VERMONT YANKEE NUCLEAR POWER CORPORATION

Ferry Road, Brattleboro, VT 05301-7002

REPLY TO
ENGINEERING OFFICE
580 MAIN STREET
BOLTON, MA 01740
(508) 779-6711

April 10, 1992
BVY 92 - 56

United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

References: (a) License No. DPR-28 (Docket No. 50-271)
(b) Letter, VYNPC to USNRC, BVY 92-055, dated April 5, 1992

Subject: Supplemental Information Regarding Proposed Alternative for Compliance with 10CFR50.55a Regarding RPV Cladding Indications

Dear Sir:

In Reference (b), Vermont Yankee requested NRC approval of a proposed alternative to the ASME Section XI Code with regard to indications discovered in reactor pressure vessel internal cladding. As stated in Reference (b), the purpose of the stainless steel reactor vessel cladding is to reduce the presence of oxide products in reactor coolant, thus reducing the demand on reactor coolant demineralizing equipment to maintain water purity. Vessel cladding does not form a part of the reactor pressure vessel structural boundary, and no credit is taken for it in the structural analysis of the vessel or vessel head. Reference (b) provided the results of our examination effort conducted during the current 1992 refueling outage, as well as the basis for approval of a proposed alternative to the ASME Section XI Code in accordance with 10CFR50.55a(a)(3).

The purpose of this letter is to formally transmit information that was presented to the NRC Staff in our meeting at NRC headquarters on Wednesday, April 8, 1992 regarding the subject issue. The requested information is enclosed as Attachment A.

Additionally, at the April 8, 1992 meeting NRC questioned the ASME Section XI requirements for the internal surfaces of the reactor pressure vessel head. Enclosed as Attachment B please find an ASME Code Interpretation which documents that there are no code required inspections of the reactor vessel head internal surfaces.

We trust that this supplemental information meets your needs; however, should you require additional information, please contact this office.

Very truly yours,

VERMONT YANKEE NUCLEAR POWER CORPORATION

Leonard A. Tremblay, Jr.

Leonard A. Tremblay, Jr.
Senior Licensing Engineer

160040

A047 1/1

Enclosed: Attachments A and B

cc: USNRC Region I Administrator
USNRC Resident Inspector - VYNPS
USNRC Project Manager - VYNPS
Mr. James Wiggins - USNRC/NRR

Presentation Graphics

from

April 8, 1992 Meeting

Vermont Yankee

Reactor Pressure Vessel

Clad Indications

1992 Refueling

NRC Presentation

April 8, 1992

Warren Murphy (VYNPC) - Senior Vice President and Manager of Operations

Frank Helin (VYNPC) - Project Engineer

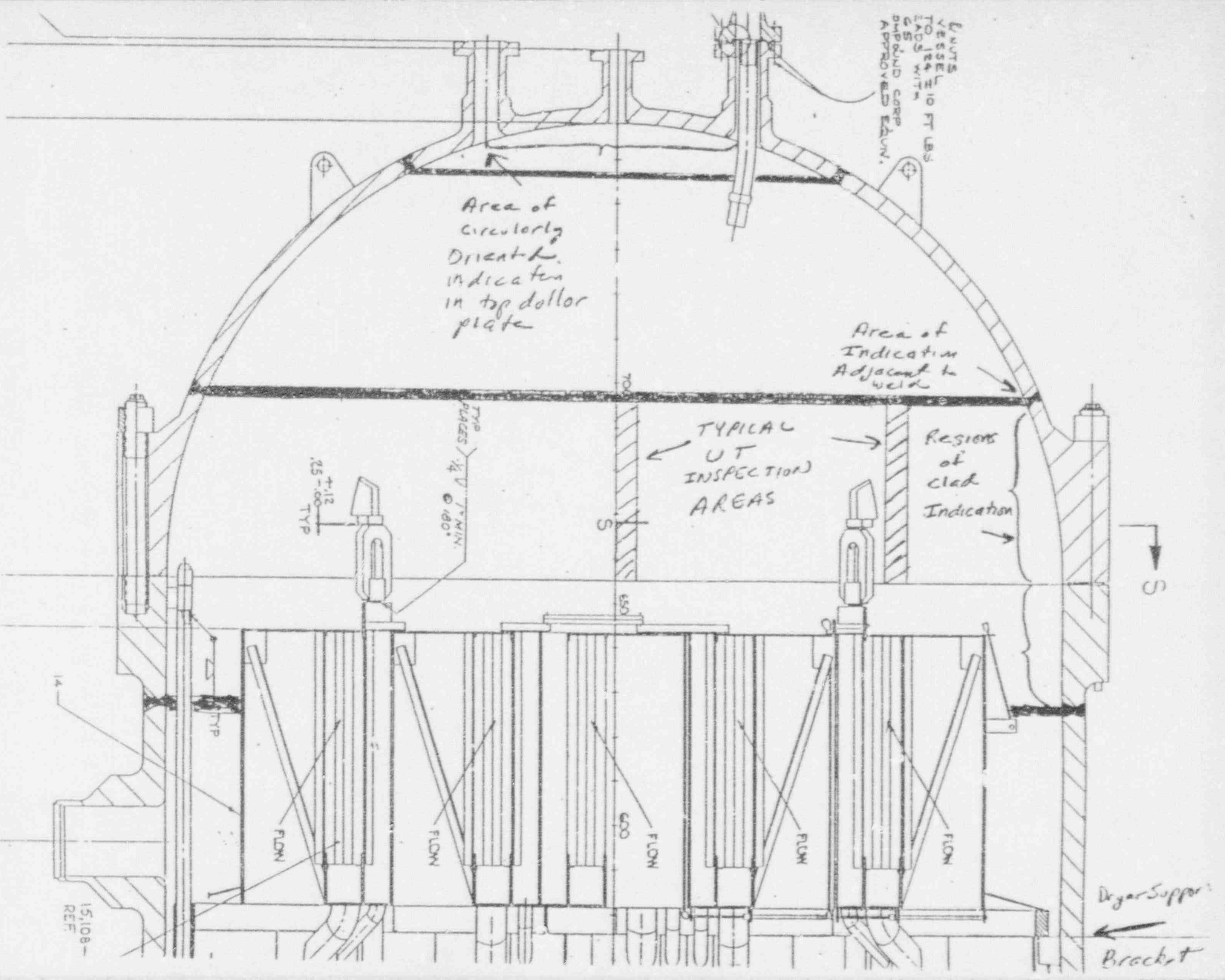
John Hoffman (YAEC) - Engineering Manager

Carl Larsen (YAEC) - ISI Level III

Tom O'Hara (YAEC) - Senior Engineer

Ken Willens (YAEC) - Principal Engineer

Art Deardorff (SIA) - Associate


& NUTS
VESSEL
TO 124 ± 10 FT LBS
EADS WITH
GS
OMPOUND CORP
APPROVED EQUIV.
Area of circularly Oriented indication in top dollar plate
Area of Indication Adjacent to weld
TYPICAL UT INSPECTION AREAS
Regions of clad Indication
S
S
700
650
600
TYP PLACES
1/4
1" MIN. @ 180°
.25 +.12 −.00 TYP
TYP
FLOW
FLOW
FLOW
FLOW
FLOW
14
15,108 REF
Dryer Support Bracket

Sequence of Events

-Under head examination conducted as recommended by GE SIL 539

-Linear rust indications observed visually

-One indication manually explored to determine depth and character. Indication became tighter and more diffuse as depth increased, indicative of IGSCC

-A number of indications were ultrasonically evaluated to determine depths

-All flaws examined in this phase were sized to be within the nominal clad thickness of 3/16"

-Independent of this activity the In-Vessel Visual Examination (IVVI) was underway as part of Inservice Inspection Program

-IVVI observed a rust indication adjacent to one of the four Dryer Support Brackets

-Area was ultrasonically examined from outside the reactor vessel

-No indication of flaw propagation into the basemetal or lack of bond was observed

-IVVI also reported some visual rust indications on inside surface of pressure vessel

-IVVI Team reviewed the photographs of the under head condition and concluded that the conditions were similar

Engineering Evaluation

-Engineering concluded that the condition was stress corrosion cracking of the stainless steel clad

- -Cladding one layer of 309 low carbon stainless steel for machine deposited clad and two layers (309/308) for manually deposited clad

-Based on prior experience it was concluded that the low carbon properties were probably lost during welding due to carbon pickup from the basemetal

-Cladding was furnace sensitized during vessel heat treatment process

-Weld metal can develop IGSCC depending on carbon/ferrite ratio

-Industry studies show negligible probability of propagation beyond the clad

Follow-on Actions

-Fracture mechanics studies performed for added assurance of safe plant operation

-Analyses based on reactor vessel stress analysis

-Consideration given to welding residual stress in clad and pressure vessel welds

-Worst case condition shows minimum of three cycles before a flaw would exceed Code allowable size. (For this to occur it must be assumed that flaw initiated just prior to shutdown and that it grows at worst case rate)

-Additional UT evaluations conducted on reactor vessel head flange cladding

-Eight locations 45 degrees apart were selected to ensure areas representative of the entire surface were examined

-Starting location was 0 Degree azimuth for ready reference in future inspections

-Sixty (60) indications were sized. All were within the clad thickness

-Portions of the circumferential indications at upper head region and flange/head weld were UT'd. A number of UT reflectors were observed. None were identified to be greater than the clad thickness

-Four additional areas on the reactor head flange inside surface were examined. Forty two (42) additional UT indications were sized. All were within the clad thickness

-Thirty two (32) indications were UT examined on the vessel shell flange cladding. All were determined to be within the clad thickness

-Ferrite readings were taken at 24 locations on the head flange and twelve locations on the shell flange. All readings were in excess of 5 percent, with the majority greater than 7.5 percent. This would rule out microfissuring, which can occur in low ferrite stainless steel weld metal

-Metal chips were removed from the head and shell flange cladding. The chemical analysis showed high carbon content (0.079 w/o and 0.111 w/o respectively). This supports previous judgement concerning possible carbon pickup from the basemetal during welding

-Follow-on evaluations all support original conclusion that condition is due to IGSCC of cladding

-More probable in manual clad regions due to low carbon content of machine welded clad (greater tolerance for carbon pickup)

-Very low likelihood of propagation into low alloy steel basemetal

-Detailed UT investigation of dryer support bracket indication, which is now known to be at least nine years old, demonstrates no propagation beyond the clad

VESSEL/HEAD FLANGE/EVALUATION

- STRESSES
  - Pressure/Bolt-up from Original Stress Report
  - Clad Stress
  - Weld Residual Stress

- FRACTURE MECHANICS MODEL
  - 360° Circumferential Crack in Cylinder

- CRACK GROWTH LAWS
  - SCC: Ford & Andresen Low Sulfur Law
  - Fatigue: ASME Section XI, Appendix A (Negligible)

- ALLOWABLE FLAW SIZE DETERMINED PER ASME SECTION XI, IWB-3600

92256r0

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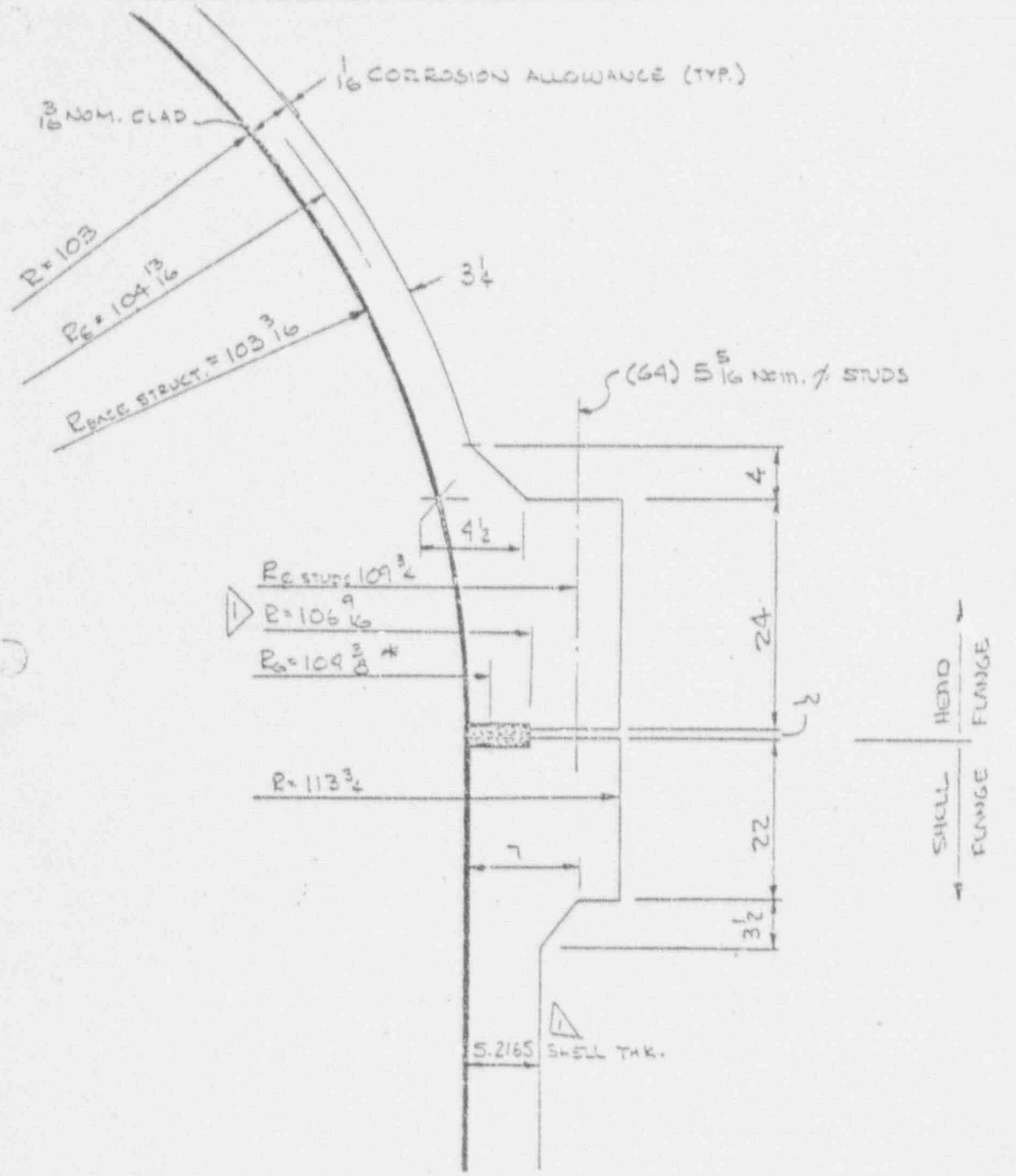
B.2 FLANGE CONFIGURATION

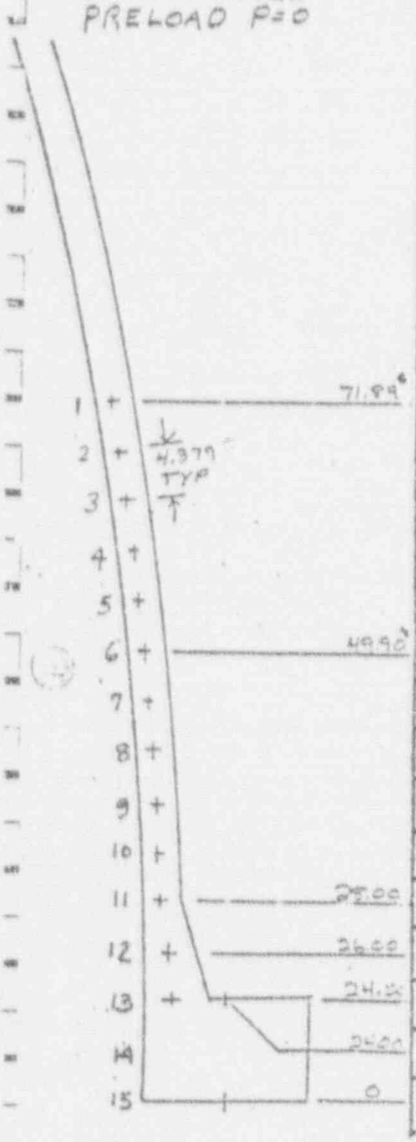


* R_G = RAD TO ℄ OF 1ST O-RING GASKET USED TO COMPUTE PRESSURE UPLIFT

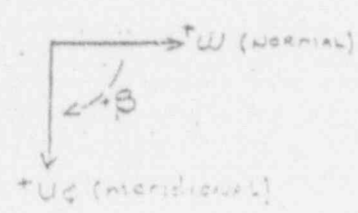
CHICAGO BRIDGE & IRON COMPANY TABLE IX OAK BROOK ENGINEERING

PRINCIPAL STRESSES & DEFORMATIONS SOURCE OF TABULATED VALUES - See Pgs. I-S1-A32/43

HEAD FLANGE PRELOAD P=0



DISPLACEMENTS			Membrane Stresses		Bending Stresses**	
Normal ω	mer U_ϕ	Rotation β	mer $\sigma_{m\phi}$	Hoop $\sigma_{m\theta}$	mer $\sigma_{b\phi}$	Hoop $\sigma_{b\theta}$
-.00534	.00394	-.00005	-83	-594	1516	474
-.00464	.00416	-.00022	-93	-427	2393	797
-.00298	.00432	-.00047	-92	-26	3374	1152
-.00004	.00436	-.00081	-76	700	4352	1526
.00454	.00421	-.00122	-40	1541	5074	1824
.01101	.00377	-.00166	21	3457	5167	1923
.01935	.00294	-.00207	106	5547	4086	1644
.02910	.00164	[illegible]	212	7992	1157	763
.03910	-.00018	-.00217	331	10490	-4412	[illegible]
.04716	-.00249	[illegible]	445	[illegible]	[illegible]	[illegible]
.04991	-.00224	.00277	654	13080	-27616	[illegible]
.04782	.00234	[illegible]	872	12560	-37192	-11140
.04199	[illegible]	.00368	973	11070	-46787	[illegible]
.03854	.00781	[illegible]	-5185	[illegible]	5151	[illegible]
-.05107	0.0	[illegible]	-6537	-15100	-13713	[illegible]

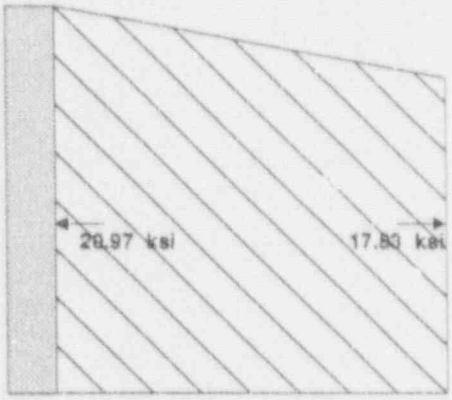


* ARC ON R ℄

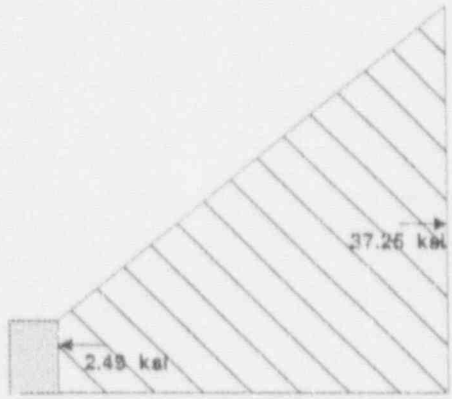
** + Bending = TENSION ON INSIDE

Subject VERMONT YANKEE PROJECT-REACTOR 9-6201-I Date [illegible] By JTK Sht I-S1-70 of

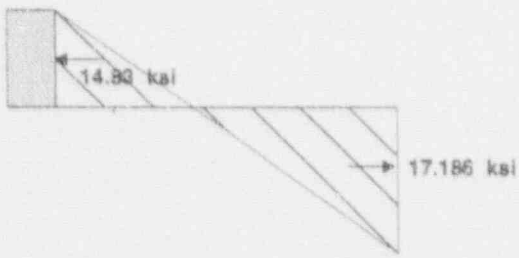
Checked by TS Date [illegible] Rev. No. 1 Date [illegible] Rev. No. Date Rev. No. Date



Location No. 1



Location No. 10



Location No. 14

MERIDIONAL STRESS DISTRIBUTIONS
(Applied Stress)

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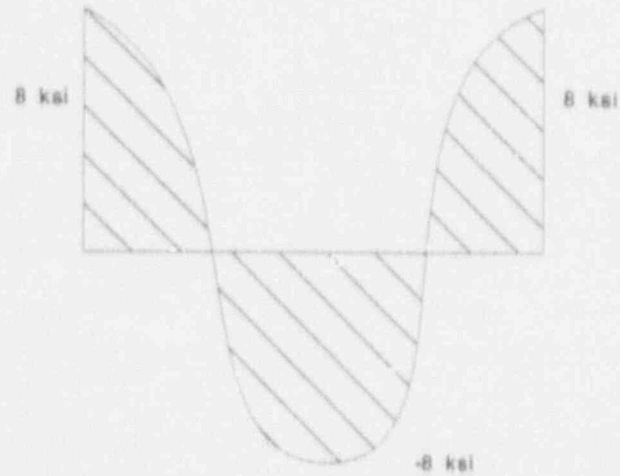
CLAD STRESS DISTRIBUTION



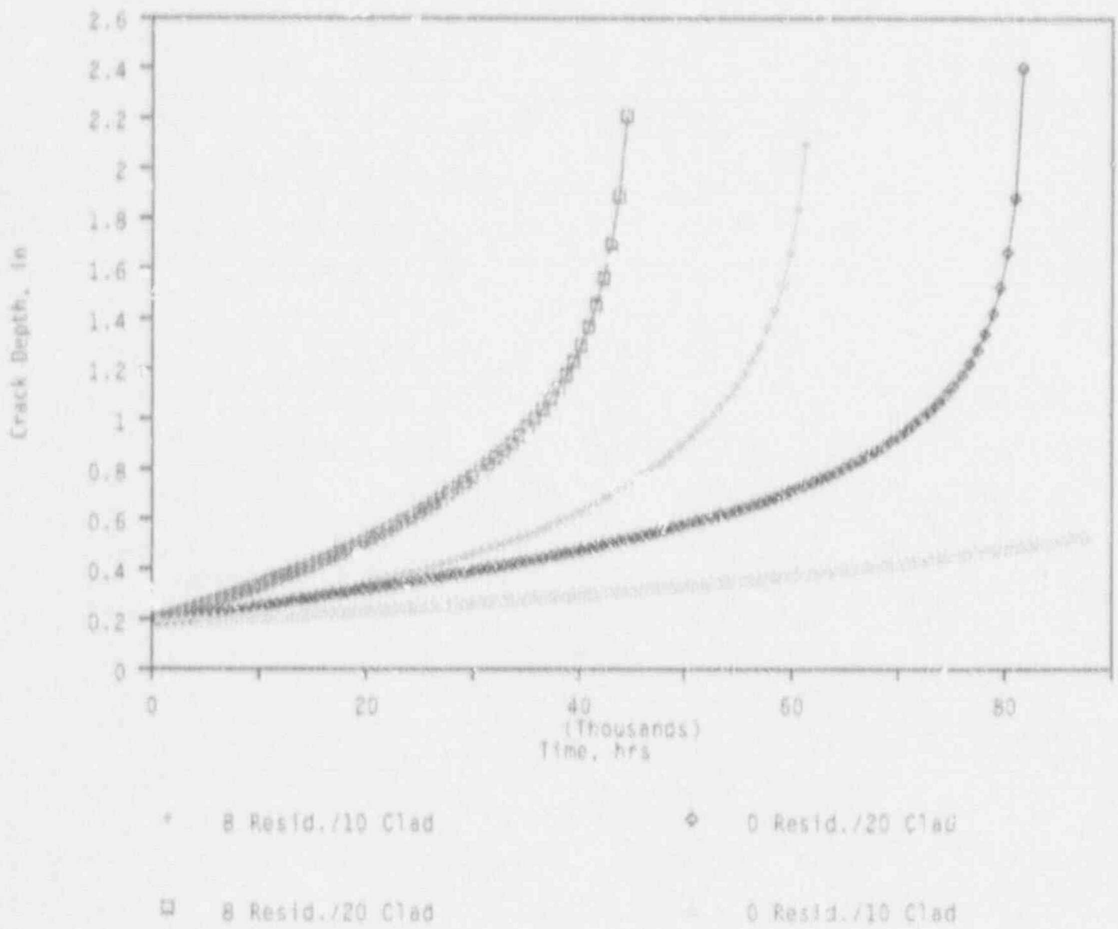
WELD RESIDUAL STRESS DISTRIBUTION
(Cosine Distribution)

STRUCTURAL INTEGRITY ASSOCIATES, INC.

92264r0

Vermont Yankee Vessel Head

Crack Growth - Location No.



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92262r0

VESSEL ADJACENT TO STEAM DRYER BRACKET

- STRESSES
  - Pressure
  - Thermal
  - Clad
  - Bracket Loads

- FRACTURE MECHANICS MODEL
  - 360° Circumferential Crack in Cylinder

- CRACK GROWTH LAWS
  - SCC: Ford & Andresen Low Sulfur Law
  - Fatigue: ASME Section XI, Appendix A (Negligible)

- ALLOWABLE FLAW SIZE DETERMINED PER ASME SECTION XI, IWB-3600

92263r0

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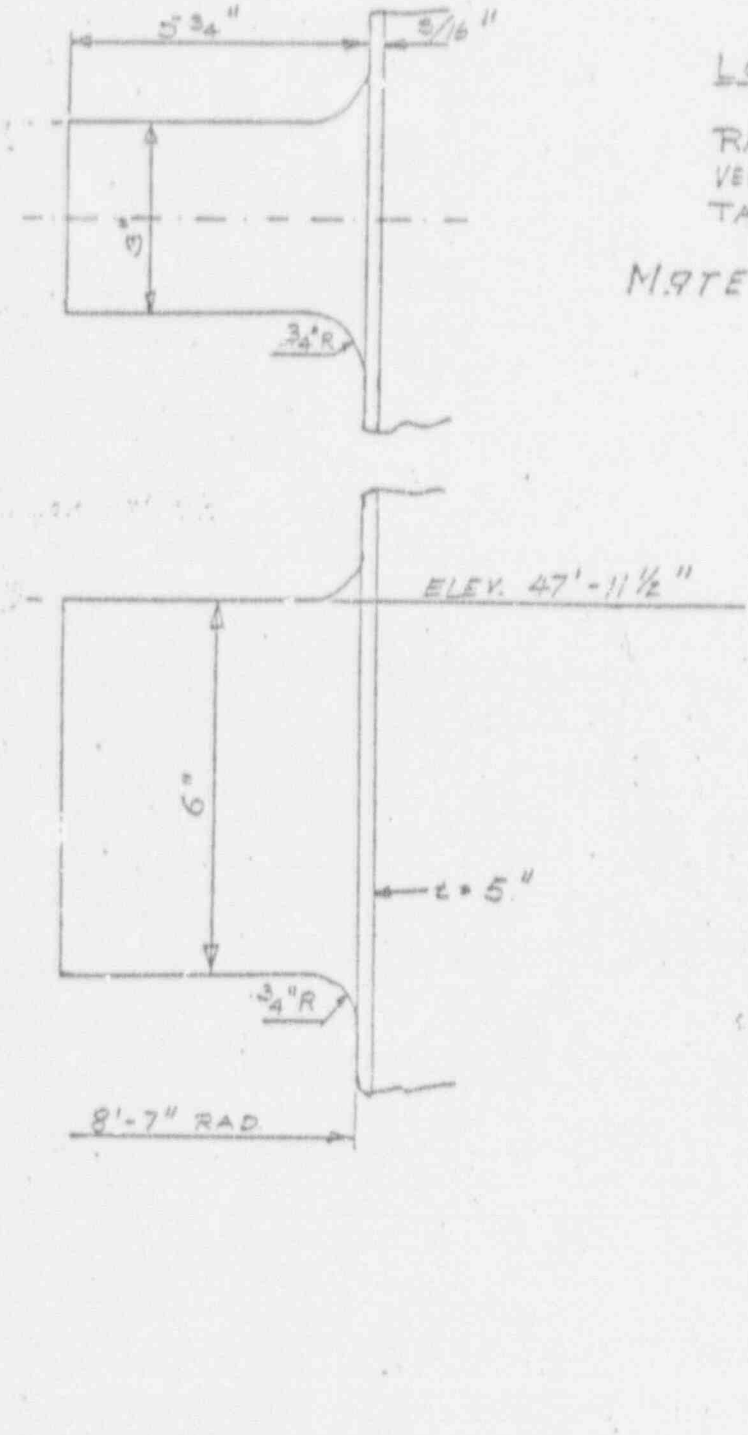
E. - STEAM DRYER SUPPORT BRACKETS

E.1 BRACKET ANALYSIS

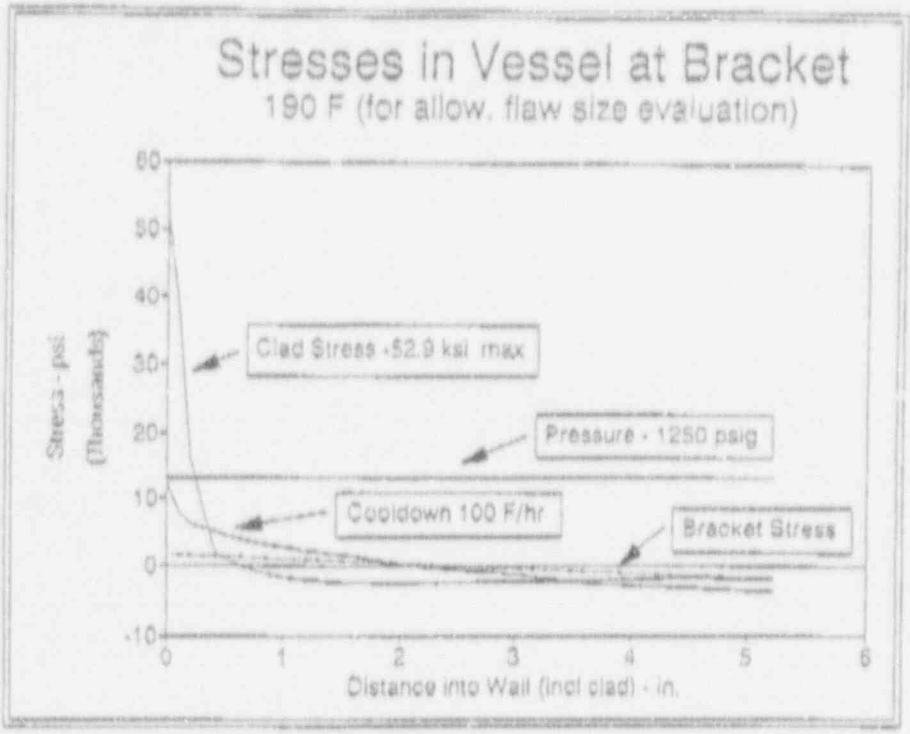


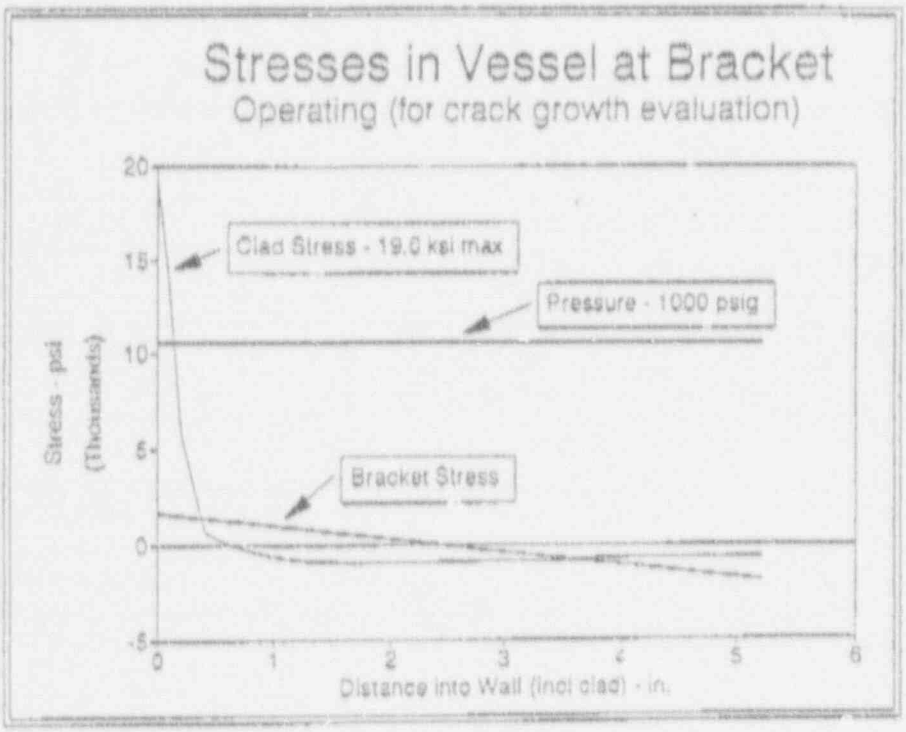
LOADING:

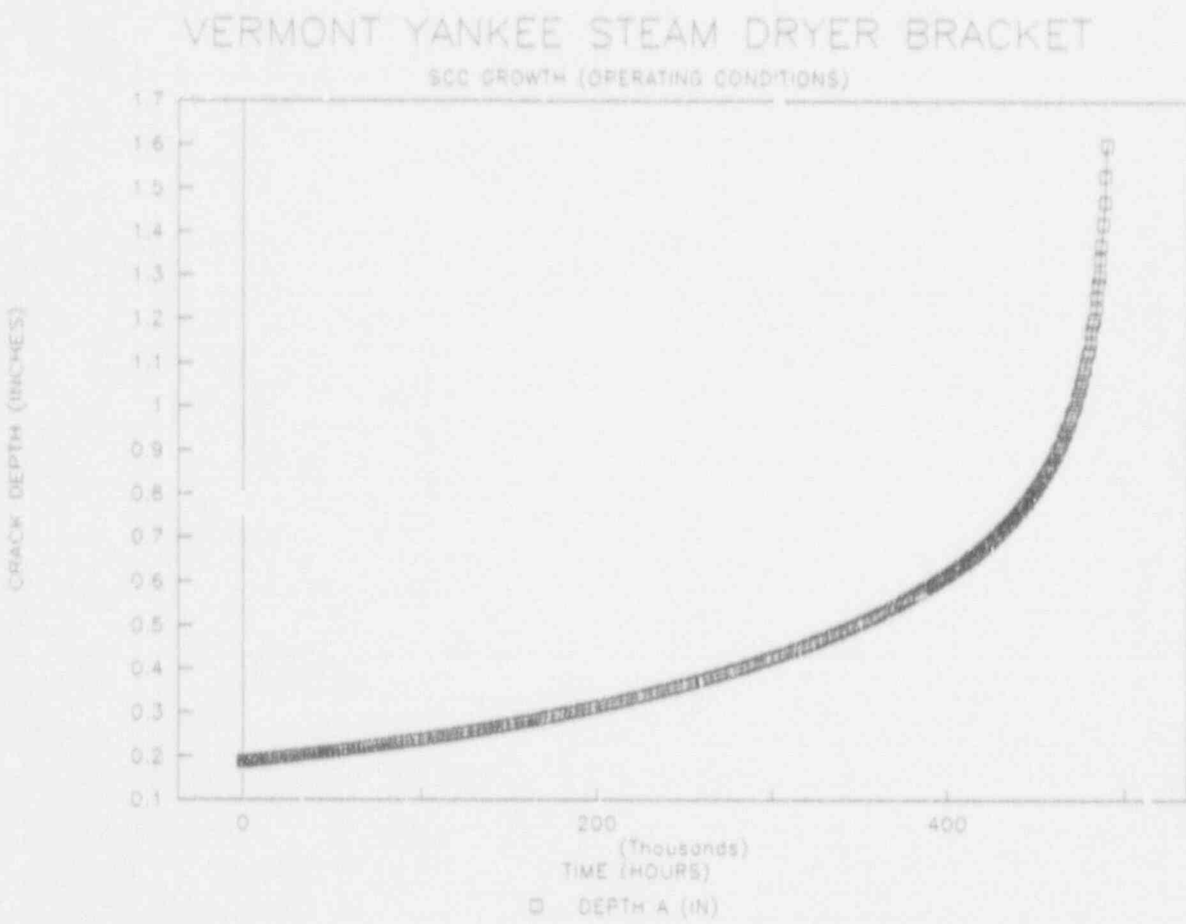
RADIAL	: 13 KIPS	= P	
VERTICAL DOWN	: 31 KIPS	$= V_L$	1
TANGENTIAL	: 8 KIPS	$= V_c$	

MATERIAL : SA 240 TYPE 304

I-S18-13


Stresses in Vessel at Bracket
190 F (for allow. flaw size evaluation)
Stress - psi (Thousands)
Clad Stress -52.9 ksi max
Pressure - 1250 psig
Cooldown 100 F/hr
Bracket Stress
Distance into Wall (incl clad) - in.


Stresses in Vessel at Bracket
Operating (for crack growth evaluation)
Stress - psi (Thousands)
Clad Stress - 19.0 ksi max
Pressure - 1000 psig
Bracket Stress
Distance into Wall (incl clad) - in.



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STRUCTURAL INTEGRITY ASSOCIATES, INC.

Report on Ultrasonic Evaluations

of

Reactor Vessel Cladding Indications

at the

Vermont Yankee Nuclear Power Station

BACKGROUND

The Vermont Yankee reactor head is 54 feet in circumference on the ID and is 3.5 inches thick in the orange peel sections and 3 inches thick at the dollar plate. The stud holes are 24 1/8 inches long through the flange. The clad is nominally 3/16 inch thick.

A visual inspection of the internal surfaces of the reactor pressure vessel head was performed on March 17, 1992 in accordance with recommendations in GE SIL No. 539. Numerous areas of rust were noted. These areas were almost exclusively limited to locations of manual cladding. Some of the areas of rust could be associated with visual linear indications. The majority of the rust marks are on the flange area with a long indication at the manual to machine clad weld interface. Approximately 2/3 of the circumference at that interface is rusted. There are also some indications on the manually clad area of the dollar plate. This area is about five feet in diameter at the top of the head. Most of the rust marks follow the clad weld beads.

DISCUSSION

In an effort to classify these indications, on March 19, 1992, two one foot square areas were penetrant tested. There are also pictures of these penetrant indications. The indications appear to closely resemble the size, frequency, and pattern of the rust areas.

Then an investigation to determine the depth of one of the more significant visible indications was undertaken. About three inches of the indication was excavated by grinding. At steps of 1/16 inch or less in depth, a penetrant test was performed to determine if the indication was still there. As the depth increased, the indication appeared to break up into more numerous finer indications and grew tighter and more diffuse. At a depth of almost 3/16 inch, the indication had almost disappeared, except for some very faint areas, which upon closer inspection appeared to be tight craze cracking, all still within the cladding.

In the meantime, various areas (about two square feet total) were ultrasonically tested (UT) with a dual 60 degree angle 2(1/2x1inch) longitudinal wave search unit with a 0.5 inch focal depth from the inside clad surface. This technique performed very well. About a dozen reflectors were noted which appeared to be associated with rust indications. These ranged in depth from 0.15 to 0.20 inch in depth. This would correspond to the thickness of the cladding within the tolerance of the ultrasonic technique and the manual cladding process.

One end of the crack which had not been excavated was then checked with the above ultrasonic technique and was found to be 0.20 inches at that location.

On March 30, 1992, a further investigation of the clad cracking was performed in an effort to better document the number and size of the indications. Eight areas around the inside of the vessel head 45 degrees apart were selected. These areas were each 30 inches high by six inches wide. The 30 inches corresponds to the height of the manually laid clad area from the flange mating surface up to the first machine clad weld bead. This area had the vast majority of the visible rust indications.

For each area a rough approximation of the number of rust indications was made, along with a rough approximation of the total length of these indications within that area. Pictures were taken of each area. Then 100% of the indications within each area were examined with the SIL recommended ID ultrasonic technique. The results of this exam are tabulated below. The number of ultrasonic reflectors that were able to be sized is reported along with the low (shallowest) and high (deepest) readings within each area.

Azimuth	Number of Indications	Total Length Indications	Number of UT Reflectors	Low UT Reading	High UT Reading
0	22	30"	8	0.10	0.18
45	44	45"	3	0.10	0.16
90	23	36"	7	0.10	0.22
135	38	52"	9	0.10	0.20
180	18	23"	10	0.08	0.22
225	15	21"	3	0.10	0.25*
270	23	34"	12	0.10	0.18
315	18	20"	8	0.10	0.18

* This reading included some geometry; at the interface of the manual to machine clad welding there was a lip with some associated undercut that measured 0.04 inches deep.

The high readings tended to be at the manual to machine clad welding interface where the long indication was.

Also 14 inches of a longer indication in the dollar plate was ultrasonically examined from the ID. Reflectors were seen in three locations. Each was 0.22 inches deep. Subsequently, a large part of the dollar plate was scanned from the OD. This inspection revealed seven reflectors which were sized at 0.10 to 0.20 inches deep. The search units used were an FTD 45 degree dual longitudinal wave 2(20x34mm) focused at 50mm and a Megasonic 60 degree dual longitudinal wave 2(1x1inch) focused at 2.75 inches.

Additionally, 28 feet of the flange to head weld area was tested from the OD. This inspection revealed three indications that were sized at 0.10 to 0.20 inches deep. However, this examination did not cover the entire manually clad area on the flange because of the flange geometry.

On April 2, 1992, it was decided to expand the sample on the ID of the reactor head. Four more areas were inspected with the dual 60 degree longitudinal wave search unit. Again, the areas were six inches wide by 30 inches high and were directly to the right of the 0, 90, 180, 270 degree azimuth locations inspected previously. The readings are as follows:

Azimuth	Number of Indications	Total Length Indications	Number of UT Reflectors	Low UT Reading	High UT Reading
0	26	30"	13	0.08	0.20
90	27	40"	10	0.10	0.18
180	21	25"	11	0.08	0.22
270	36	40"	8	0.10	0.18

The four steam dryer support lugs on the inside of the reactor pressure vessel were visually inspected in accordance with the VY ISI Program. This video inspection revealed a rust indication on the cladding near the top fillet weld on the lug at azimuth 215. Apparently, rust was bleeding through a clad crack from the vessel base material.

In order to see if this crack propagated into the base material, an ultrasonic inspection was performed from the outside of the vessel. First, a straight beam was used to positively locate the lug. (The vessel wall back reflection disappeared and the back wall of the lug was noted.) Then the area around the lug was interrogated with typical vessel weld inspection search units. These consisted of a 45 degree 1/2 x 1 inch 2.25 Mhz shear wave search unit and a 60 degree 1/2 x 1 inch 2.25 Mhz shear wave search unit. These search units were calibrated in accordance with the ASME Code on the vessel calibration block. Neither of these search units detected any indications that exceeded the clad roll signal.

Then several special search units were used. These are as follows:

Model	Size	Angle	Mode	Focal Distance
RTD	2(20x34)mm	45	Dual Long	40 mm
RTD	2(20x34)mm	60	Dual Long	45 mm
PTD	2(20x34)mm	70	Dual Long	45 mm
Megasonics	2(1.0x1.0)in	60	Dual Long	7 inch
Megasonics	2(1.0x1.0)in	60	Dual Long	2.75 inch

None of the above search units detected any indications that appreciably exceeded the clad roll signal. All of the angle beam search units were able to detect the fillet weld faces. All of the search units were also able to detect the 2% notch through the clad on the 5 1/2 inch thick vessel calibration block with a signal to noise ratio ranging from 3:1 to 10:1. The search unit which displayed the best signal to noise ratio was the 45 degree RTD.

Each search unit was scanned over a large area to compare typical clad noise with the area of interest and to make sure the flaw location was interrogated. Each search unit was also skewed 15 degrees side to side during scanning. There were no scanning restrictions.

The lug area was rescanned with a straight beam to assure that the cladding was not peeling away from the base material. No evidence of this was detected. However, as part of the straight beam examination, it was noted that there was apparent lack of penetration in the original weld root area. This weld discontinuity could not be service related; any stress related flaws would initiate at the weld perimeter. This type of ultrasonic inspection (straight beam from the OD surface) was probably not performed during the construction effort.

On April 2, 1992, the investigation of the rust areas expanded to the ID of the vessel upper shell course and lower flange. Similar rust indications had been seen in this area with the remote visual vessel examination by submarine. By direct visual observation the indications appeared identical, however, the quantity appeared to be less. The longest rust areas were at the interface of the manual to machine clad areas about 2 1/2 feet down from the mating surface. There were also some rust lines in the region that was designed to be machine clad, but there were many ground areas in this region, which may be evidence of manual clad repair.

Ultrasonic readings were taken from the ID in the same manner as on the head. The 32 readings ranged from 0.10 to 0.26 inches deep. The deeper spots were at the manual to machine clad interface. The readings are as follows:

Location Below Flange Surface	Stud Area	Depth Readings (inches)
29"	60-61	.24, .26, .22, .25, .25
36"	57-59	.20
45"	57-59	.20, .18
4"	57-59	.20
30"	54-55	.22, .24, .23
36"	54-55	.20
42"	54-55	.18
4"	47-49	.10
10"	47-49	.15
2"	47-49	.20
8"	47-49	.12
4"	47-49	.15
2"	47-49	.12, .10
8"	47-49	.15
12"	47-49	.12
30"	47-49	.16
46"	47-49	.20
2"	33-36	.12
10"	33-36	.18, .18, .12, .15, .16
36"	33-36	.17

It was decided to reevaluate the reflectors at stud locations 60-61 and 29" down, because they appeared to be deeper than any seen before. The thickness of the cladding in those locations was investigated with a high resolution straight beam search unit. The MSEB 4 dual pitch-catch was able to measure the depth of the clad to base metal interface on the calibration block and also in the vessel. A location was discovered in this reevaluation that was 0.30 inches deep. However, it was found that the cladding varied from 0.20" to 0.32" deep in this area. The results were as follows. Locations are left of the left side of the 0 degree guide rod.

Location	Indication Depth	Clad Interface Depth
24"	0.24"	0.25 - 0.30"
27 1/2"	0.26"	0.24 - 0.27"
31"	0.26"	0.26 - 0.27"
33"	0.26"	0.20 - 0.30"
34 1/2"	0.30"	0.25 - 0.32"
36"	0.25"	0.25 - 0.30"

All of the search units used were capable of discerning the 2% notch in the vessel calibration block with more than adequate signal to noise ratio. The ID technique was applied to the block from the clad side and the notch was sized correctly. This gives a high degree of confidence that indications on the vessel were sized correctly and that none approach the size of the notch. Also, the ID and OD technique sizing results were within the same range.

The investigation techniques, visual, penetrant, and ultrasonic, followed the recommendations of the SIL. It is understood that the ultrasonic techniques were reviewed by the NRC for Quad Cities and were qualified at the EPRI NDE Center by performance demonstration on controlled flaw samples. This is based on a telephone conversation with Commonwealth Edison.

All inspections support the conclusion that the cracking is limited to the clad.

ATTACHMENT B

Interpretation: XI-81-12

Subject: Section XI, Division 1, IWB-2500-1, Category B-N-1, Preservice Examination Requirements for Reactor Vessel Interior, 1980 Edition With Winter 1980 Addenda

Date Issued: December 18, 1981

File: BC-81-593

Question (1): Is it the intent of Section XI, Division 1, 1980 Edition with Addenda through Winter 1980, that the extent of the visual examination VT-3 required in Table IWB-2500-1, Examination Category B-N-1, item B 13.10, is limited to those areas of the interior of the reactor vessel shell and bottom head that are made accessible for examination by removal of components which are normally removed during a normal refueling outage?

Reply (1): Yes.

Question (2): Is the interior of the vessel closure head considered a part of item B 13.10, Examination Category B-N-1, Table IWB-2500-1?

Reply (2): No.