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Date: May 23, 1997

JMHLTR: 97-0063

To: U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Subject: Dresden Nuclear Power Station, Unit 3
Core Shroud Examination Final Results,
Revision 1.
NRC Docket No. 50-249

- References:
- (1) J. M. Heffley (ComEd) to USNRC Letter, Submittal of Core Shroud Inspection Results for Dresden Unit 3, dated May 22, 1997.
 - (2) NRC Generic Letter 94-03, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors".
 - (3) BWRVIP Document GENE-523-113-0894, "BWR Core Shroud Inspection and Evaluation Guidelines," dated September 1994.
 - (4) BWRVIP Document BWRVIP-03, "Reactor Vessel and Internals Examination Guidelines," dated October 1995.
 - (5) BWRVIP Document BWRVIP-07, "Guidelines for Reinspection of BWR Core Shrouds," dated February 1996.
 - (6) J. S. Perry (ComEd) to USNRC Letter, Submittal of Core Shroud Inspection Plan for Dresden Unit 3, dated May 22, 1996.
 - (7) J. F. Stang (USNRC) to I. Johnson Letter (ComEd), Dresden Nuclear Power Station, Unit 3 - Core Shroud Inspection Plan (TAC No. M96759), dated March 28, 1997.
 - (8) Sargent & Lundy NDIT No: S040-DH-0453 transmitting Calculation CMED-060298, "Flaw Evaluation for Core Plate Support Ring for Unit 3 Core Shroud."

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The purpose of this letter is to supersede in its entirety the letter of May 22, 1997 (Reference 1) transmitting the results of the Unit 3 core shroud inspection. Due to an administrative oversight, typographical errors were inadvertently made in Attachment 1 and Table 1 to the reference letter.

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This letter, then, provides the final results of the Unit 3 core shroud examinations. The examinations were performed in conjunction with the comprehensive shroud repair to assure that structural integrity of the core shroud is maintained. The examinations of the reactor core shroud were performed in accordance with ComEd's submittal of the Core Shroud Inspection Plan for Dresden Unit 3 [Reference (6)] and Boiling Water Reactor Vessel Internals Project (BWRVIP) guidelines in References (3), (4), and (5). The examinations were completed on April 28, 1997.

The examinations of the core shroud consisted of ultrasonic examination (UT) and enhanced visual examination (EVT-1) of the shroud vertical welds, along with enhanced visual examination of the ring segment welds and remaining design reliant welds and structures. The ultrasonic examinations were performed in accordance with the BWRVIP "Standards for Ultrasonic Examination of Core Shroud Welds" and the visual examinations were performed in accordance with the BWRVIP "Standards for Visual Inspections of Core Shrouds." Additionally, eddy current and ultrasonic examinations were used as aids in identifying the location of ring segment welds associated with the shroud head flange ring, the top guide support ring, and the core plate support ring.


In light of the recent industry experience with extensive shroud vertical weld cracking, ComEd opted to significantly expand the initial examination scope over that proposed in the Reference (6) Inspection Plan and approved by the NRC Staff in Reference (7). In the original inspection plan, ComEd committed to performing enhanced visual examination of 25% of the equivalent length of all vertical welds from either the inner diameter (ID) or outer diameter (OD) surface, along with enhanced visual examination of 25% of the ring segment welds from all accessible surfaces. The expanded examination scope, included ultrasonic and enhanced visual examination of the accessible length of each shroud vertical weld (12 total) from the shroud OD, along with enhanced visual examination of each ring segment weld (16 total) from all accessible surfaces.

As detailed in Attachment 1, the examinations of the core shroud design reliant structures performed at Dresden Unit 3 resulted in no indications of cracking that compromise the structural integrity of the core shroud design reliant structures.


Future examinations and evaluations of the Dresden Unit 3 core shroud design reliant structures will be performed per the schedules and methods specified in the latest revision of the BWRVIP Document BWRVIP-07, "Guidelines for Reinspection of BWR Core Shrouds," in effect six months prior to the scheduled start date for the outage in which the examinations and evaluations will take place.

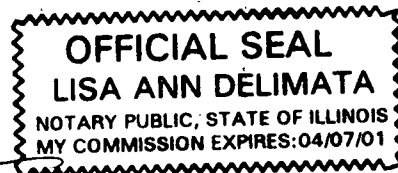
If there are any questions concerning this matter, or need for further clarification, please contact Mr. Frank Spangenberg, Regulatory Assurance Manager, at (815) 942-2920, extension 3800.

Sincerely,


for J. M. Heffley
Station Manager
Dresden Nuclear Power Station

Subscribed and Sworn to before me
on this 23 day of
May, 1997.


Notary Public



- Attachments:
- Table 1 - Dresden Unit 3 Core Shroud Examination Summary
 - Figure 1 - Dresden Unit 3 Core Shroud Examination Roll Out
 - Figure 2 - Core Plate Support Ring Vertical Cracking (Typical)
 - Attachment 1 - Dresden Unit 3 Core Shroud Examination Final Results
 - Attachment 2 - GE Nuclear Energy - Root Cause Evaluation of Core Plate Support Ring Vertical Cracking

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- cc:
- A. Bill Beach, Regional Administrator - RIII
 - W. J. Kropp, Branch Chief - RIII
 - J. F. Stang, Project Manager - NRR
 - Senior Resident Inspector - Dresden
 - Office of Nuclear Facility Safety - IDNS

ATTACHMENT 1

DRESDEN UNIT 3 CORE SHROUD EXAMINATION FINAL RESULTS

The following is a summary of the core shroud examination scope and results. Details of the specific areas examined and the results of the examinations are presented in Table 1 and Figure 1.

- The ultrasonic examination scope consisted of shroud vertical welds V5 through V7 (located between the H1 and H2 circumferential welds), V14 through V19 (located in the beltline region between circumferential welds H3 and H5), and V26 through V28 (located between circumferential welds H6 and H7). A total of 551 inches of the 760 inches of total cumulative vertical weld length (or 72.5%) was examined by at least one search unit from one side of the weld. Individual UT length coverage of all 12 vertical shroud welds ranged from between 34% and 96% per weld. These examinations resulted in no reportable indications.
- The enhanced visual examination scope consisted of the ring segment welds associated with the shroud head flange ring (V1 through V4), top guide support ring (V8 through V13), and core plate support ring (V20 through V25); the H8 and H9 circumferential welds at the shroud repair hardware locations; and the OD surface of all 12 vertical shroud welds on the side of the weld opposite from the UT search unit. These examinations resulted in no reportable indications in the area of interest.

However, circumferential cracking associated with the H2, H3, and H5 welds, as well as vertically oriented cracking in the vicinity of the V23 and V25 core plate ring segment welds was identified during performance of the ring segment weld examinations. The H2, H3, and H5 welds were not part of the core shroud examination scope per the Reference (6) Inspection Plan, because the installed comprehensive shroud repair was designed to structurally replace circumferential shroud welds H1 through H7. Therefore, the observed circumferential cracking has no adverse impact on core shroud structural integrity.

The vertically oriented cracking identified in the vicinity of the V23 and V25 ring segment welds was contained in an area of heavy localized grinding on the OD surface of the ring. The cracking is confined to this area of localized grinding and branches down from the circumferentially oriented cracking in the lower heat affected zone (HAZ) of the H5 weld (see Figure 2).

It is important to note that the ring segment welds cannot be identified visually, as all surfaces of the ring were machined after the six individual segments were welded together. As a result of this machining process, heavy circumferential machining grooves are evident on the majority of the ring surface, except where localized grinding was performed. In order to verify the location of the ring segment welds, eddy current examination was performed and a review of archived OD tracker ultrasonic examination data from the D3R13 outage was reviewed. The archived UT data for the top guide and core plate support rings very clearly showed areas of high attenuation (signal from fillet weld was lost) at 6 locations spaced 60 degrees apart, which is consistent with the lengths for the individual ring segments. The azimuthal location for each of these ring segment welds was identified and then the areas identified were cleaned and inspected using enhanced visual examination. Because the ring segment welds cannot actually be seen, the examination of each weld area included all of the area between two readily discernible landmarks encompassing the azimuth identified for the weld location (i.e., between two jet pump pairs, between two shroud head bolt lug sets, etc.).

TABLE 1

DRESDEN UNIT 3 CORE SHROUD EXAMINATION SUMMARY

Component	Area Inspected	Inspection Results
Shroud Head Flange Ring Segment Welds: V1 Through V4	Enhanced visual examination of ~ 6" to 12" length of ring material encompassing each weld. Inspected OD, ID and top of ring.	No Reportable Indications
Top Guide Support Ring Segment Welds: V8 Through V13	Enhanced visual examination of ~ 6" to 12" length of ring material encompassing each weld. Inspected OD and ID of ring.	No Reportable Indications in Area of Interest
Core Plate Support Ring Segment Welds: V20 Through V25	Enhanced visual examination of ~ 6" to 12" length of ring material encompassing each weld. Inspected OD of ring. Supplemental UT examination of V23 and V25	See Note 1
Vertical Welds V5 Through V7 (Between H1 & H2)	Ultrasonic examination of between 34% and 69% of the length of each weld. Enhanced visual examination of entire weld length from shroud OD on side of weld opposite of UT search unit.	No Reportable Indications
Vertical Welds: V14 Through V19 (Beltline Area)	Ultrasonic examination of between 40% and 95% of the length of each weld. Enhanced visual examination of entire weld length from shroud OD on side of weld opposite of UT search unit.	No Reportable Indications
Vertical Welds: V26 Through V28 (Between H6 and H7)	Ultrasonic examination of between 47% and 75% of the length of each weld. Enhanced visual examination of entire weld length from shroud OD on side of weld opposite of UT search unit.	No Reportable Indications
Jet Pump Support Plate to Shroud Support Ring Weld H8	Enhanced visual examination of ~ 12" of weld in area of repair hardware attachments at 4 locations: 20°, 110°, 200°, and 290° azimuths.	No Reportable Indications
Jet Pump Support Plate to RPV Weld H9	Enhanced visual examination of ~ 12" of weld in area of repair hardware attachments at 4 locations: 20°, 110°, 200°, and 290° azimuths.	No Reportable Indications

Note 1: Vertically oriented cracking was identified visually in the vicinity of the V23 and V25 ring segment welds. Supplemental UT sizing provided the following information:

V23 - 2.8 inches in vertical length extending downward from the H5 circumferential weld. Maximum radial through wall depth was 0.50 inches, with average depth between 0.25 inches and 0.40 inches.

V25 - Exact vertical length could not be determined due to shallow depth and flaw orientation, however, the area of flaw length sized was 1.2 inches in vertical length extending downward from the H5 circumferential weld. Maximum radial through wall depth was 0.25 inches, with average depth between 0.15 inches and 0.25 inches.

Supplemental ultrasonic examination was performed on the vertically oriented cracking in these two areas in order to quantify flaw depths and to determine if the cracking was actually associated with the heat affected zones of the V23 and V25 welds, rather than simply an axial component of the H5 circumferential crack that propagated into the heavily ground area of the ring. The flaws were sized as follows:

- V23 - 2.8 inches in vertical length extending downward from the H5 circumferential weld. Maximum radial through wall depth was 0.50 inches, with average depth between 0.25 inches and 0.40 inches.
- V25 - Exact vertical length could not be determined due to shallow depth and flaw orientation, however, the area of flaw length sized was 1.2 inches in vertical length extending downward from the H5 circumferential weld. Maximum radial through wall depth was 0.25 inches, with average depth between 0.15 inches and 0.25 inches.

The UT technique employed was only able to scan a five inch area adjacent to the cracking due to interference with the jet pump mixers. However, these scans did not reveal any evidence of a ring segment weld in the ground areas containing the vertically oriented flaws, although the UT technique should have seen evidence of the weld, if it were present.

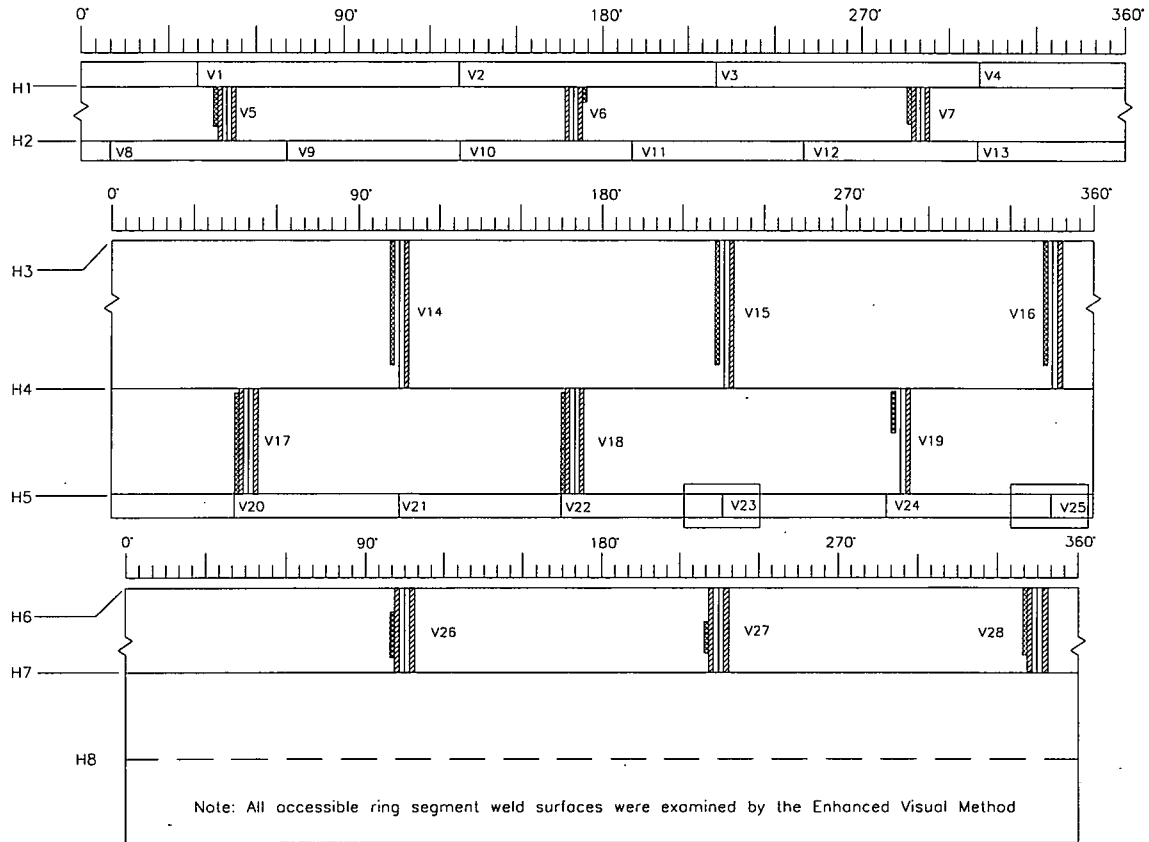
In order to ensure that a ring segment weld would have been identified during the supplemental UT, if it were present, weld material response comparisons were performed utilizing BWRVIP qualification data obtained from UT scans performed on a ring segment weld mock-up, using the same type of search units employed at Dresden Unit 3. The ring segment weld was clearly discernible in this qualification data. This comparison indicates that evidence of a ring segment weld would have been seen if the weld was present in the vicinity of the flaws. Based upon the above, it is believed that the vertically oriented flaws identified in the vicinity of the V23 and V25 ring segment welds are simply axial components of the circumferential cracking contained in the lower heat affected zone of the H5 weld as a result of the surface cold working introduced by heavy localized grinding (see Attachment 2, GE Nuclear Energy - Root Cause Evaluation of Core Plate Support Ring Vertical Cracking).

Additionally, even if it were assumed that the vertically oriented cracking was associated with the V23 and V25 ring segment welds, the radial depth of the cracking is shallow and structural margins are ensured for a minimum of 4 operating cycles after applying a radial crack growth rate of 5×10^{-5} inches per hour. The core plate support ring is 4.0 inches thick with a radial width of 10.68 inches, where only an area of 7.4 square inches of unflawed ligament is required for the ring to maintain full structural integrity under all design basis and beyond events. (Reference 8)

In summary, the examinations of the core shroud design reliant structures performed at Dresden Unit 3, per the Reference (6) Inspection Plan, resulted in no indications of cracking that compromise the structural integrity of the core shroud design reliant structures.

FIGURE 1

DRESDEN UNIT 3 CORE SHROUD EXAMINATION ROLL OUT






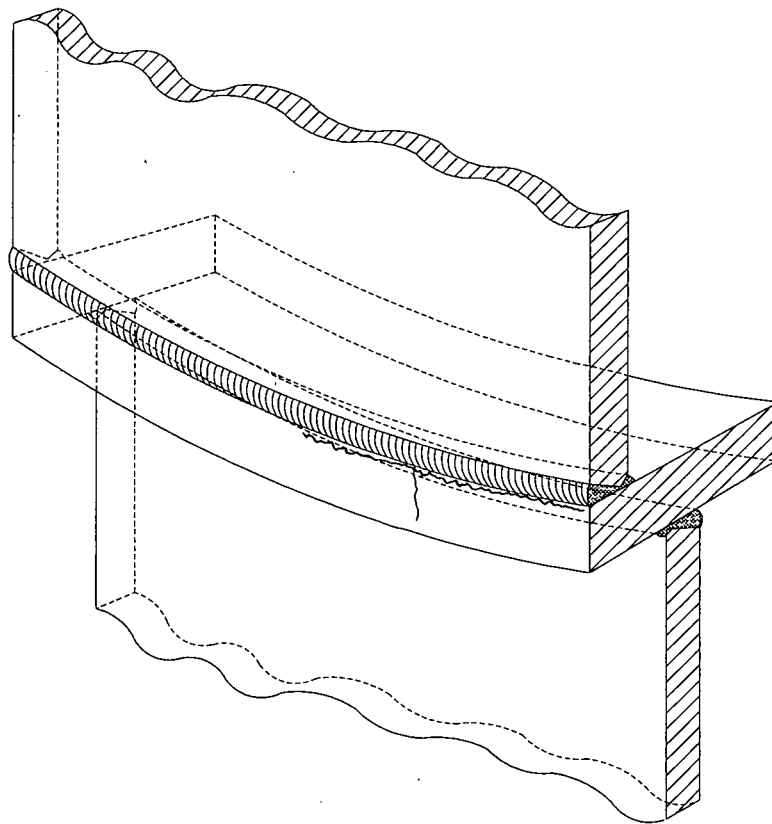
-  Enhanced Visual Examination Area
-  UT Volumetric Examination (Side Examined From)
-  UT Flow Sizing Performed in this Area

FIGURE 2

CORE PLATE SUPPORT RING INDICATION (TYPICAL)



ATTACHMENT 2

GE NUCLEAR ENERGY - ROOT CAUSE EVALUATION OF CORE PLATE SUPPORT
RING VERTICAL CRACKING



May 15, 1997

Mr. G. Whitman
Engineering Programs
Dresden Nuclear Power Station

Subject: Materials Review to Assess Likely Cause of Vertically Oriented Cracking in the Dresden-3 Core Plate Support Ring

Dear Mr. Whitman,

The purpose of this letter report is to document the independent GENE Materials Engineering review that was performed to evaluate the metallurgical factors that were associated with the vertically oriented IGSCC indications found in the Dresden Unit 3 Core Plate Support Ring. The scope of the review included (1) discussion of the indications with ComED engineering personnel, (2) an independent review of the videotape of the IVVI inspection of areas in the vicinity of ring segment welds V23 and V25, (3) a review of the UT Inspection report of the vertical crack indications and (4) a discussion of the UT techniques used in the UT inspection of the visually identified crack indications. The review was performed at your request to develop an understanding of the causes for crack indications based on all the available inspection information.

Background

Examinations were performed at Dresden Unit 3 Nuclear Power Plant in conjunction with the comprehensive shroud repair to assure that structural integrity of the core shroud is maintained. The examinations of the reactor core shroud were performed in accordance with ComEd's commitment to NRC Generic Letter 94-03 and BWRVIP guidelines contained in BWRVIP-01, 03 and 07. The examinations were completed on April 28, 1997. The examinations of the core shroud included enhanced visual examination (EVT-1) and ultrasonic examination (UT) of the shroud vertical welds along with EVT-1 and limited UT of the ring segment welds. For the core plate support ring, the visual inspections were performed at circumferential locations known to be in the vicinity of the ring segment welds based on previous UT inspection of the H5 weld in an earlier outage. The location of the six welds in relation to other readily identifiable landmarks (e.g., jet pumps, shroud lugs) was known and was used as reference for the locations inspected. In two regions, those associated with the location of the V23 and V25 ring segment welds, vertically oriented IGSCC indications were found. A materials

assessment of the findings in the V23 and V25 locations was requested to better understand the causes of cracking.

Independent Assessment

a. Review of the Visual Inspection Videotape

The first evaluation performed was a review of the videotape documenting the visual inspections of the core plate support ring regions in the vicinity of the V23 and V25 ring segment welds. Both areas were visually examined from the bottom of the ring up to and including the H5 weld. Each area will be discussed separately.

V23 Region

This region can be characterized as exhibiting areas of definite grinding. In these regions, grinding marks at differing angles could be easily discerned. Further up, there were also areas of uniform appearance without deep grinding marks. In the entire region, there were none of the distinctive horizontal machining marks that were seen over most of the core plate ring outside surface. These machining marks were observed again at the H5 elevation where they clearly aided H5 crack initiation. The vertical cracking indications are observed over much of the vertical height of the ring (found to be 2.8" in length by UT). All of the cracking had clear IGSCC features: crack branching and non-linear characteristics. While the crack was predominantly vertical in nature, it did exhibit branches to both the left and right of the primary vertical direction. Some of the branches changed direction significantly. At the top of the vertical crack indication, the crack front intersected with the H5 cracking. This H5 crack followed the machining grooves to the right of the ground patch and also continued to the left of the vertical indication in the ground area. This cracking would not have been expected if there were a vertical weld seam. The weld material's resistance to IGSCC would retard any crack initiation in most cases, and the cracking would stop.

V25 Region

The visual examination of the V25 region also revealed crack indications. These indications were also associated with ground areas. The grinding marks were very distinct for this location. The cracking was not continuous over the vertical height of the core plate ring. The vertical cracking length (with UT showing that the detectable flaw length being 1.2 inches) extended downward from the H5 circumferential weld. This cracking also had clear IGSCC features: crack branching and non-linear characteristics.

b. Review of the UT Inspection Processes and Inspection Results

Following the visual detection of crack indications, efforts were undertaken to perform UT examination of the indications. These inspections were able to size the length and depth of cracking and to interrogate the material for evidence of the V23 and V25 welds. The inspections established that the cracks were shallow. For the V23 location the indication depths were measured to be between 0.25 and 0.4" except at the H5 intersection where the depth was measured to be 0.5". For the V25 location the depths were evaluated to be generally less than 0.25". These depths were less than the depths observed for the circumferential H5 cracks.

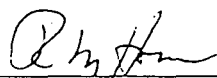
The UT examinations performed were also able to assess whether the cracking was definitively associated with a weld. The UT made use of evaluation techniques that had been used to identify ring segment welds at the EPRI NDE Center. The ring segments at Dresden Unit 3 were similar in geometry to the EPRI mockup and the core shroud inspection employed the same type of search units. The suction cup scanner that was used was able to volumetrically inspect a region of ~2.5" on either side of the crack to size the indications as well as detect signal changes due to the presence of weld metal. The UT examination at both locations did not find any evidence of weld metal. The absence of a weld metal signature was in contrast to the examinations performed with the same procedures and search units in the EPRI mockup examinations. There the weld was detected. This information supports the visual inspection results and is consistent with IGSCC that has initiated due to surface cold work. It should be noted that the UT examinations did not cover the entire regions and therefore did not positively locate the actual ring segment weld.

c. Consideration of Other Factors

There are other factors that could also be considered in assessing the most likely contributors for initiation of the shallow crack indications. First, the depth of the cracking, except near the intersection of the H5 weld, was shallow. The plant has operated for a significant time (>15 years) thereby providing ample time for any HAZ cracking to deepen beyond the surface to a depth where the residual stress driving force would become compressive. The maximum depth of HAZ cracking is often found to be deeper than 0.5". This is consistent with the depths found for the H5 cracking in the azimuth near the V25 location. The shallower crack depth is consistent with surface cold work as being the driving force for crack initiation. It is well known that cold work can be an important contributor to crack initiation. Surface grinding that produces measurable surface hardening has been shown to initiate IGSCC in both the laboratory as well as in the field. Finally, the type of surface grinding along the vertical length of core plate support ring could be indicative of removal of handling attachments used in the fabrication and installation of the core internals. This type of surface attachment along with its subsequent removal would certainly introduce grinding and surface residual stresses that could result in initiation of shallow cracking of the type observed.

Discussion and Conclusions

Austenitic stainless steels susceptibility to IGSCC crack initiation are influenced by several factors. The most common contributors in un-creviced geometries are HAZ sensitization due to welding and surface cold work. For the two locations in the core support plate ring with vertical crack indications, many of the surface features support the case that this cracking is associated with localized grinding leading to cold working which in turn served to initiate IGSCC. These features include the visual appearance of the surface, some of the branching characteristics of the crack and the UT measured crack depths. The other important factor that supports this mechanism for crack initiation is the apparent absence of a vertical weld in the area of cracking. Without a weld, there is no ring segment HAZ that would have led to sensitization. The absence of a weld is based on the UT examination which did not show the presence of a weld. This examination technique has been shown to be effective in detecting ring segment welds with no weld crown. The absence of a weld is also supported by the behavior of the H5 crack which traveled through the ground region in the V23 region. Based on this information, it is reasonable to conclude that these crack indications were initiated by cold working and surface condition and were not located in the weld sensitized HAZ associated with the core plate ring segment welds.

Prepared by 

R. M. Horn, Engineering Fellow: Materials Technology

Reviewed by: 

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Approved by: 

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