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# Volume 2
# Flaw Evaluation and Repair Design Report
# Fall 1988 Refueling Outage
# Dresden Nulear Power Plant Unit 2

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ABSTRACT

An extensive ultrasonic (UT) examination program during the Fall 1988 Dresden Unit 2 refueling outage revealed the presence of IGSCC flaw indications in a number of susceptible austenitic stainless steel welds. Volume 1 of this report demonstrated that the flawed pipe analysis and weld overlay repair design in support of these UT flaw indications meets the requirements of Generic Letter 88-01, NUREG-0313, Revision 2 and agreements between the U. S. Nuclear Regulatory Commission and Commonwealth Edison.

This volume provides a reconciliation of the as-built dimensions, examination results and shrinkage effects resulting from the application of these weld overlay repairs.

Dresden Unit 2 has implemented hydrogen water chemistry (HWC) since 1983. The presence of the IGSCC flaw indications observed in these examinations is under investigation by Commonwealth Edison and others in the nuclear power industry and is outside the scope of this report.

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## 1.0 INTRODUCTION

Extensive ultrasonic (UT) examinations of austenitic stainless steel welds potentially susceptible to intergranular stress corrosion (IGSCC) were performed during the Fall 1988 Dresden Unit 2 refueling outage. As a result of these examinations, IGSCC or IGSCC-like flaw indications were evaluated in several stainless steel welds in the recirculation and reactor water cleanup (RWCU) systems. The details of the flaws and the evaluations and repair designs are contained in References 1 and 2. The flaws evaluated are shown for reference in Table 1-1 [1].

With the exception of weld PD1A-D14 (28-inch recirculation), weld overlay repairs were designed for all of the flawed welds, including the build-up of three (3) existing leakage barrier weld overlays to a "standard" design basis.

Volume 1 of this report [1] provided:

- the results of the detailed analysis of weld PD1A-D14 which justified continued service in accordance with Generic Letter 88-01 [3] and NUREG-0313, Revision 2 [4], and
- the design bases, stress data and the detailed design dimensions for the weld overlay repairs which were applied during this refueling outage.

Volume 2 provides the data and analytical results which reconcile the as-built weld overlay dimensions and as-measured axial shrinkage with the designs [1]. This volume is organized into several sections as follows:

Section 2 of this volume demonstrates that the as-built dimensions of the weld overlay repairs meet the designs provided in Reference 1.

Section 3 provides the results of the nondestructive examinations (NDE) of the weld overlay repairs, both the preservice examination of those applied this outage and the inservice inspection of the previously applied weld overlay repairs.

Section 4 provides the results of stress analyses on the recirculation and RWCU systems which evaluate the effects on these systems of the as-measured weld overlay axial shrinkages.

Section 5 provides recommendations for specific actions required for long term service for some of the weld overlays applied during the Fall 1988 refueling outage.

TABLE 1-1

Dresden Unit 2
Flaw Characterization - Fall 1988 Refueling Outage

| Weld Number | Size NPS | Configuration | Flaw Characterization |
|---|---|---|---|
| Recirculation System | | | |
| PD1-D16 | 12 | Elbow - Pipe | 2 axials (max. depth 33%) |
| PD1/L2 | 12 | Reducer - Pipe | 3 axials (max. depth 87%) |
| PD2-D5 (Note 1) | 12 | Elbow - Pipe | 2 circumferentials (1" x 25% and 1" x 20%)<br>5 axials (max. depth 63%) |
| PD3-D1 | 12 | Elbow - Pipe | 4 axials (max. depth 76%) |
| PD4-D22 | 12 | Elbow - Pipe | 7 axials (max. depth 83%) |
| PD5-D20 (Note 1) | 12 | Elbow - Pipe | 2 circumferentials (2.4" x 20% and 0.6" x 25%)<br>23 axials (max. depth 92%) |
| PD5-D21 | 12 | Elbow - Pipe | 5 axials (max. depth 43%) |
| PD6-D18 | 12 | Elbow - Pipe | 1 axial (max. depth 70%) |
| PD7-D12 | 12 | Elbow - Pipe | 2 axials (max. depth 64%) |
| PD8-D9 | 12 | Elbow - Pipe | 2 axials (max. depth 77%) |
| PD8-D10 | 12 | Elbow - Pipe | 8 axials (max. depth 76%) |
| PD9-D7 | 12 | Elbow - Pipe | 4 axials (max. depth 80%) |
| L1-D24 | 22 | Header - End Cap | 3 circumferentials - (Total 15-1/2" x 35% max.)<br>6 axials (max. depth 83%) |
| L5-D3 | 22 | Header - End Cap | 8 axials (max. depth 87%) |

TABLE 1-1
(continued)

Dresden Unit 2
Flaw Characterization - Fall 1988 Refueling Outage

| Weld Number | Size NPS | Configuration | Flaw Characterization |
|---|---|---|---|
| PD1A-D14 (Note 2) | 28 | Elbow - Pipe | 1 circumferential (1" x 10%) |
| Reactor Water Cleanup (RWCU) System | | | |
| 8-K12 | 8 | Elbow - Pipe | 1 circumferential (2" x 35%)<br>1 axial (max. depth 45%) |
| 8-14 | 8 | Elbow - Pipe | 4 circumferentials (Total 16" x 73% max.)<br>1 axial (max. depth 31%) |
| 8-K14 | 8 | Elbow - Pipe | 1 axial (max. depth 81%) |
| 8-15 | 8 | Elbow - Pipe | 1 circumferential (3.5" x 48%) |
| 8-K15 | 8 | "5D Bend" - Pipe | 3 circumferentials (4" x 85%, 1.5" x 81%, and 1" x 42%)<br>2 axials (max. depth 81%) |
| 8-K16 | 8 | Elbow - Pipe | 2 circumferentials (1-3/4" x 44% and 2" x 52%) |
| 8-K17 | 8 | Elbow - Pipe | 1 circumferential (3" x 48%)<br>2 axials (max. depth 66%) |

Notes:

(1) Reported as flawed from previous examinations

(2) No significant change from previous examination results

## 2.0 RECONCILIATION OF DESIGN AND AS-BUILT WELD OVERLAY DIMENSIONS

### 2.1 Weld Overlay Dimensions

Eleven (11) new "standard" design basis weld overlay repairs (five in the recirculation system and six in the RWCU system) were applied, and three (3) existing weld overlay repairs were built-up to "standard" design during the Fall 1988 Dresden Unit 2 refueling outage. In addition, several leakage barrier weld overlay repairs were applied. All overlays were designed using the requirements of Generic Letter 88-01 [3] and NUREG-0313, Revision 2 [4], with two exceptions. These being:

- Two-layer leakage barrier weld overlays were applied to those welds which contained only axial flaw indications. In the case of weld L5-D3 (22-inch recirculation header-to-end cap), the additional requirement for a minimum of two (2) unrepaired layers was invoked.

- As additional work is planned for the leakage barrier weld overlays in a subsequent refueling outage, bonding ultrasonic (UT) and liquid penetrant (PT) examinations were performed on the leakage barrier weld overlay repairs.

The design bases, analyses and dimensions of the weld overlay repairs which were applied and/or built-up during the Fall 1988 refueling outage were reported in Volume 1 [1].

### 2.2 Comparison of As-built and Design Dimensions

The design and as-built weld overlay repair dimensions are summarized in Table 2-1. In all cases, the as-built thickness of the weld overlay repairs met or exceeded the design dimensions, as explained below.

The as-built widths in four cases were only slightly less than the design dimensions. As previously noted, a "standard" weld overlay repair design was specified and later revised to a "leakage barrier" design in some cases. In one case (PD7-D12), the welding had progressed sufficiently such that the thicker "standard" design thickness, and therefore a slightly narrower weld overlay, was applied. In the remaining welds, the width is also sufficient for structural considerations, and is believed to be sufficient for the performance of UT examinations. These weld overlays would require additional welding only if required to successfully perform UT examinations at a later date.

Table 2-1

Dresden Nuclear Power Plant - Unit 2
Fall 1988 Refueling Outage

As-built Weld Overlay Data

| Weld Number | Design Bases | Thickness Design | Thickness As-built | Width Design | Width As-built |
|---|---|---|---|---|---|
| **12-inch Recirculation Riser Welds** | | | | | |
| PD5-D20 | Standard | 0.21 | 0.40 | 4.5 | 5.00 |
| PD2-D5 | Standard | 0.25 | 0.32 | 4.5 | 4.88 |
| PD19-D13 | Standard | 0.23 | 0.33 | 4.5 | 4.84 |
| PD2-D4 | Standard | 0.24 | 0.35 | 4.5 | 4.72 |
| PD3-D2 | Standard | 0.24 | 0.40 | 4.5 | 4.97 |
| PD7-D12 | L.B. | 2 layer | 0.37 | 5.0 | 4.69 |
| PD3-D1 | Standard | 0.22 | 0.39 | 4.5 | 4.71 |
| PD5-D21 | L.B. | 2 layer | 0.13 | 5.0 | 5.44 |
| PD1-D16 | L.B. | 2 layer | 0.11 | 5.0 | 4.98 |
| PD6-D18 | L.B. | 2 layer | 0.17 | 5.0 | 5.17 |
| PD9-D7 | L.B. | 2 layer | 0.14 | 5.0 | 5.08 |
| PD4-D22 | Standard | 0.22 | 0.22-0.40 | 4.5 | 4.55 |
| PD8-D9 | L.B. | 2 layer | 0.11 | 5.0 | 5.53 |
| PD8-D10 | L.B. | 2 layer | 0.12 | 5.0 | 5.82 |
| PD1/L2 | L.B. | 2 layer | 0.18 | (1) | 4.06 |

Table 2-1
(Continued)

Dresden Nuclear Power Plant - Unit 2
Fall 1988 Refueling Outage

As-built Weld Overlay Data

| Weld Number | Design Bases | Thickness Design | Thickness As-built | Width Design | Width As-built |
|---|---|---|---|---|---|
| L1-D24 | Standard | 0.36 | 0.40-0.53 | 4.7(2) | 4.88 |
| L5-D3 | L.B. (3) | (3) | 0.175 | 5.3(4) | 5.34 |
| **8-inch Reactor Water Cleanup Welds** | | | | | |
| 8-K15 | Standard | 0.19 | 0.34 | 4.0 | 4.59 |
| 8-K17 | Standard | 0.22 | 0.33 | 4.0 | 4.00 |
| 8-K12 | Standard | 0.22 | 0.26 | 4.0 | 3.81 |
| 8-15 | Standard | 0.20 | 0.28-0.42 | 4.0 | 3.97 |
| 8-K14 | L.B. | 2 layer | 0.24 | 3.0 | 4.37 |
| 8-14 | Standard | 0.19 | 0.28 | 4.0 | 5.34 |
| 8-K16 | Standard | 0.19 | 0.23 | 4.0 | 4.36 |

Notes:

(1) 2.5 inches on riser side, blend into reducer on other side
(2) 2.7 inches on header and 2.0 inches on end cap
(3) A minimum of two (2) unrepaired layers
(4) 3.0 inches on header and 2.3 inches on end cap

## 3.0 WELD OVERLAY EXAMINATIONS

### 3.1 Introduction

Nondestructive examinations (NDE), such as visual (VT), liquid penetrant (PT) and ultrasonic (UT) examination and other in-process measurements/tests are performed prior to, during and after the process of applying weld overlay repairs. These examinations are intended to confirm a clean, sound weld metal deposit, assure resistance of the weld overlay to IGSCC and provide controls meant to assure meeting the design requirements of the weld overlay repair.

Prior to welding, the surface of the weldment and the adjacent region is PT examined to detect the presence of any through-wall flaws which might interfere with the weld overlay application. These are repaired (seal welded) prior to weld overlay application.

During the welding operation, particularly the first layers, the weld puddle is visually observed to detect evidence of axial flaws which may penetrate the base metal into the weld deposit. These are manifested as "steam blow-outs" or other weld puddle irregularities.

Visual observation, measurement of the delta ferrite content and determination of the thickness are performed on the first weld overlay layer. If "steam blow-outs" or other weld puddle irregularities are observed, a base metal weld repair is performed. A minimum delta ferrite content of 7.5 FN is required. If this is not achieved, the low delta ferrite layer is "discarded" and the design thickness of the weld overlay is revised.

After completion of the welding and surface conditioning (grinding) to the criteria established by Commonwealth Edison, the weld overlay repair and adjacent base metal are PT examined. For "standard" weld overlay repairs, the completed weld overlay and a portion of the base metal under the weld overlay is UT examined using the methods developed by the EPRI NDE Center. For the two-layer leakage barrier weld overlay repairs, only a bonding UT examination is performed.

## 3.2 Preservice UT Examination Results

The preservice UT examination results for the five (5) "standard" design basis weld overlay repairs and three (3) weld overlay repairs built-up to a "standard" design basis during the Fall 1988 Dresden 2 refueling outage are presented in Table 3-1. Surface conditioning of the "standard" overlays applied this outage for the six (6) RWCU welds was not done at this time because of ALARA and schedule considerations, and possible replacement of this piping at a future outage.

No indications were evaluated in six (6) of the seven (7) 12-inch and the one (1) 22-inch "standard" weld overlay repairs in the recirculation system. Axial IGSCC flaw indications (4), as well as interbead lack of fusion, were evaluated in one (1) weld overlay (PD5-D20). The thickness of this weld overlay is such that the "standard" weld overlay thickness remains in the area of the "deepest" flaw indication, that is the minimum remaining ligament is greater than the "standard" thickness. The interbead lack of fusion has been evaluated per ASME Section XI and is acceptable to the standards of IWB-3514 (Table IWB-3514-2). Repairs to this weld overlay are planned for a future outage.

No IGSCC flaw indications were reported in the other weld overlay material, but an area of lack of bond was observed at the weld overlay/base metal interface of the welds shown in Table 3-2.

This lack of bond is 0.8 square inch or less and is acceptable for continued operation per the acceptance criteria of ASME Section XI (See Table 3-2).

In six (6) of the UT examinations, axial IGSCC flaw indications were evaluated in the base metal under the weld overlay.

### 3.3 Inservice UT Examination Results

Six (6) weld overlay repairs which were applied during previous refueling outages were UT examined during the Fall 1988 refueling outage. All of these repairs are of "standard" design and included four (4) 12-inch weld overlay repairs in the recirculation system and two (2) weld overlay repairs in the RWCU system. The results of these examinations are summarized in Table 3-3.

### 3.4 Other Examinations

Due to ALARA considerations as well as the outage schedule, a two-layer leakage barrier weld overlay design was applied to the welds which contained only axial flaws (See Reference 1). Commonwealth Edison's intent is to build up these weld overlays to a "standard" design basis at a future refueling outage. For these weld overlay repairs, the as-welded surface was prepared for PT and bonding UT examinations.

The final PT examination results for all the weld overlay repairs were acceptable, per the Commonwealth Edison PT procedure and acceptance criteria. Rounded indications were observed in the PT examination of four (4) weld overlay repairs. These indications were ground until removed and weld repaired. The repaired area was PT examined and found acceptable.

A straight beam bonding UT was performed on all weld overlays. Lack of bond was evaluated in four (4) standard weld overlay repairs. A summary of these indications is contained in Table 3-2.

The first layer delta ferrite content of all the weld overlay repairs, with one exception, met the 7.5 FN minimum. Weld overlay repair 8-K14 was between 5 and 7.5 FN. This is a two-layer leakage barrier design and will be built up to a "standard" design thickness, considering this "discarded" layer thickness, in a future refueling outage.

## 3.5 Conclusions

The UT examinations (preservice and inservice) demonstrate the acceptability for continued service of the "standard" weld overlay repairs.

In one weld overlay repair (PD5-D20), axial IGSCC flaw indications extended into the weld overlay. Commonwealth Edison plans to repair this weld overlay in a future refueling outage.

For those two-layer leakage barrier weld overlay repairs applied during the current refueling outage, Commonwealth Edison plans to build up and examine these weld overlays to a "standard" design basis thickness and perform preservice UT at a future outage. These future actions are detailed in Section 5 of this report.

Table 3-1

Ultrasonic Examination Results
Weld Overlay Repairs
Dresden Unit 2 - Fall 1988 Outage

| Weld Number | Ultrasonic Examination Results | | Resolution |
|---|---|---|---|
| | Weld Overlay | Base Material | |
| 12-inch recirculation | | | |
| PD3-D2 | NRI | 4 axials | Acceptable (2) |
| PD19-D13 | NRI | 3 axials | Acceptable |
| PD2-D5 | NRI | 2 axials | Acceptable |
| PD2-D4 | NRI | NRI | Acceptable |
| PD5-D20 | 4 axials (1) | 11 axials | Acceptable (2) (planned to be repaired next outage) |
| PD3-D1 | NRI | 4 axials | Acceptable |
| PD4-D22 | NRI (1) | 4 axials | Acceptable (2) |
| 22-inch recirculation | | | |
| L1-D24 | NRI | NRI | Acceptable (2) |

(1) Interbead lack of fusion acceptable per ASME Section XI also evaluated
(2) Lack of bond also noted

Table 3-2

# Ultrasonic Bonding Examination Results
## Weld Overlay Repairs
## Dresden Unit 2 - Fall 1988 Outage

| Weld Number | Bonding Ultrasonic Examination Results |
|---|---|
| 12-inch recirculation | |
| PD5-D20 | 4 areas total = 1-3/4 sq. in. |
| PD3-D2 | 1 area total = 0.2 sq. in. |
| PD4-D22 | 1 area total = 0.1 sq. in. |
| 22-inch recirculation | |
| L1-D24 | 1 area total = 0.8 sq. in. |

All others have no reportable lack of bond

Table 3-3

Ultrasonic Examination Results
Inservice Inspection of Previously
Applied Weld Overlay Repairs

| Weld | Fall 1988 Results | | |
|---|---|---|---|
| Number | Weld Overlay | Base Metal | Fall 1986 Results [5] |
| 12 inch Recirculation system | | | |
| PD4-D23 | No indication | 8 axials | No indications in WOR |
| PD7-D11 | No indication | No indication | No indications in WOR |
| PD9-D8 | No indication | 1 circumferential & 2 axials | No indications in WOR |
| PD19-D14 | No indication | 1 axial | No indications in WOR |
| 8 inch reactor water cleanup system | | | |
| 8-12 | No indication | 1 circumferential | No indications in WOR |
| 8-K13 | No indication | 1 circumferential | No indications in WOR |

# 4.0 EVALUATION OF WELD OVERLAY SHRINKAGE-INDUCED STRESSES

## 4.1 Introduction

As the weld metal applied during a weld overlay repair solidifies and cools, the weld overlay shrinks axially. This effectively shortens the length of the run of piping in which the repair is situated. This shrinkage produces both axial and bending stresses at other locations in the piping system. Although this stress is a secondary steady state stress of a type not usually addressed by the Code of construction, it can have a predicted effect on the growth of flaws at the stressed locations. In addition, stresses of this type may have some effect on initiation of flaws in unflawed locations. Consequently, it is necessary to evaluate the effects of weld overlay shrinkage-induced stresses on the repaired system as a whole.

## 4.2 Analysis

In order to evaluate these stresses, a finite element model of the recirculation system from the outlet nozzles to the inlet nozzles was developed. The geometry of the model was taken from [6]. The resulting model is illustrated in Figure 4-1. The model was constructed using the commercially available program SUPERSAP [7].

A similar model of the repaired section of the reactor water cleanup system was prepared using the same program. This section of the RWCU system is located inside of the drywell, and is essentially anchored at the shutdown cooling line and the drywell penetration. Consequently, shrinkage in the repaired portion of the RWCU has no effect on stress in the recirculation system. Therefore, the two systems can be treated separately. Figure 4-2 illustrates the RWCU model.

The as-measured weld overlay shrinkages for weld overlays applied during the 1988 outage were taken from the inspection data [5] and applied to the models shown in Figures 4-1 and 4-2. Table 4-1 lists the shrinkages measured during this outage. In addition, shrinkage values for those overlays which were previously applied to the recirculation system were also incorporated into the finite element model of the recirculation system. These prior shrinkages from Reference 5 are shown in Table 4-2.

A static stress analysis of each repaired system was performed. Weld overlay shrinkage was simulated by imposing a pseudo-thermal contraction at each overlay repaired element, with the imposed pseudo-temperature determined from the measured shrinkage. The recirculation system model was conservatively assumed to be rigidly anchored at the two (2) outlet and ten (10) inlet nozzles. The stresses calculated by these analyses are summarized in Tables 4-3, 4-4, and 4-5.

Table 4-3 presents the results for the recirculation system location (PDIA-D14) known to contain a flaw indication which is not weld overlay repaired. Flaw analysis of this location is contained in Volume 1 of this report. In the Volume 1 flawed pipe analysis, the weld overlay shrinkage stress was assumed to be 1000 psi, since as-built data was not available when that report was written. The shrinkage result at the analyzed location, as shown in Table 4-3, is 963 psi, so the Volume 1 analysis [1] is quite representative with respect to the analysis of as-built weld overlay shrinkage stresses.

Table 4-4 presents weld overlay shrinkage stress results for the five highest stressed unrepaired ISI weld locations in the recirculation system, all of which occur in the 12-inch recirculation risers. Table 4-5 lists the stress at the only unrepaired ISI weld location in this run of the RWCU system. The highest shrinkage stress at non-ISI weld locations is only 2.558 ksi in this RWCU piping.

## 4.3 Acceptance Criteria

There are no criteria available for the acceptance of weld overlay shrinkage stresses. The conclusion, based upon the comparison with shrinkage-induced stresses at other plants, is that the shrinkage stresses produced by the weld overlay repairs applied previously and during 1988 do not lead to an unacceptably high stress state in the recirculation or RWCU systems. The flaw analysis documented in Volume 1 is not invalidated by these results, since that analysis of a flawed location assumed a shrinkage stress of 1000 psi, and the actual value at the flawed location is 963 psi.

Table 4-1

Dresden Nuclear Power Plant - Unit 2
Fall 1988 Refueling Outage

As-built Weld Overlay Shrinkage Data

| Weld Number | Shrinkage, in. |
|---|---|
| **12-inch Recirculation Riser Welds** | |
| PD5-D20 | 0.253 |
| PD2-D5 | 0.275 |
| PD19-D13 | 0.016 (1) |
| PD2-D4 | 0.027 (1) |
| PD3-D2 | 0.055 (1) |
| PD7-D12 | 0.301 |
| PD3-D1 | 0.256 |
| PD5-D21 | 0.234 |
| PD1-D16 | 0.195 |
| PD6-D18 | 0.273 |
| PD9-D7 | 0.242 |
| PD4-D22 | 0.26 |
| PD8-D9 | 0.281 |
| PD8-D10 | 0.164 |
| PD1/L2 | 0.188 |
| **22-inch Recirculation End Cap Welds** | |
| L1-D24 | 0.055 |
| L5-D3 | 0.117 |
| **8-inch Reactor Water Cleanup Welds** | |
| 8-K15 | 0.387 |
| 8-K17 | 0.343 |
| 8-K12 | 0.305 |
| 8-15 | 0.367 |
| 8-K14 | 0.297 |
| 8-14 | 0.375 |
| 8-K16 | 0.266 |

Notes:
(1) Additional shrinkage due to weld build-up of existing weld overlay

Table 4-2

Dresden Unit 2
Previous As-built Weld Overlay Shrinkage Data[1]

| Weld Number | Axial Shrinkage (in.) |
|---|---|
| PD4-D23 | 0.234 |
| PD7-D11 | 0.177 |
| PD9-D8 | 0.240 |
| PD19-D14 | 0.240 |
| PD2-D4 | 0.188 |
| PD3-D2 | 0.141 |
| PD19-D13 | 0.266 |

[1] Total of axial shrinkage recorded during Spring 1983 and Fall 1986 outages, Reference 5.

Table 4-3

Weld Overlay Shrinkage-Induced Stress at Flaw Evaluation Location

| Weld Number | Stress (ksi)[1] |
| --- | --- |
| PDIA-D14 | 0.963 ksi |

[1] A value of 1 ksi was assumed in the flaw evaluation presented in Volume 1. This result supports that assumption.

Table 4-4

Weld Overlay Shrinkage-Induced Stresses in Recirculation Risers: Five Unrepaired ISI Weld Highest Stress Locations

| Weld Location | Stress (ksi) |
|---|---|
| PD1-D15 | 13.265 |
| PD6-D19 | 11.099 |
| PD5/L1 | 6.446 |
| PD7/L4 | 5.420 |
| PD8/L4 | 5.326 |

Table 4-5

Weld Overlay Shrinkage-Induced Stresses
in Reactor Water Cleanup System Inside Containment:
Unrepaired ISI Weld Location

| Weld No. | Stress (ksi) |
|---|---|
| 8-16 | 0.626 |

Note: The highest shrinkage stress at other locations (non-ISI weld) in this piping run is 2.558 ksi.

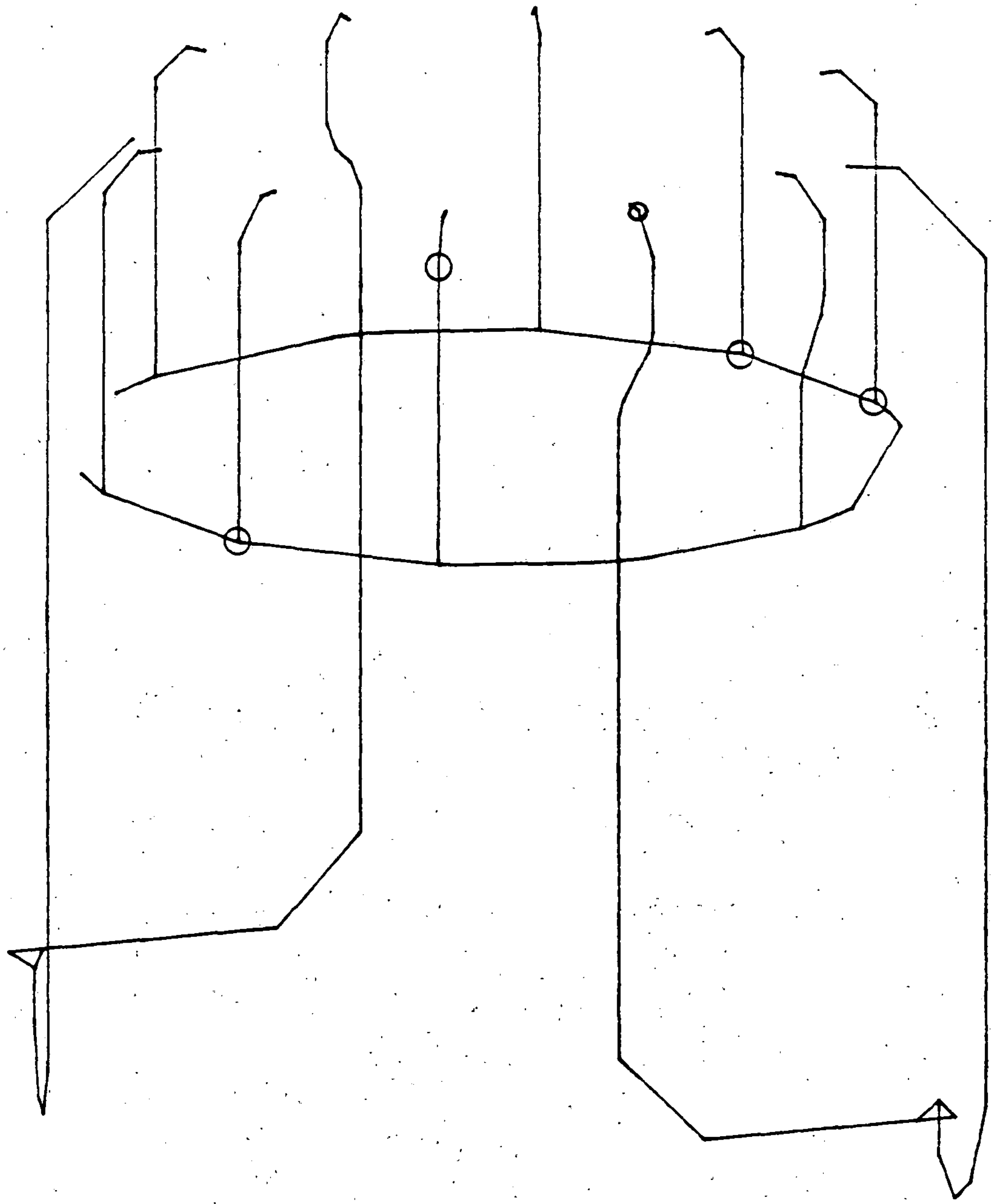

Figure 4-1. Finite Element Model of Dresden Unit 2 Recirculation System, with Five Highest Shrinkage Stress Locations Circled for Unrepaired (No Flaws) ISI Welds

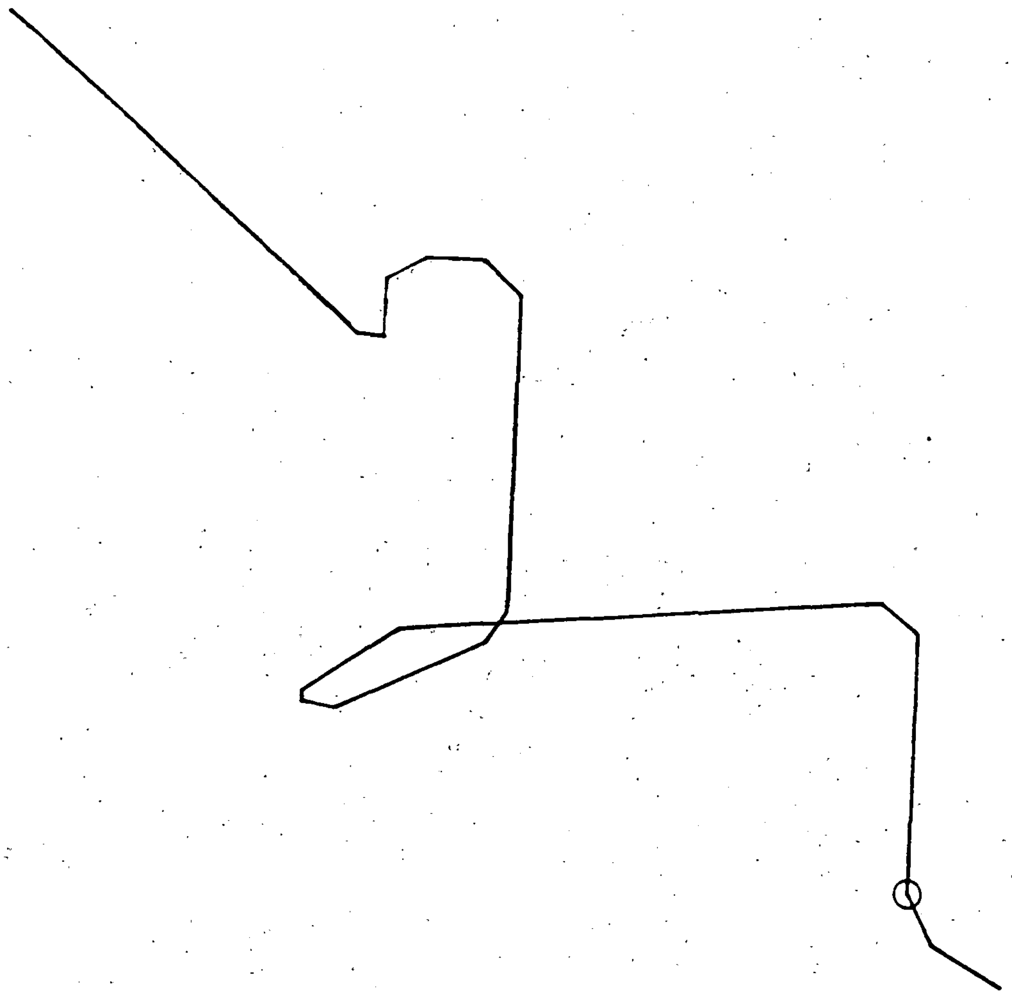

Figure 4-2. Finite Element Model of Dresden Unit 2 RWCU System, Inside Containment, from Shutdown Cooling Piping to Containment Penetration, With the Unrepaired (No Flaws) ISI Weld Location Circled

# 5.0 FUTURE ACTIONS

## 5.1 Introduction

Commonwealth Edison's initial design criteria for weld overlay repairs applied during the Fall 1988 refueling outage required a "standard" design basis [3,4] repair to be applied to all flawed welds 12-inch and under. This design philosophy was implemented in the preparation of weld overlay repair designs for the weld build-up of the three (3) existing 12-inch recirculation riser weld overlay repairs and the two (2) flawed 12-inch recirculation riser welds which were evaluated early in the UT examination program. "Standard" designs were also prepared for the large majority of the recirculation system welds.

As the UT examinations expanded and the extent of the repairs was better known, the outage schedule dictated that a reduced scope of work was required. To this end, discussions were held with the NRC and the design criteria were changed as follows:

- a two-layer leakage barrier weld overlay repair is applied to each weld containing only axial flaws in welds that are 12-inch and under. Note that a standard overlay had already been applied to some welds when this leakage barrier decision was reached (PD3-D1 and PD4-D22).

- For the 22-inch recirculation header-to-end cap weld which contains only axial flaw indications (L5-D3), a minimum of two (2) unrepaired weld overlay layers are required, and

- For all other flawed weldments, the minimum weld overlay thickness shall be the "standard" design basis thickness [2,3].

This section describes the recommended future actions for each of the weld overlays applied during the Fall 1988 refueling outage which will "upgrade" the existing weld overlays to a "standard" design basis in accordance with References 3 and 4.

## 5.2 Recommended Future Actions

To meet the requirements of a long life "standard" weld overlay repair [3,4], a weld overlay must:

- meet the dimensions which comply with the design criteria of References 3 and 4, and

- be suitable for periodic volumetric (UT) examination.

The actions necessary to meet these criteria are summarized in Table 5-1.

In the case of the weld overlay repairs which were applied to the non-isolable portion of the RWCU system, Commonwealth Edison is investigating the option of replacing this portion of the system.

Table 5-1

Dresden Nuclear Power Plant - Unit 2
Fall 1988 Refueling Outage

Weld Overlay Future Actions

| Weld Number | Future Action(s) |
|---|---|
| 12-inch Recirculation Riser Welds (1988 WORs) | |
| PD5-D20 | Needs repairs next outage (flaws in WOR) |
| PD2-D5 | None (1) |
| PD19-D13 | None - 1988 build-up (1) |
| PD2-D4 | None - 1988 build-up (1) |
| PD3-D2 | None - 1988 build-up (1) |
| PD7-D12 | Thick/width = standard design requires "surface" and UT exam |
| PD3-D1 | None (1) |
| PD5-D21 | Build-up to standard |
| PD1-D16 | Build-up to standard |
| PD6-D18 | Build-up to standard |
| PD9-D7 | Build-up to standard |
| PD4-D22 | None (1) |
| PD8-D9 | Build-up to standard |
| PD8-D10 | Build-up to standard |
| PD1/L2 | Build-up to standard |
| 12-inch Recirculation Riser Welds (Previous WORs) | |
| PD4-D23 | None (1) |
| PD19-D14 | None (1) |
| PD7-D11 | None (1) |
| PD9-D8 | None (1) |
| 22-inch Recirculation End Cap Welds (1988 WORs) | |
| L1-D24 | None (1) |
| L5-D3 | Build-up to standard |

Table 5-1
(Continued)

Dresden Nuclear Power Plant - Unit 2
Fall 1988 Refueling Outage

Weld Overlay Future Actions

| Weld Number | Future Action(s) |
|---|---|
| 8-inch Reactor Water Cleanup Welds (1988 WORs) | |
| 8-K15 | "Surface" & UT |
| 8-K17 | "Surface" & UT |
| 8-K12 | "Surface" & UT |
| 8-15 | "Surface" & UT |
| 8-K14 | Build-up to standard (2) |
| 8-14 | "Surface" & UT |
| 8-K16 | "Surface" & UT |
| 8-inch Reactor Water Cleanup Welds (previous WORs) | |
| 8-K13 | None (1) |
| 8-12 | None (1) |

Notes:
(1) Future examinations per NUREG-0313, Rev. 2 required.
(2) Needs additional design considerations due to low delta ferrite weld deposit

## 6.0 CONCLUSIONS

Volume 1 of this report [1] discussed the flaw indications evaluated during the extensive UT examination program during the Fall 1988 Dresden Unit 2 refueling outage, as well as the flawed pipe analysis, weld overlay repair design basis and weld overlay repair design dimensions. This volume:

- compares the as-built dimensions to these design dimensions,
- evaluates the NDE and inspection results from the examination of the weld overlays applied this refueling outage, as well as the inservice inspection results of the weld overlay repairs which were applied in prior refueling outages, and
- evaluates the effects of the axial shrinkage which results from weld overlay application on the affected piping systems.

The conclusions from the dimensional data and evaluations follow.

1. The as-built weld overlay repair thicknesses and lengths are acceptable, in accordance with NUREG-0313, Rev. 2.

2. The preservice UT examination results for the "standard" weld overlay repairs applied during this refueling outage justify acceptability for operation. In one weld overlay (PD5-D20), Commonwealth Edison plans to repair axial flaw indications which penetrate into the weld overlay material in a future refueling outage.

3. The inservice UT examination results of the weld overlay repairs applied in prior refueling outages justify acceptability for continued service.

4. Results of the analyses of the effects of the weld overlay induced axial shrinkages are acceptable. The shrinkage stresses at the highest stressed locations in the recirculation and RWCU systems are typical for such repairs. The shrinkage stress at the 28-inch recirculation system weld PD1A-D14 with an unrepaired flaw indication is below the assumed value used to evaluate this flaw for acceptability.

5. The recommended future actions are consistent with Generic Letter 88-01 [2] and NUREG-0313, Revision 2 [3] and will result in a "standard" design basis weld overlay repair of all flawed welds except the acceptable flawed 28-inch recirculation system weld PD1A-D14.

## 7.0 REFERENCES


1. Structural Integrity Associates, Inc. Report SIR-89-004, Revision 1, " Flaw Evaluation and Repair Design Report Fall 1988 Refueling Outage Dresden Nuclear Power Plant Unit 2 - Volume 1," February 1989.

2. Commonwealth Edison (Mr. J. Silady) Letter to U. S. Nuclear Regulatory Commission (Dr. T. Murley) dated February 6, 1989 "Dresden Nuclear Power Station Unit 2 - Report of Inspections of Stainless Steel Piping in Accordance with Generic Letter 88-01."

3. U. S. Nuclear Regulatory Commission Generic Letter 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping" January 25, 1988.

4. U. S. Nuclear Regulatory Commission NUREG-0313, Revision 2, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," January 1988.

5. Nutech Engineers Report CEC-79-204, Revision 0, "Evaluation and Disposition of Flaws - Dresden Nuclear Power Plant Unit 2 (Fall 1986 Outage)" February 1987.

6. Computer Math Model, CECo Drawing M-1157C-1, Rev. 1, (1983), sh. 1-3.

7. Algor Interactive Systems, Inc., "Software User Guide for Supersap," 1987.

8. Impell stress report, Dresden Unit 2 Recirculation System, Impell Project No. 0590-144, 79-14 Analysis Problem No. D2-RRCI-01C, July 31, 1985.