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RENBERGER,D.L. Washington Public Power Supply System MA/y
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YOUNGBLOOD,B.J. Licensing Branch 1

SUBJECT: Forwards responses to Structural Enginerring Branch Round 2, Set 1 questions re sacrificial shield wall.

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G02-80-218
October 3, 1980

Docket No. 50-397

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D. C. 20555

Attention: Mr. B. J. Youngblood, Chief
Licensing Branch 1
Division of Licensing

Gentlemen:

Subject: WPPSS Nuclear Project No. 2
Responses to Round Two Questions
Set One, Structural Engineering Branch (SEB)
Concerning the Sacrificial Shield Wall

Reference: Letter, NRC (Tedesco) to WPPSS (Ferguson), "Structural Review of the Proposed Corrective Weld At the 541 Foot Construction Joint of the WNP-2 Sacrificial Shield Wall", dated September 19, 1980

Enclosed please find sixty (60) copies of the responses to Round Two, Set One questions from the Structural Engineering Branch (SEB) concerning our proposed corrective weld at the 541 foot elevation on the WNP-2 Sacrificial Shield Wall. These responses will be incorporated formally into the FSAR in the next amendment and are identical to the responses given to SEB informally in our October 1st meeting in the form of Burns and Roe Technical Memorandum No. 1204.

We understand that with the formal receipt of these questions with this letter that you are now in a position to write a letter to us on our docket approving our proposed corrective weld. We request that you expedite your efforts in this regard as we need NRR release on the

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proposed weld as soon as possible so as not to impact our restart schedule on the wall. The Office of Inspection and Enforcement (Headquarters and Region V) has stated that a copy of the docket letter to them is sufficient documentation to confirm your approval of the design and provide for the release of the technical 'hold' on the corrective weld.

Very truly yours,

DL Renberger

D. L. Renberger
Assistant Director
Technology

DLR:OKE:cph

cc: MD Lynch - NRC (telecopy)
FP Schauer - NRC (telecopy)
A. Toth - NRC Regional Inspector
DP Haist - NRC Region V
B. Bedrosian - B&R
JJ Verderber - B&R
ND Lewis - EFSEC, Olympia
JR Lewis - BPA
WNP-2 Files

STATE OF WASHINGTON)
) ss
COUNTY OF BENTON )

Responses to Round Two Questions Set One, Structural Engineering Branch (SEB) Concernging the Sacrificial Shield Wall

D. L. RENBERGER, Being first duly sworn, deposes and says: That he is the Assistant Director, Technology, for 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 October 3, 1980

D. L. Renberger
D. L. RENBERGER

On this day personally appeared before me D. L. RENBERGER 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 3rd day of October, 1980

Shirley A. Reese
Notary Public in and for the State of Washington
Residing at Kennewick

Round 2 Set 1

Responses to Structural Engineering Branch (SEB)

Questions

130.45 - 130.49

Q. 130.045

Provide typical welding details for the column splice plates, the skin plates, and the shim plates at the construction joint in the sacrificial shield wall (SSW) at elevation 541'-5". These details should include the size and length of welds and an indication whether the welds are continuous or intermittent. Indicate the maximum total loads which are transferred at this joint.

Response:

This request concerns welding details at the interface El. 541'-5" and the magnitude of loads transferred at the interface. The requested information is furnished below:

a. Typical welding details for the column splice plates are shown on B&R Drawing S835 included in Reference 1, Attachment 5. Welding details for the exterior splice plate are shown in the detail entitled, "Typical Exterior Splice Plate at Columns" and consist of the following: (See Fig. 130.45-1 - from Dwg. S835 for convenience)

   Above the interface, El. 541'-5", the splice plate is welded to the W24 column and the ring channel by 50.5 inches of 3/4 inch fillet weld.

   Below the interface, the splice plate is welded to the ring box by a complete penetration single bevel weld, 2 inches by 14 inches.

   The welding of the interior splice plate is shown in the detail entitled, "Typical Interior Splice Plate at Columns" and consists of the following: (See Fig. 130.45-2 - from Dwg. S835 for convenience)

   Above the interface, the splice plate is welded to the W24 column and the ring channel by 32 inches of 3/4 inch fillet weld and 12 plug welds each 1 7/16 inches in diameter.

   Below the interface, the splice plate is welded too the ring box by 46 inches of 3/4 inch fillet weld and by 4 plug welds each 1 13/16 inches in diameter.

b. The connections of the skin plates to the ring members adjoining the interface, Elevation 541', are shown in Section 1602 on B&R Drawing S783 included in Reference 1, Attachment 5. Fillet welds, 3/8 to 1/2 inch in size, are provided all around the periphery of each skin plate. (See Fig. 130.45-3 - from Dwg. S783 for convenience).

c. The shim plates provided at the interface are shown in Leckenby Drawing F124 included in Reference 1, Attachment 4, last page. The shim plates were driven in place and were not intended to be welded. In certain cases they have been welded inadvertantly to the upper channel by slot welds. This has no structural significance. (See Fig. 130.45-4 - Dwg. F124 for convenience).

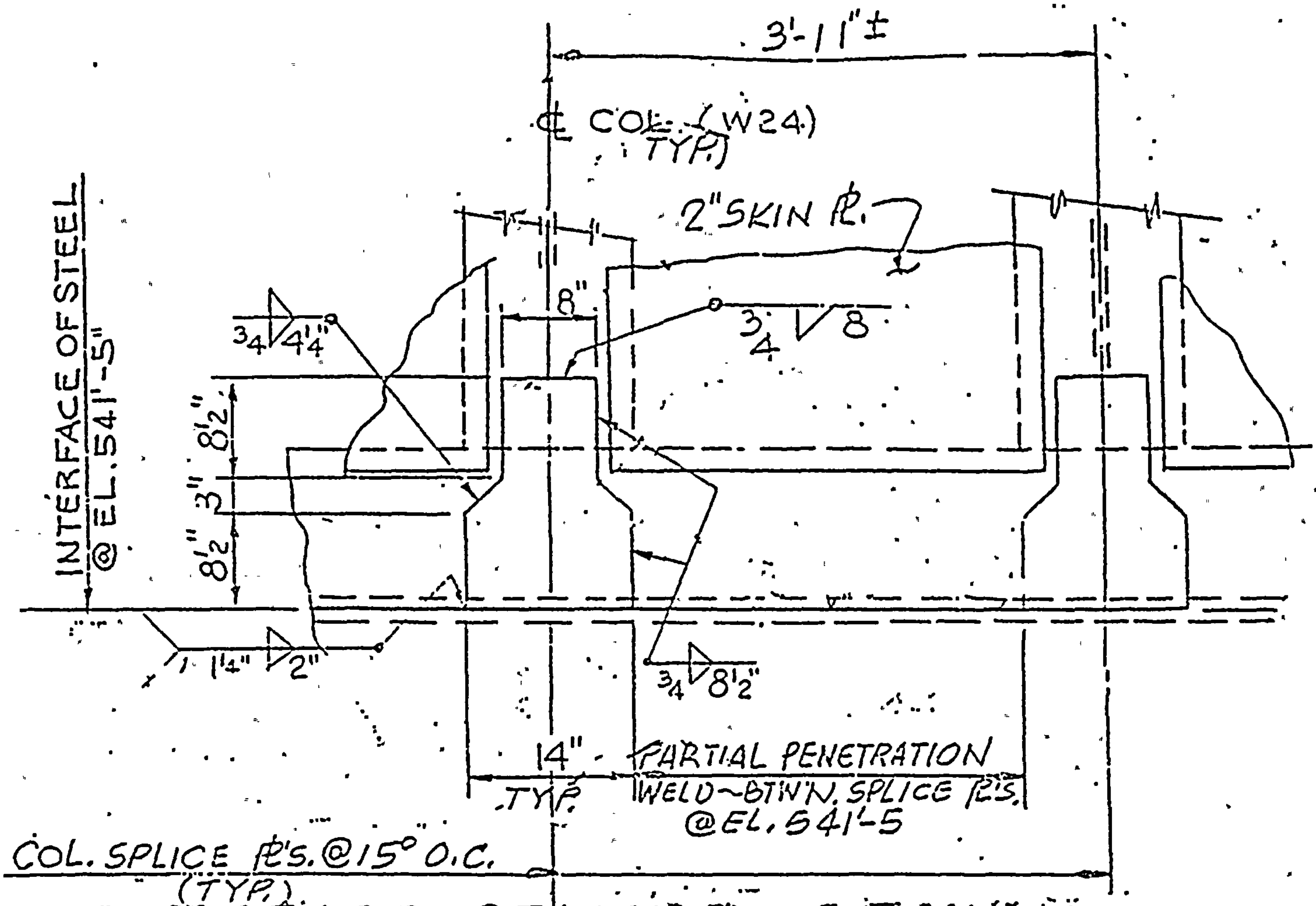
d. The maximum horizontal shear loads in one 15 degree panel of the wall are due to a combination of loads involving annulus pressures and pipe break reactions both due to a feedwater line break together with seismic and dead and live loads. The magnitudes of the controlling panel shear loads which are transferred across the interface joint are 327.0 kips tangential along centerline of wall and 27.4 kips radial along line of column web.

e. The maximum vertical loads transferred across the joint by one set of column splice plates are due to a combination of loads involving reactions due to pipe break (in drywell proper), seismic, dead, and live loads. The controlling vertical loads consist of vertical force of 307.4 kips along column axis, moment about radial axis at column center line equal to 87.4 inch kips, and moment about tangential axis at center of wall equal to 8210.2 inch kips.

References:

1. WPPSS report, "Engineering Evaluation of the WNP-2 Sacrificial Shield Wall", transmitted to NRC on WPPSS letter G02-80-168, August 1, 1980.

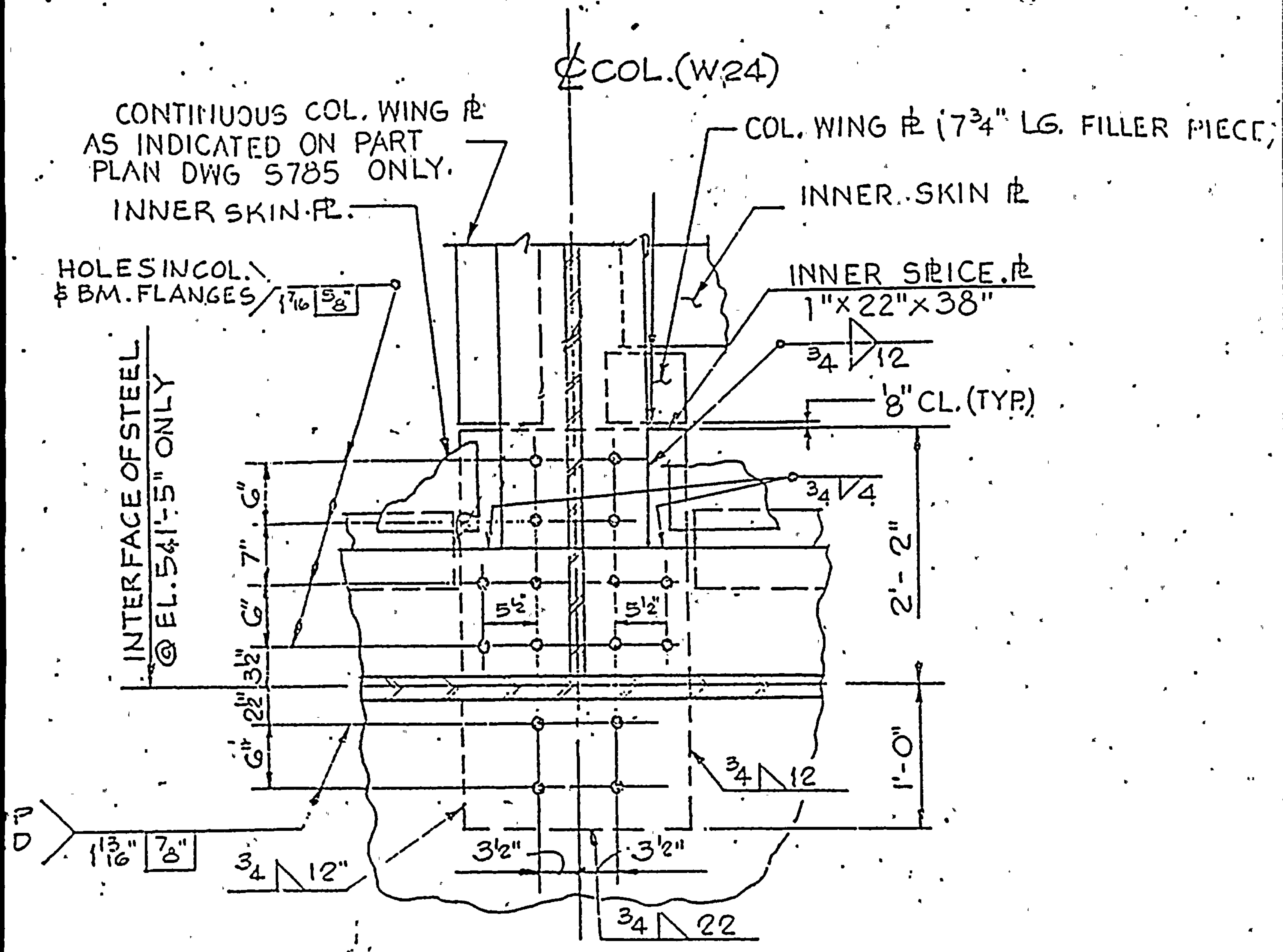
[illegible]




TYP. EXTERIOR SPLICE PL @ COLUMNS

(FROM DWG S 835)

Fig. 130-45-1

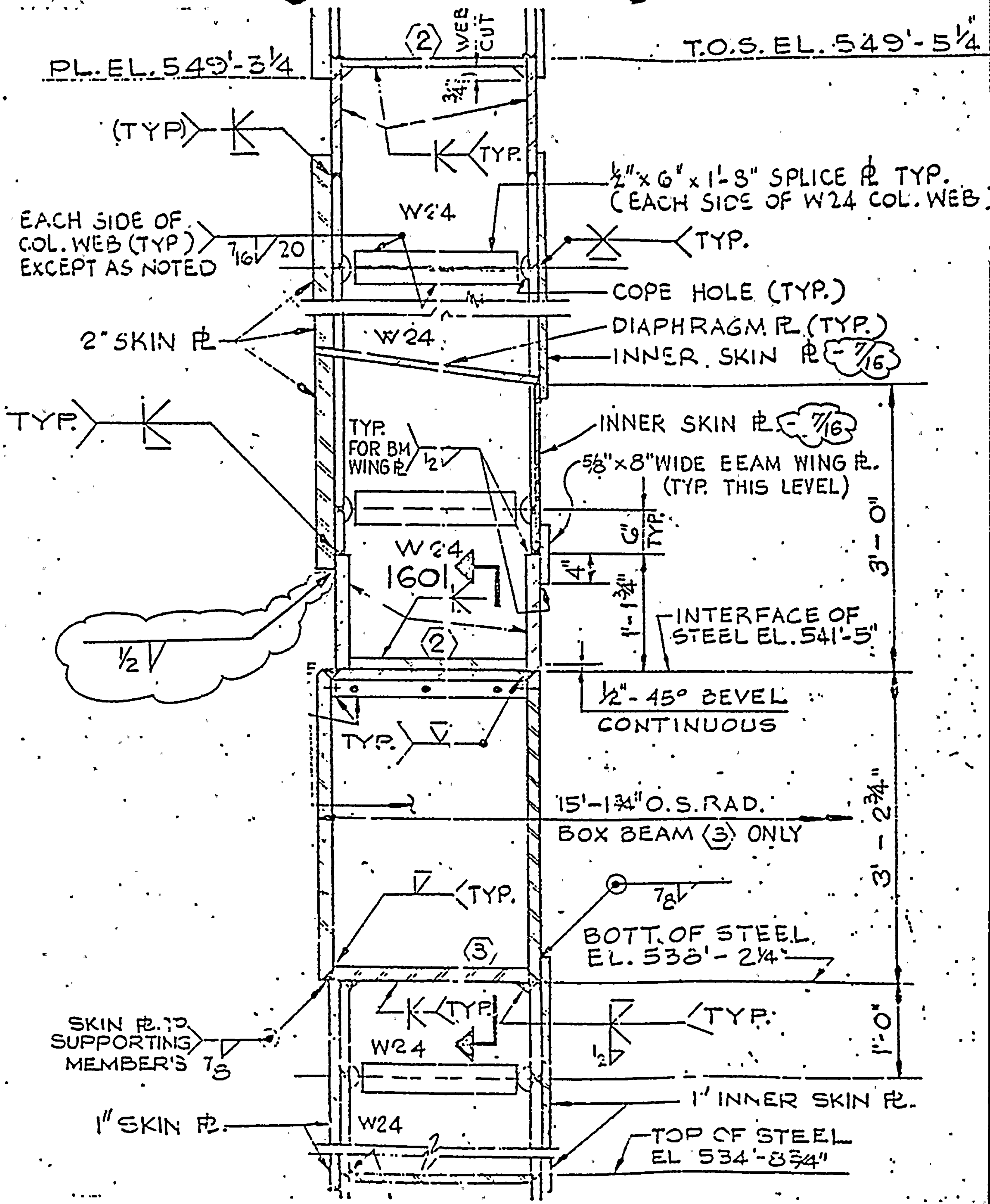



# TYP. INTERIOR SPLICE ℞. @ COLUMNS

(LOOKING FROM INSIDE WALL)

(FROM DWG. S 835)

Fig 130-45 - 2

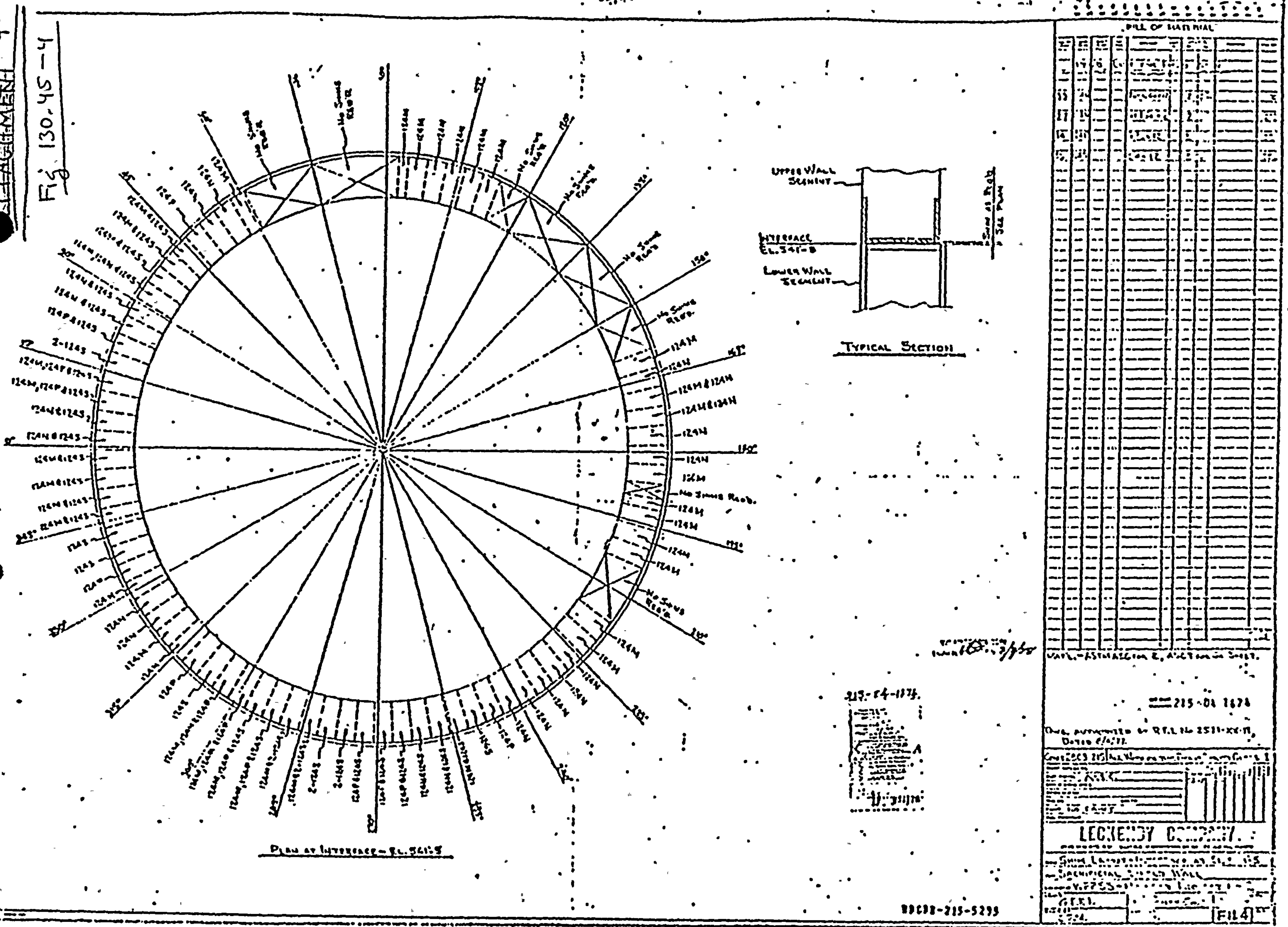



FROM DWG. S 783

Fig 130.45-3

ATTACHMENT 4

Fig 130.45-4



Q. 130.046

The tangential shear in the ring channel above and below the 541' construction joint in the SSW is taken up equally by the inner and outer skin plates while your proposed corrective weld is only on the outer skin plate. Accordingly, describe the redistribution of loads at the 541' construction joint. Identify the structural elements which resist the localized bending moment due to this "side-stepping" of the tangential shear introduced by your proposed corrective weld at this construction joint. Explain in detail how all the structural loads are transmitted to the box ring below this construction joint.

Response:

This request is concerned with the method of transmission of tangential shear from the ring channel above the joint interface at Elevation 541'-5" through the corrective weld at the interface and then into the ring box below the interface. To clarify the transmission of the shear and the redistribution of forces that occurs at the interface, a sketch showing the forces acting on the ring channel and on the ring box for one 15 degree panel of the wall is enclosed as Figure 130.461.

a. The redistribution of loads at Elevation 541'-5" is shown in the sketch. As shown thereon, symmetrical tangential loads from the upper wall are applied from above equally on the interior and exterior flanges of the channel. These symmetrical tangential forces on the channel are equilibrated by a set of forces along the lower exterior edge of the channel applied through the correction weld. This equilibrating set of forces consists of a uniformly distributed longitudinal force and a distributed radial force whose magnitude varies linerarly between extreme values at the ends of the weld. In effect, the equilibrating set is statically equivalent to the applied symmetric forces acting in the reverse direction.

b. The preceding redistribution of upper symmetric forces on the channel into asymmetric lower forces at the interface occurs in reverse for the ring box. Thus, the asymmetric forces acting at the top of the box are converted into symmetric shears in the side plates of the box member; these symmetric shears are transmitted to the lower wall. The asymmetric set of forces from the correction weld consist of the same uniform longitudinal force and varying radial force as above but acting in the opposite direction on the upper exterior edge of the box. The equilibrium of the box member is then maintained by uniformly distributed longitudinal forces of equal magnitude acting on the interior and exterior side plates of the box.

c. The preceding description and Fig. 130.46-1 show that the channel and box members above and below the interface are each subjected to bending moments about the vertical axis. Analysis has been made to determine the resultant stresses in the members; the analysis is done ignoring the continuity of the members beyond the panel in question. Since the box member has substantially larger sectional properties than the channel, calculations were made for the channel member only. These calculations together with the associated calculations for the equilibrating forces in the correction weld were transmitted to NRC in Attachment 4 of Reference 1 and are included here as Figure 130.46-2 for convenience. As indicated in the calculations, the resultant bending and shear stresses in the members (shear - 9.9 KSI, bending - 0.8 KSI), are low and are well within permissable values.

d. Consistent with the load transfer path through the joint at El.541'-5" assumed in the orginal design, where all horizontal shears are resisted by slot welds, the proposed corrective weld is designed to resist these horizontal shears. The design margins resulting from this design are discussed in Attachment 4 to Reference 1.

If, alternately, one assumes that all the loads to be transferred through the joint at El. 541'-5" will be jointly resisted by the corrective weld and the splice plates, increased design margins will result for the corrective weld.

References:

1. WPPSS report, "Engineering Evaluation of the WNP-2 Sacrificial Shield Wall", transmitted to NRC on WPPSS letter G02-80-168, August 1, 1980.

ATTACHMENT 5

**BURNS AND ROE, INC.**
Headquarters Office—Oradell, N.J.

W.O. No. 3900-03 Date [redacted]/26/80 Book No. SV[redacted] Page No. ____
Drawing No. 5783 Calc. No. 6.19.37 Sheet ____ Cont. on Sheet ____
By MJ Checked ____ Approved ____
Title WPPSS - HANFORD NO. 2 - REACTOR BLDG - SACRIFICIAL SHIELD WALL

SUBJECT - CORRECTION MEASURES AT INTERFACE EL. 541'-5"

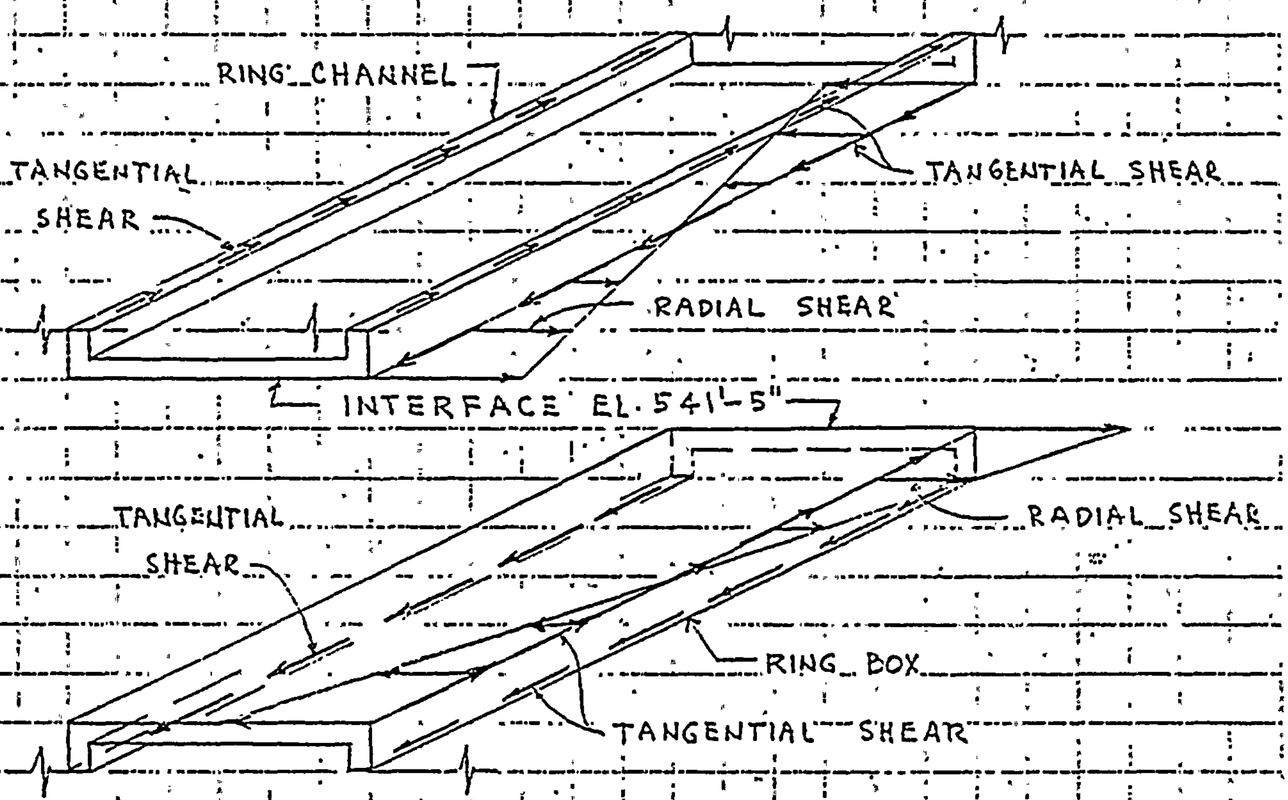



FIG 130.46-1 VIEW OF SSW INTERFACE AT ELEV. 541'-5"
SHOWING
REDISTRIBUTION OF HORIZONTAL SHEAR STRESS

Form BR 8002-2 (5/78)

**BURNS AND ROE, INC.**

W.O. No. 3900-03 Date [redacted]/80 Book No. SV [redacted] Page No. 53
Drawing No. 5783 Calc. No. 6.19.37 Sheet 9 of 24
By M. Fiacclow Checked [illegible] 1-11-90 Approved [illegible] 7/21/[illegible]
Title WPPSS - HANFORD NO.2 - REACTOR BLDG - SACRIFICIAL SHIELD WALL

SUBJECT: CORRECTION MEASURES AT INTERFACE EL. 541'-5"

H. ANALYSIS OF PROPOSED CORRECTION MEASURES

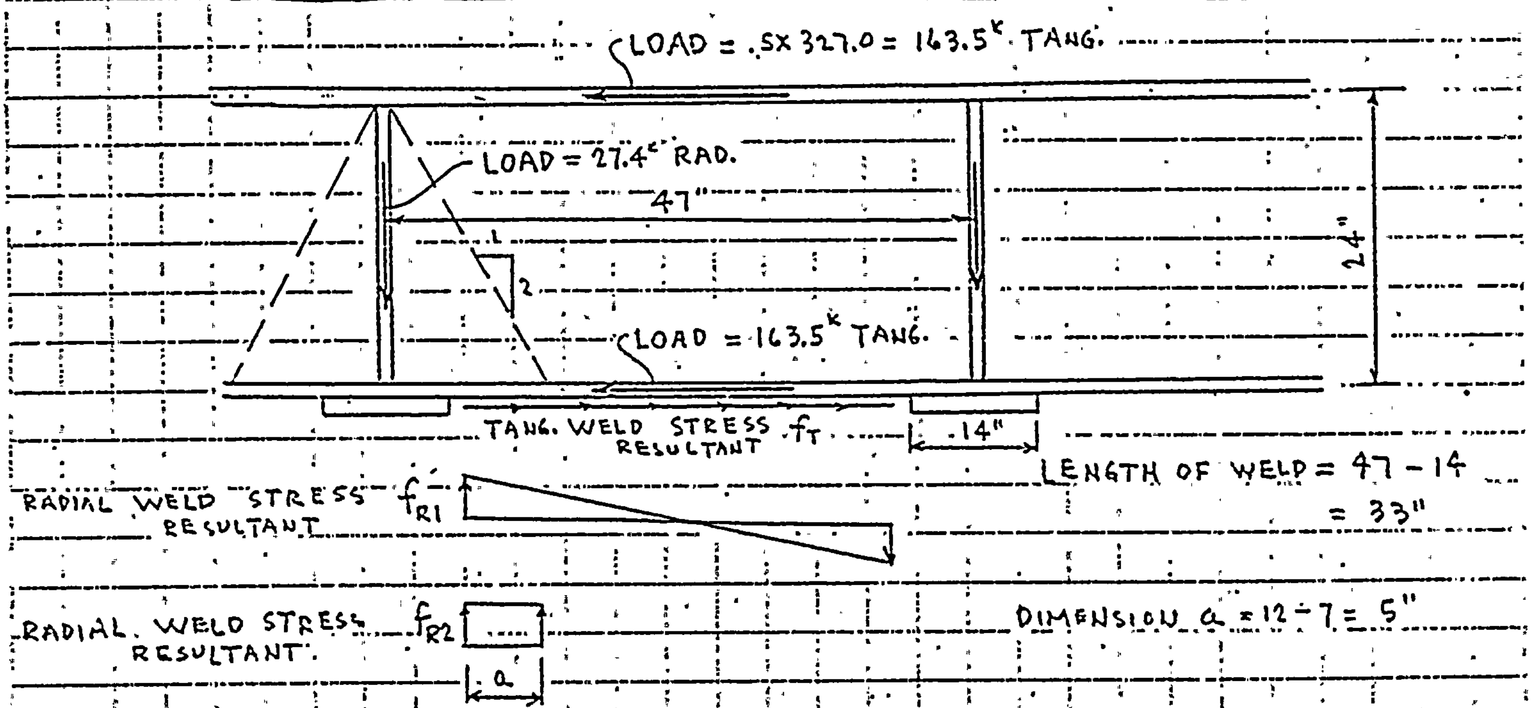
3. STRESSES IN CORRECTION WELDS

a. HORIZONTAL FORCES PER PANEL - CONTROLLING LOADING

$H_R = 27.4^k$ RADIAL AT COLUMN WEB

$H_T = 327.0^k$ TANGENTIAL TAKEN AS ACTING WITH HALF ALONG EACH SKIN PLATE LINE.

b. PLAN OF PANEL SHOWING LOADS & WELD STRESS RESULTANTS




c. WELD STRESS RESULTANTS

TANGENTIAL: $f_T = \frac{327.0}{33.0} = 9.91^{k/''}$

RADIAL: $f_{R1} = \frac{163.5 \times 24 \times 6}{33^2} = 21.62^{k/''}$ - DUE TO $163.5^k$ AT 24" ECCENTRIC.

$f_{R2} = \frac{5 \times 27.4}{5.} = 2.74^{k/''}$ DUE TO $27.4^k$

MAX. SHEAR FORCE PER INCH $= \left[9.91^2 + (21.62+2.74)^2\right]^{\frac{1}{2}} = 26.3^{k/''}$

d. MAX. PERMISSIBLE WELD SHEAR PER INCH (LOAD COMB. 5)

$f_M = 1.6 \times 21 \times 1.87 = 62.8^{k/''}$ MATERIAL: A36
ELECTRODES: E70XX

e. DESIGN MARGIN

$D.M. = \frac{62.8}{26.3} = 2.39$

W.O. No. 3900-03 Date [redacted]/4/80 Book No. SU [redacted] 89 Page No. 54

Drawing No. 5783 Calc. No. 6.19.37 Sheet 10 of 24

By M. Fielicow Checked [signature] 1-11-80 Approved [signature] 7/21/80

Title WPPSS - HANFORD NO. 2 - REACTOR BLDG. - SACRIFICIAL SHIELD WALL

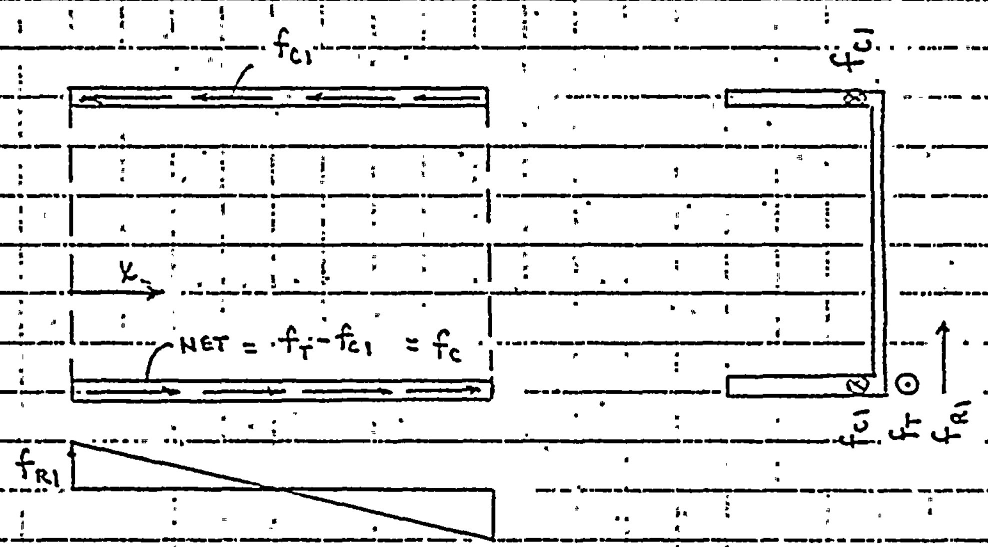
SUBJECT: CORRECTION MEASURES AT INTERFACE EL 541'-5"

H. ANALYSIS OF PROPOSED CORRECTION MEASURES

4. CHECK CHANNEL MEMBER ⟨2⟩ UNDER CORRECTION DESIGN LOADING

a. LOADING LAYOUT

1. AS A CONSERVATISM, CONTINUITY OF CHANNEL IS IGNORED.




b. LOADING MAGNITUDES

$f_{c1} = \frac{163.5}{33} = 4.95^{k/''}$ $\quad f_T = 9.9^{k/''}$ $\quad$ NET $= f_c = 9.9 - 4.95 = 4.95^{k/''}$

$f_{R1} = 21.6^{k/''}$

c. BENDING

$$M = \frac{21.6x^2}{2} - \frac{21.6x}{16.5} \cdot \frac{x}{2} \cdot \frac{x}{3} - 4.95(24)x = 10.8x^2 - .218x^3 - 118.8x$$

FOR MAX M, $\frac{dM}{dx} = 21.6x - .654x^2 - 118.8 = 0$ OR $x^2 - 33.03x + 181.65 = 0$

$$x = .5\left[33.03 \pm \sqrt{33.03^2 - 4 \times 181.65}\right] = .5\left[33.03 \pm 19.09\right] = 6.97'', 26.06''$$

$$M_{MAX} = 10.97(6.97)^2 - .218(6.97)^3 - 118.8(6.97) = 369.^{''K}$$

$S_w = 460^{''3}$

$f_b = \frac{369}{460} = 0.80^{k/\square''}$ O.K.

d. SHEAR

MAX $V = .5 \times 21.6 \times 16.5 = 178.2^k$

$v = \frac{178.2}{24 \times .75} = 9.9^{k/\square''}$ O.K.

Q. 130.047

You indicate in the Enclosure to Attachment 4 of your report that the seismic loads used in your analysis of the partial penetration weld, are based on your current definition of seismic loads and not on the original seismic loads used to design the sacrificial shield wall. Provide a complete list of both your original and current seismic loads. Indicate the differences in your assumptions and your methods of analysis for these two sets of seismic loads.

Response:

The current and original seismic loads in the controlling panel used in the analyses and design of the correction weld are tabulated below:

| | Current | Original |
|---|---|---|
| Tangential Shear | $13.6^k$ | $41.3^k$ |
| Radial Shear | $3.8^k$ | $12.0^k$ |

The assumptions and the method of analysis used to obtain the original seismic loads are presented in Sections 3.7.1, 3.7.2.1.1 through 3.7.2.1.8, 3.7.2.3 and 3.7.2.3.of the FSAR. The current seismic loads are obtained from finite element soil structure interaction analysis in accordance with NRC Standard Review Plan Section 3.7.2.

Q. 130.048

In Technical Memorandum No. 1188, you state that the design response spectra at all mass point of your mathematical model of the reactor building were generated in your soil-structure interaction analysis. Our current licensing position requires that you analyze the soil-structure interaction using both the half-space (lumped spring-mass or compliance function) methodology and the shear beam, finite element representation of the soil foundation. Our concern in this matter is that the results obtained by the finite element approach using the deconvolution procedure and the FLUSH computer program, may not be acceptable. Accordingly, we require that all seismic loads and the corresponding design response spectra be recalculated by employing a half-space, soil spring model and that you adopt the higher values calculated by either of the two methods discussed above.

Response:

The original seismic analysis utilizes lumped spring mass and damper representation for soil structure interaction effects. The soil spring constants are calculated using elastic half-space theory. However, the soil damping values are conservatively assumed to be low values as presented in Table 3.7-1 of the FSAR instead of those calculated from half-space theory as recommended in Section 3.7.2 of the Standard Review Plan. Consequently, the original seismic loads are substantially higher than those which would have been obtained from half-space methodology as suggested in this question.

In connection with the sacrificial shield wall correction weld addressed in the responses to questions 130.45, 46, 47, and 49, analysis of the correction weld was made using, in turn, the results from each seismic method in the controlling combination of loads. Design margins are calculated which are equal to the ratio of the permissible stress in the correction weld to the maximum stress using the controlling load combination. With the current seismic definition based on finite element soil structure interaction analysis the design margin afforded by the weld is 2.4. With the seismic loads as originally defined (lumped mass-spring model) the design margin in the correction weld is 2.1. Thus, relatively high design margins result with both methods of seismic analysis. This follows because the seismic loads are relatively small compared to other loads in the controlling load combination, namely, annulus pressures and pipe break reactions.

In connection with the structural design of the balance of the plant, the current regulatory position referred to in this question will be conformed with. The FSAR will be revised in the future accordingly.

Q. 130.049

In the last part of Attachment 4, "Analysis and Design of Sacrificial Shield Wall," you state that the inner and outer skin plates are treated as a single plate having a thickness equal to the combined thickness of both plates. Such an assumption is incorrect for out-of-plane bending. Additionally, it is not clear in your report what type of plate element and the associated boundary conditions for these plate elements, are used in your computer model. Indicate whether the plate elements at the interface are treated differently for the free edges of the as-built structure.

Response:

This request is concerned with the structural modelling of the skin plates as part of the overall structural model used in the analysis and design of the Sacrificial Shield Wall (SSW). Information pertinent to this request is furnished below:

a. The paper entitled, "Analysis and Design of Sacrificial Shield Wall", part of Attachment 4 in Reference 1, which is referred to in this request, respresents a condensation of the information on that subject in WPPSS Report No. WPPSS-74-2-R2-B (Reference 2) which was submitted to and approved by NRC in 1975. As noted in the approved report, the methods of finite element analysis are used to include the effect of the skin plates as part of the framework. The inner and outer plates in a panel are treated as one plate having combined thickness of both plates and joined to the framework at the framework panel joints. A plane stress type of finite element of rectangular or triangular shape is utilized in the computer program. The curvature of the plates is considered in evaluating the permissible stress in the plates. The membrane stresses (normal stresses and shear stresses) are funished as computer output for each plate element. These are used in the design of plate thickness and of attachment welds which are based on Part 1 of the AISC Code.

b. Based on preliminary analysis for the SSW, it had been determined that the principal structural function to be served by the skin plates was to afford additional capacity against in-plane forces carried by the structural framework made up of the structural columns and ring beams. The structural model of the wall consists of 378 members and 136 plate elements. In order not to overcomplicate a model which was already fairly complex, it was decided to adopt the conservative approach of assigning all out- of-plane bending capacity to the structural members (columns and ring beams) and utilizing a plane stress type of element for the skin plates. With this model, all necessary out-of-plane bending capacity required by the loading is provided in the design of the structural members and the skin plates transmit membrane forces only. It was noted above that in the plate element computer model, one plate having the combined thickness of the inner and outer plates is used. However, the permissible stress in each plate is calculated on the basis of the thickness of one plate only.

c. As was previously stated the plate elements used in the computer model are of the plane stress type. The plate element boundary conditions used in the computer analysis, which utilized the computer program STRUDL, derive from the finite element methodology in the program. Although the plates are physically connected all around the periphery, in the finite element methodology, the elements are taken to be joined to each other and the frame work only at the nodes; equilibrium and compatibility of displacements is enforced at the nodes. Thus, in the analysis, all elements have similar boundary conditions in that they are treated as connected only at the nodes.

However, in actual design, the difference which applies to the plate elements at the interface relative to the transfer of plate forces through the nodes, is taken into account. In general, the skin plates away from the interface are connected to peripheral structural memebers which intersect at the nodes so that transfer of plate forces through the structural members to the nodes is automatic. At the interface, the skin plate forces are transmitted to the ring channel and the W24 columns which in turn must transfer the load across the interface. This is done via the correction weld and the splice plates.

References:

1. WPPSS report, "Engineering Evaluation of the WNP-2 Sacrificial Shield Wall", transmitted to NRC on letter G02-80-168, August 1, 1980.

2. WPPSS Report No. WPPSS-74-2-R2-B entitled, "Sacrificial Shield Wall Design Supplemental Information" submitted to NRC by letter G02-75-240, dated August 19, 1975 and approved by NRC byletter dated October 15, 1975.