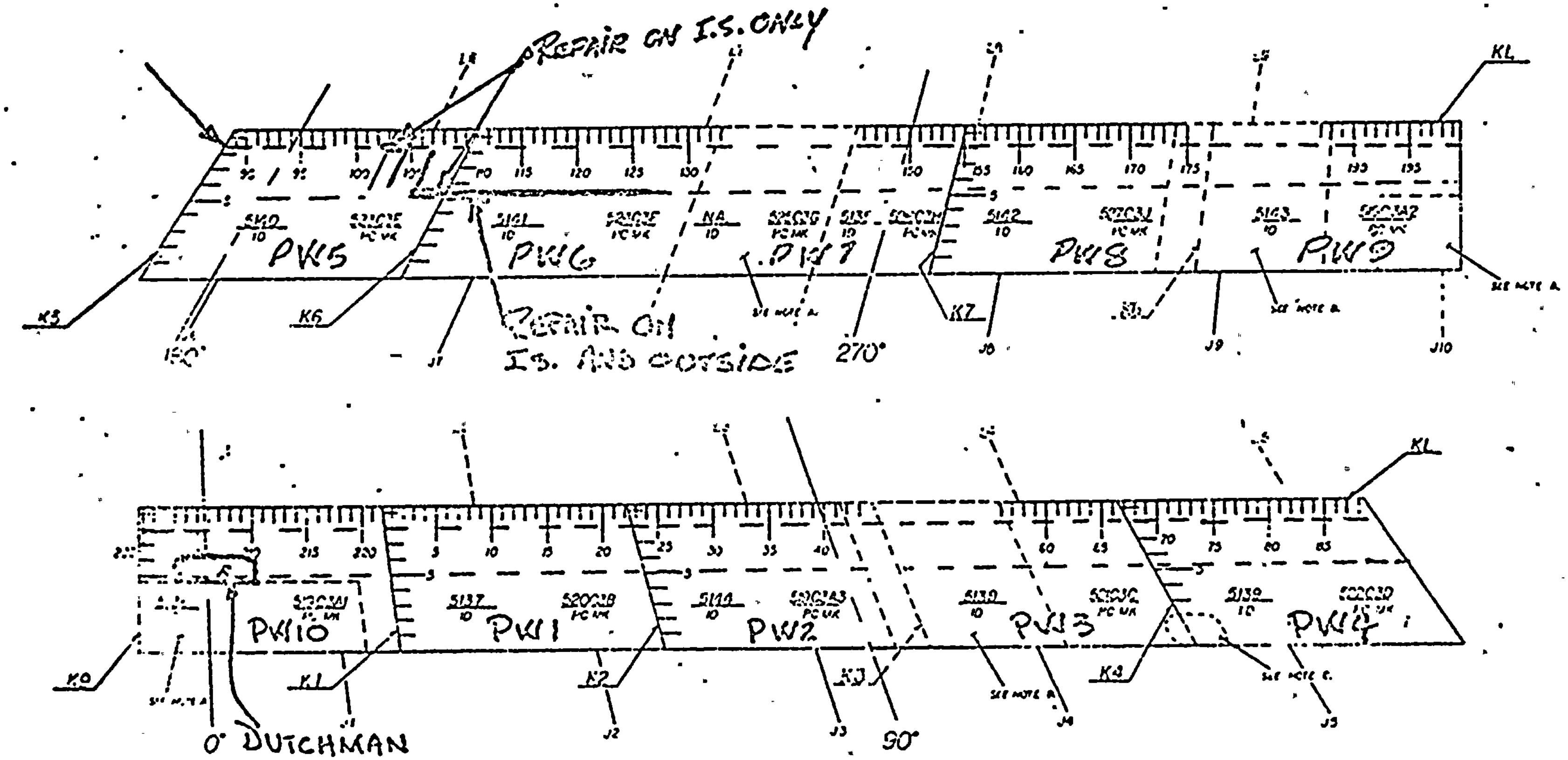
VIEWED FROM INSIDE
NOT TO SCALE

SHOP DWG. 536-542
ERECTION DWG. E19
FILE CC.

FOR APPROVAL

CERTIFIED DRAWING
APPROVED FOR CONSTRUCTION

ATTACHMENT NO. 36



NOTES:

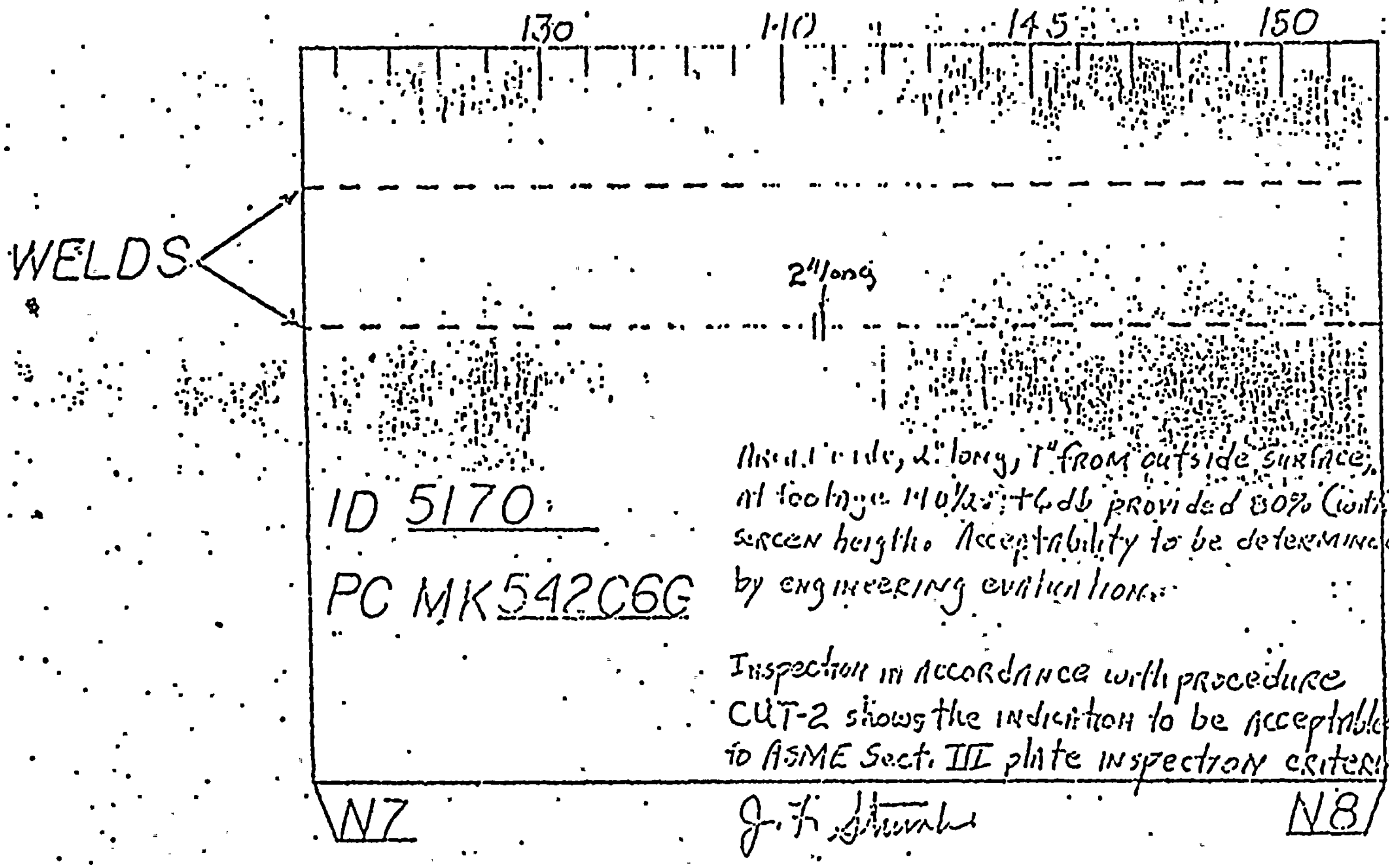
VIEWED FROM INSIDE
NOT TO SCALE
SHOP DWG.
ERECTION DWG
FILE

LEGEND
ACCEPT ——
REJECT - - - -
WELDER

DRAWING
FOR APPROVAL
DATE
APPROVED FOR CONSTRUCTION
DATE

NOTATIONS IN THIS COLUMN INDICATE WHERE CHANGES HAVE BEEN MADE

ATTACHMENT #4



Axial indic., 2" long, 1" from outside surface, at footage 140/145; +4db provided 80% (with 1/4", 4MHz probe) screen height. Acceptability to be determined by engineering evaluation.

Inspection in accordance with procedure CUT-2 shows the indication to be acceptable to ASME Sect. III plate inspection criteria.

J. F. Stuart

VIEWED FROM INSIDE

ULTRASONIC REPORT ATTACHMENT

CONTRACT 12764

RPT. NO 1-75

Page 3

Washington Public Power Supply System
A JOINT OPERATING AGENCY

P. O. Box 968 3000 Geo. Washington Way Richland, Washington 99352 Phone (509) 946-9681

March 7, 1975
G02-75-72

RECEIVED MAR 10 1975 DIR. OF REG. OPERATIONS

Mr. R. H. Engelken, Director
Nuclear Regulatory Commission
Region V
1990 North California Blvd.
Walnut Creek Plaza, Suite 202
Walnut Creek, California 94596

Subject: WPPSS NUCLEAR PROJECT NO. 2 (DOCKET 50-397)
FABRICATION DIFFICULTIES, STEEL CONTAINMENT VESSEL

Dear Mr. Engelken:

The purpose of this letter is to advance information to you regarding the nature of the fabrication difficulties being experienced in the attachment of the main steam relief valve platform support ring to the WNP-2 steel containment vessel under construction by Pittsburg-Des Moines (PDM). It is our position that these fabrication problems are not classed as a deficiency reportable under the provisions of paragraph 50.55(e) of 10 CFR 50. The following summary of findings and progress in the examination of this problem are presented for your review:

1) The basic problem is the presence of what appears to be "lamellar tears" in containment vessel plate adjacent to the weld attaching the large "box-girder" which is the support ring. (The configuration is provided as Attachment 1 to this letter).

2) These tears were detected in the course of routine inspection, recorded and reported to the appropriate Engineering and Quality Assurance organizations for disposition in accordance with the procedures of the PDM, Burns & Roe and WPPSS Quality Assurance Programs.

3) The extent of these "tears" can be summarized as follows:

   a) Two tears on the top, 8'-7" and 7'-4" long, and one 2' long on the bottom were detected visually in preparation for routine magnetic particle testing.

3) continued:

b) There was one 6" indication on the top and approximately 21 other indications opposite the bottom weld which were detected in the course of 100% ultrasonic testing of remaining weld zones on top and bottom. These indications range from 1/4" to 40" in length.

4) We have directed Burns & Roe, the Architect-Engineer and Construction Manager, to do whatever is required to resolve this problem as expeditiously as possible. The actions to date consist of:

a) An evaluation of the characteristics of a sample of metal from the tear area by Anamet Laboratories Inc., and the U.S. Steel Research Laboratory (see Attachment 2) which have established the conformance of the material to the specification; no defects in the material adjacent to the fracture, and a conclusion by the PDM Chief Welding Engineer that a "lamellar tear of a restrained joint" had occurred. Working with this as a preliminary diagnosis, an evaluation of the evidence by the Burns and Roe metallurgist resulted in a concurrence with this opinion.

b) A separate evaluation of fabrication techniques and any significant fabrication stresses is being conducted by PDM and Burns & Roe. This evaluation has not yet been finalized.

c) PDM has prepared a repair procedure in accordance with the requirements of Section III of the ASME Code and obtained the approval of the Authorized Inspector (Factory Mutual Engineering), Burns & Roe and plans to proceed with defect removal of the first of the tears.

To further summarize Burns & Roe and PDM findings at the present, this appears to be related to the combination of the heavy section of the material and the geometry involved. This problem was considered in the design of the weld geometry by PDM, and further review of design and fabrication technique is underway to establish the cause of the tears and determine repairs and/or modifications required to complete an approved containment vessel.

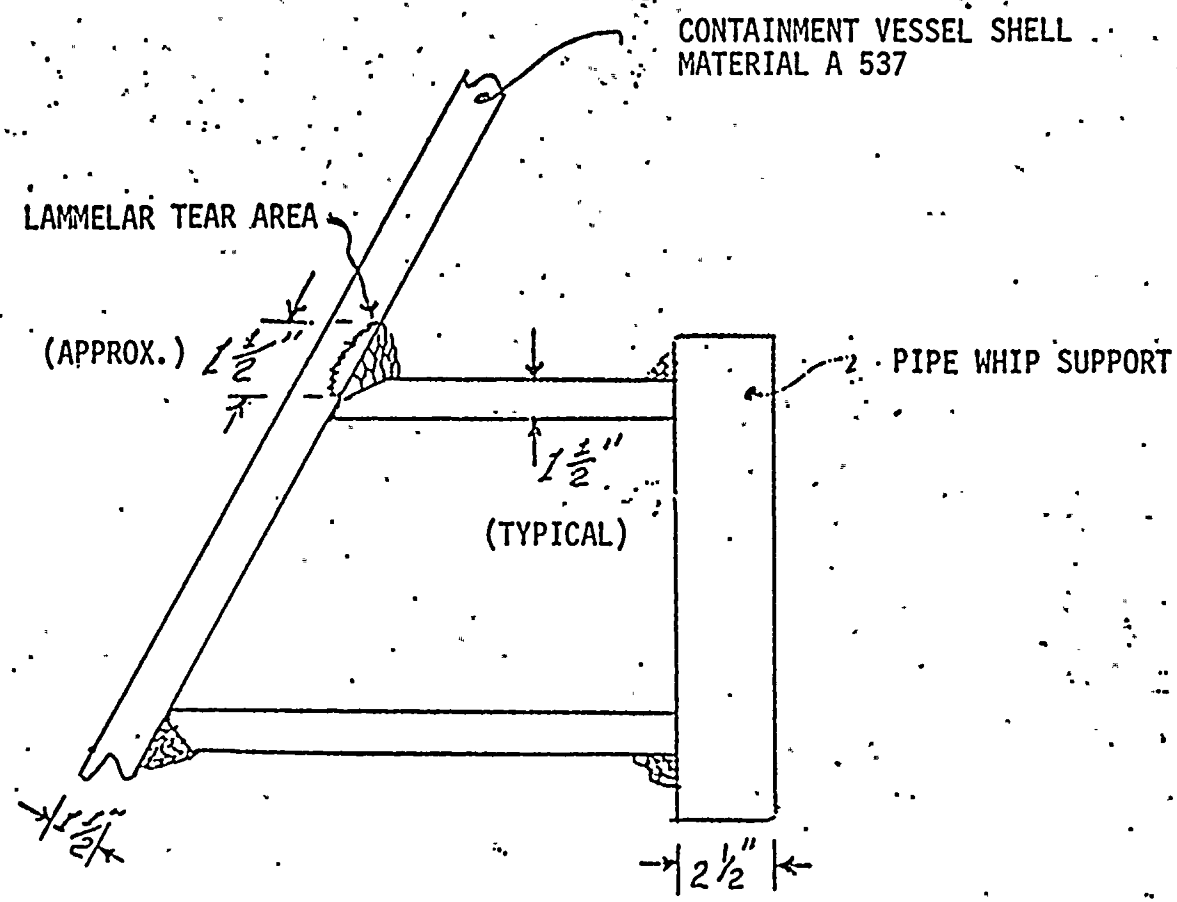
We will keep you informed of further developments.

Very truly yours,

J. J. Stein

J. J. STEIN
Managing Director

JJS:MEW:cab
Attachments



ATTACHMENT 1 - SKETCH OF VESSEL-SUPPORT GEOMETRY.

PITTSBURGH-DES MOINES STEEL COMPANY D. 4

January 28, 1975.

United States Steel Corporation
600 Grant Street
Room 4331
Pittsburgh, Pa. 15230

RECEIVED

JAN 30 '75

RICHLAND

Attention: Mr. Ron Norris

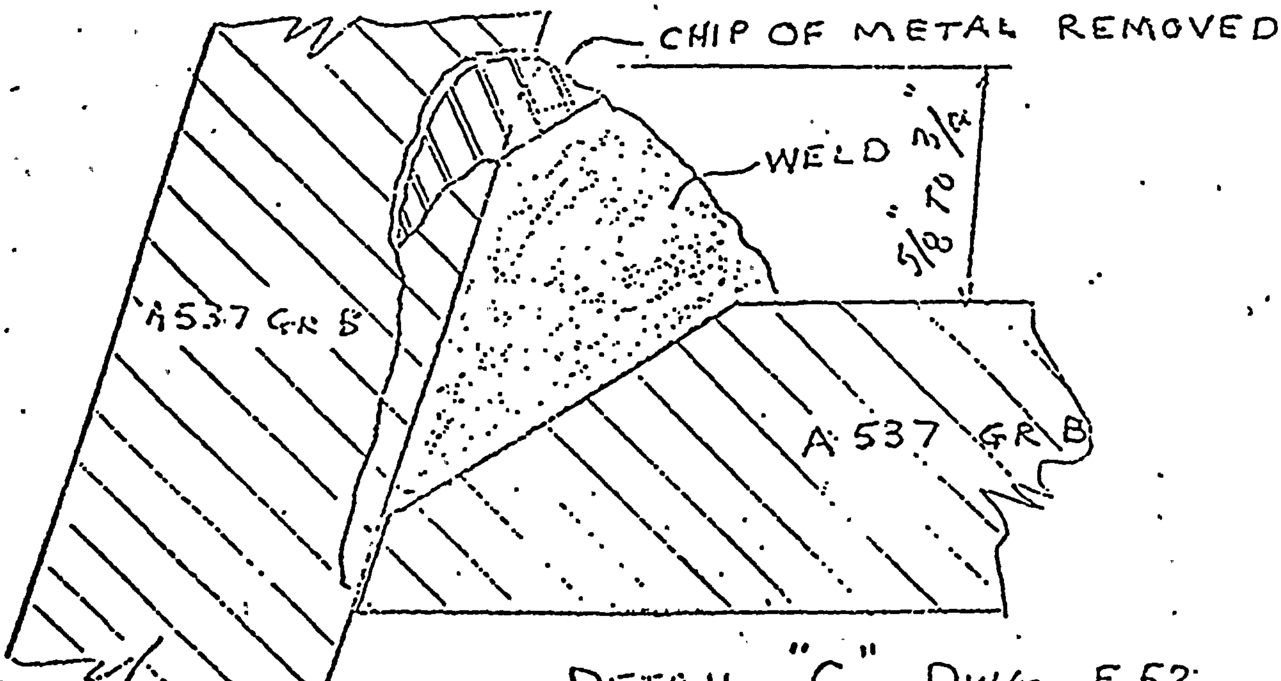
Subject: Contract 12764
Weld Craking on Toe of Fillet
made to Face of 1½" Plate

Dear Mr. Norris:

Reference is made to our telephone conversation of January 27, 1975 requesting assistance from United States Steel Corporation in interpreting what may have caused several cracks in making a girder connection to the shell plate of the above contract.

We are asking for your evaluation in this matter as a follow-up request to us by Burns and Roe's metallurgist, the engineers on this contract.

I mentioned to you that I had discussed this problem with Dr. O. Doty at your laboratory and he felt that if he had United States Steel's sales approval, he would proceed to evaluate the problem. You agreed and under separate cover, we are sending Dr. Doty a drawing showing the vessel and girder design and a chip of metal removed from the cracked area. The chipped piece was removed from the area noted in sketch below:



DETAIL "C" DWG. E52

United States Steel Corporation January 28, 1975.

The chipped out piece has some tool marks used in removing the section and the balance is dark in color. We believe the dark color is caused by ARCAIR gouging heat. The Burns and Roe metallurgist showed concern about the fracture and would like to know whether it is a brittle or ductile fracture.

We believe this is a well recognized phenomena and will discuss it further after Dr. Doty's evaluation. By copy of this letter Dr. Doty will be notified to submit any written report to United States Steel Corporation Technical Service prior to issue.

The material used in the structure was supplied by United States Steel.

<u>7'-4" Area</u>		
1½" Shell	HT W73051	Slab 03W2
1½" Webs	HT 71D656	Slab 237648
<u>8' Area</u>		
1½" Shell	HT W73051	Slab 05W2
1½" Webs	HT 71D656	Slab 237648

An early written reply will be appreciated since Burns and Roe Engineers are delaying approval of our repair procedure until they receive United States Steel Corporation's opinion.

Sincerely,

PITTSBURGH-DES MOINES STEEL COMPANY

L. Colarossi

LC:mfb

Larry Colarossi, Chief Welding Engineer.

RECORD OF EVENTS

1) Friday, January 3, 1975.
   a) Crack originally discovered by PDM personnel during visual inspection of the pipe whip support to containment vessel shell weld, prior to preparations for performing MT inspection of the pipe whip support weld.
2) Friday, January 3, 1975.
   a) PDM QA - Les Sutton, put hold tags, Numbers 00287 and 00288, on the vessel shell adjacent to the crack area.
   b) PDM Project Manager - Max Schulze, contacted Nick DeStefano - PDM Western Division Welding Engineer, Santa Clara, for assistance in evaluating cracking problem.
3) Saturday, January 4, 1975.
   a) Nick DeStefano arrived on site from Santa Clara.
   b) Removed a specimen from the cracked area for chemical analysis. The specimen included a section of the containment vessel base material and pipe whip support weld.
   c) Crack area specimen sent to: Anamet Lab, Berkely, Calif., for analysis by Nick DeStefano. (For results of specimen analysis see Anamet Lab Report, Letter dated January 17, 1975, Anamet Lab No. 175.102, P.O. 9364)
4) Monday, January 6, 1975
   a) Burns & Roe QA - MG Krisher, was advised by LR Sutton - PDM QA, of existence of pipe whip support crack, and that PDM was proceeding with repair using routine repair procedure.
   b) PDM QA Site performed preliminary UT Scan of crack area using Site NDT technician.
   c) PDM QA - LR Sutton requested assistance of NDT-UT Technician from corporate QA (Provo Shop) to UT entire crack area.
5) Tuesday, January 7, 1975
   a) Burns & Roe QA - MG Krisher, advised by PDM QA - LR Sutton, that the scheduled repair was not a "routine" repair, and repairs would be stopped pending further evaluation of the crack areas.
6) Wednesday, January 8, 1975.
   a) PDM, NDT-UT Level I Technician, M. Cameron, arrived from Provo Shop. Proceeded with UT inspection of crack area. (See PDM Deviation or Variation Report (DVR) on results of UT inspection. Dated January 13, 1975. (B&R File No. E52-0802)

RECORD OF EVENTS

7) Friday, January 10, 1975

a) UT inspection by Provo Shop UT Technician completed. (See item 6 for Report No.)

8) Monday, January 13, 1975

a) PDM QA - LR Sutton, prepared NCR on pipe whip support crack. Transmitted same to Burns & Roe Site QA on 1/15/75.

9) Saturday, January 18, 1975

a) Visual inspection of the pipe whip support crack areas was performed by H. Lunt, Burns & Roe N.Y. (see conference notes No. 316, dated 1/18/75) and L.J. Rousseau, WPPSS. (See IOM, No. QA-2-75-21, dated 1/23/75).

b) H. Lunt, Burns & Roe N.Y., requested that PDM remove another specimen for fracture analysis.

10) Monday, January 20, 1975

a) PDM removed the requested specimen per H. Lunt's request. Specimen was shipped to PDM's corporate Metallurgy Department, Pittsburgh. A section of the specimen was sent by PDM Metallurgy Dept. to US Steel (Manufacturers of the base material) for their evaluation. (See letter, US Steel to PDM, dated February 3, 1975, for their analysis of fracture).

11) Period January 21 through February 21, 1975

a) Exchange and evaluation of correspondence, test reports, and preparation of repair procedure dated 1/29/75.

12) Monday, February 24, 1975

Burns & Roe notified by PDM QA, letter addendum to NRC 213-0058 of third crack approximately two (2) feet long, located in bottom plate of subject pipe whip support. Nature of the cracked area is the same as described for the top plate of this pipe whip support.

13) Saturday, March 1, Sunday, March 2

a) Further Ultrasonic Testing by Hamill Manufacturing Company (Report No. 001) resulting in complete map of significant indications on both top and bottom of girder.

PDM

ATTACHMENT 1a

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

NEVILLE ISLAND • PITTSBURGH, PENNSYLVANIA 15225 • PHONE (4

RECEIVED
MAR 6 1975
WPPSS

WNP NO. 2	
K NALE	
L LARRIERE	
GE TRAPP	
GE DEEGAN	
GL GELHAUS	
J HARRINGTON	
SITE MANAGER	
~~COMMISSIONING~~	
D Howard	

March 3, 1975

PDMBR-213-75-13

Burns and Roe, Inc.
320 Fulton Avenue
Hempstead, New York 11550

Attention: Mr. J. J. Verderber,
Project Engineering Manager

Subject: Engineering Evaluation of Pipe Whip Support Defect, WPPSS Nuclear Project No. 2

Reference: 1) B&R NCR-213-00053

2) PDM DVR - HA2

3) USS Corporation Letter to Mr. J. F. McCarthy, dated February 3, 1975

Gentlemen:

In response to the above references you requested an engineering evaluation of the defects at the upper pipe whip support.

Rigid structures of this type produce high strains in weld metal and the adjacent parent metal. Plates are inherently weaker in the through thickness direction than in the longitudinal or transverse directions. If the strains, produced as the weld metal cools to ambient temperature cause stresses in the plate in its through thickness direction beyond its ultimate tensile strength, the plate fails by lamellar tearing. Lamellar tears have a distinct appearance. The fracture will follow various planes of weakness for short distances and shift to other planes of weakness at other depths from the plate surface giving the fracture a wood like appearance.

The weld joint at this location was designed to minimize the possibility of lamellar tearing by making the weld a partial penetration, one sided weld instead of a full butt weld.

PDMBR-213-75-13 March 3, 1975
Mr. J. J. Verderber

These welds and adjacent parent plate are satisfactory where they can be demonstrated by NDE methods to be sound.

These tears occur during the cool down of the weld or the metal and weld yield enough to accomodate the weld shrinkage. They never appear at a later time as happens with some other types of cracks.

This phenomenon is not new in the steel construction industry. They occur frequently in box girder type bridges.

Our repair procedure has included the best known precautions to minimize the possibility of lamellar tearing reoccurring in the repaired areas.

To insure that all areas of lamellar tearing have been discovered, we are 100% ultrasonic checking the remainder of the welds between the girder and shell.

I believe this letter will answer any metallurgical questions you may have. Will you please respond A.S.A.P. so that we may field repair.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

J.H.A.

J. H. Adams, Chief Engineer

JHA/gt

cc: WPPSS - J. E. Woolsey, Project Manager

PITTSBURGH-DES MOINES STEEL COMPANY

Page 4 of 4
DCR 41-2.

REPAIR OF WELD AT PIPE WHIP SUPPORT TO SHELL

(1) Place electric heater at opposite side of top and bottom annular plate at location of repair. This heater should extend at least 5'-0 beyond either side of the repair area.

(2) Place electric or gas heater on top and bottom annular plate and face plate. This heater should extend at least 5'-0 beyond either side of repair area.

(3) Preheat Item (2) to 300°F Min., Preheat Item (1) to 200°F Min.

(4) Maintain preheat differential and gouge out defect (Gouge from end to center).

(5) Disc grind gouged area to clean surface.

(6) MT - Disc ground area.

(7) Maintaining preheat as specified in Item (3), weld overlay on shell plate and MT every layer. As the welding progresses the differential of 100°F, preheat temperature will eventually be leveled off to the same preheat temperature all around (Maintain as closely as possible an interpass of 300°F Max. at the weld and 100°F differential between weld and pipe whip support at all times).

(8) Complete welding of annular plate to shell plate. MT - every 1/4" and final cover.

(9) After welding is completed; insulate the heated area and hold temperature of 350°F to 400°F for at least 2 hours and slow cool.

(10) MT after area has cooled to ambient temperature.

RECEIVED

JAN 1 ? 19?5

[illegible] 42744