ATTACHMENT 2

General Electric Company Report GENE-523-28-0294, Revision 1, dated June 1994, Recommended Inspection Criteria for the Dresden 2 and 3 Shrouds.

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GENE-523-28-0294
Revision 1
DRF 137-0010-7
Class II
June 1994

Recommended Inspection Criteria for the Dresden 2 and 3 Shrouds

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IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

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1.0 BACKGROUND

The purpose of this report is to develop inspection criteria for the Dresden Units 2 and 3 shrouds in accordance with recommendations presented in GE Services Information Letter (SIL) Number 572, Revision 1 (SIL 572).

SIL 572 recommends examinations of accessible areas on both the inside diameter (ID) and outside diameter (OD) surfaces of the core shroud at the next scheduled refueling outages for all plants with Type 304 stainless steel shrouds with six or more years of power operation, and for all plants with L-Grade stainless steel shrouds with eight or more years of power operation. Power operation is defined as operation where the reactor is above 200°F. The Dresden 2 and 3 shrouds are fabricated from 304 stainless steel, and each plant has more than 6 years of power operation; therefore, inspection of the shrouds is warranted during the next scheduled refueling outages. SIL 572 recommends that any visual examinations be performed with an enhanced VT-1 system that can resolve a standard one (1) mil wire on the inspection surface. If no cracks are observed, it is recommended that the shroud be re-examined at every second refueling outage. If cracking is observed, the shroud should be re-examined during each refueling outage, and a structural margin analysis should be performed to assess operability. The inspection sample should be based upon a statistically significant sampling of the accessible areas.

Figure 1 shows, in a flow diagram format, the steps involved in the evaluation of the inspection results. The Reference 1 report documents screening criteria which may be used as a basis for dispositioning flaws discovered in the shroud during inspection, as suggested by the "COMPARE AGAINST VISUAL SCREENING CRITERIA" box in Figure 1. Reference 1 uses limit load and linear elastic fracture mechanics (LEFM) techniques to determine allowable flaw sizes assuming continuous length flaws. Alternate screening criteria are presented in this report which use similar methodology to that used in Reference 1, but take account for non-continuous flaws (i.e., separate uncracked regions distributed around the shroud circumference). This alternate approach is based on the premise that inspection times may be significantly shorter if the objective is to find the minimum amount of material needed to maintain structural margins rather than determining the full extent of any cracking which might be present.

The alternate approach described here, along with SIL 572, provide a basis for the plant-specific recommendations made for Dresden 2 and 3. The recommended inspection plan that follows can be performed by using enhanced visual examination, ultrasonic examination or some combination thereof. There are distinct advantages and disadvantages associated with each of these inspection techniques which should be considered before selecting the inspection method, such as the cost to perform each type of exam and the associated impact on critical path time. The relative merits of each inspection technique are not discussed in this report.

2.0 TECHNICAL APPROACH

In this section, inspection criteria are developed which are used as a basis for the inspection recommendations which follow. The methodology used here is consistent with the limit load and LEFM techniques presented in Reference 1. However, the criteria developed here take into account distribution of uncracked material around the circumference of the shroud. This approach is less restrictive than that used in Reference 1, where it was assumed in the limit load approach that cracks were continuous. Therefore, the technical approach used here is to find the minimum amount of uncracked material at each weld location to meet the necessary structural margins (including safety factors). The condition of the uninspected locations of each weld remains unknown with this approach; in fact, much of it may be uncracked. However, for this conservative approach, it is assumed that they could be cracked. This assumption has no consequence to the structural adequacy of the shroud if it can be shown that the inspected regions are adequate from a structural standpoint, taking into account the necessary safety factors and future crack growth.

The limit load approach used here is depicted in Figure 2 where four equally distributed uncracked regions are assumed. The length of each of these regions is to be determined for each shroud horizontal weld such that structural margins applicable to limit load methodology are realized and, where applicable, margins resulting from a LEFM approach are realized as well. From Reference 1, crack growth is estimated to be 0.833 inch for a 24-month fuel cycle. Therefore, the analyzed length of each uncracked section used in this evaluation was assumed to differ from the minimum required inspection length by twice the crack growth (i.e., 2 x 0.833" = 1.67" assuming crack growth from both ends of the uncracked region).

The neutral axis shown in Figure 2 is first determined by equilibrating the force resulting from the applied membrane stress, P_m, in the uncracked cross section with the force resulting from a stress equal to the flow stress in each of the uncracked regions. The flow stress of the material is taken to be $3S_m$. Once the stress distribution in the four uncracked regions is determined, the resulting moment about the centroidal axis is calculated, and this is used to determine an equivalent bending stress, P_b', in the cracked section. Finally, consistent with ASME Code, Section XI, IWB-3640 procedures, $P_b' + P_m$ is compared to the following:

$$(P_b + P_m) * S.F.$$

where:
- P_b = Applied bending stress in uncracked section.
- P_m = Applied membrane stress in uncracked section.
- S.F. = Safety factor consistent with Appendix C of Section XI of the ASME Code.
  - = 1.4 for faulted conditions
  - = 2.8 for normal/upset conditions

The lengths of four equally spaced, uncracked locations is structurally adequate if $(P_b + P_m) * S.F.$ is less than $P_b' + P_m$. As a final step, verification that the length obtained from this limit load approach exceeds the proximity criteria for adjacent flaws (from Reference 1) is performed.

Consistent with Reference 1, LEFM proximity limits must also be satisfied for welds H4 and H5. Calculations were performed for welds H4 and H5 to account for the LEFM effect adjacent flaws have on each other to ensure that flaws separated by the uncracked region length are acceptable (assuming the entire distance between uncracked regions was cracked). These calculations resulted in a minimum distance between flaws such that the stress intensity, K, (including the appropriate safety factor) was within the allowable material toughness value of 150 $ksi\sqrt{inch}$ used in Reference 1. The minimum spacing between flaws at these locations is the limiting (i.e., greater) result of both the limit load and LEFM methodologies.

Based on the loading described in Reference 1, the results of the limit load approach (as well as the LEFM approach for H4 and H5) described above are given in Table 1 for each weld. The weld locations are as identified in Reference 1. These results demonstrate that four equally spaced uncracked regions, each with lengths corresponding to that shown in Table 1, provide adequate material to maintain all structural margins.

Table 1: Limit Load/LEFM Results
(Assuming 4 Equally Spaced, Uncracked Regions)

Weld	Limiting Condition	Minimum Required Inspection Length per Uncracked Region(1) (inches)
H1	Faulted	5.7
H2	Faulted	5.7
H3	Faulted	5.7
H4	Faulted	6.9(2)
H5	Upset	14.6(2)
H6	Faulted	8.0
H7	Faulted	10.5

NOTE: (1) From Reference 1, crack growth is estimated to be 0.833 inch for a 24-month fuel cycle. Therefore, the length of each uncracked section used in the evaluation was assumed to be the minimum inspection length reported here less crack growth from both sides of the uncracked region. Additionally, this length must be greater than the proximity criteria spacing requirement of Reference 1. Thus, the following was used in the evaluation for weld H1:

Proximity criteria spacing requirement from Reference 1 = 5.67"
Length used in evaluation = 1.83"
Inspection length = Length + crack growth = 1.83" + 2(0.833")
= 3.50"
Thus, the minimum required inspection length is 5.67"

(2) For these locations, LEFM techniques are applicable due to fluence considerations. The LEFM proximity criteria produced more limiting results than the limit load criteria, so the LEFM limits are tabulated at these locations.

3.0 INSPECTION CRITERIA

Based on the limit load/LEFM approach described in Section 2.0, the recommended inspection criteria for Dresden 2 and 3 are summarized below:

1. Based on the results of Table 1, inspect four equally spaced regions around the circumference of the shroud for *each* of the horizontal welds H1 - H7. The length of each inspected region should be at least equal to that shown in Table 1 in order for all structural margins to be met. Since the approach used here is to identify four regions which have uncracked material, inspection of accessible areas that meet the criteria presented here should be performed for both the ID and OD surfaces, if accessible, to verify the absence of cracking. However, considering the various factors (end grain effects, fluence, environment/water chemistry and potential inaccessibility), it is recognized that the examination of the H1 OD, H2 OD, H3 ID, H4 ID, H5 OD, H6 OD and H7 OD surfaces will provide the most critical data for use with this examination approach (e.g., the areas noted are felt to be more susceptible to crack initiation).

2. If the extent of uncracked material identified in step (1) is insufficient to meet the limit load/LEFM results presented in Table 1 for any given weld, additional areas of that weld must be examined in order to demonstrate structural margin through analysis.[a] The extent of the additional examination is dependent upon the amount of uncracked material identified in the four initial regions. Using an approach similar to that described in Section 2.0, additional regions distributed around the circumference can be identified for further inspection with the intent of locating an amount of distributed, uncracked material which satisfies structural margins (limit load for all welds as well as LEFM for welds H4 and H5). This iterative approach will be pursued by Commonwealth Edison Company during the shroud inspection based on the results achieved.

3. From Reference 1, the allowable crack length for axial welds is longer than the width of the plate material used in the shroud fabrication. Based on this, it is not possible that axial flaws would exceed allowable flaw lengths. Therefore, examination of vertical welds is not necessary for demonstrating structural margins.

4. In addition to the areas identified above, inspection of additional areas of the shroud should be considered based on a review of the fabrication records contained in Reference 2. The information contained in Reference 2 suggests actions may have been taken which would cause local areas of cold work on the shroud. Because of the known susceptibility of such areas to IGSCC, inspection of these areas is appropriate. For example, Attachment D-2 of Reference 2 notes that the shroud head lugs were "hammered" to alleviate out-of-tolerance spacing concerns. However, the specific lugs which received this treatment were not identified. Based on this, a location-specific inspection recommendation cannot be provided; however, inspection consistent with existing analysis is prudent (i.e., lug inspection consistent with recent shroud head bolt assessments). Additionally, if other cold worked locations are identified during the inspection, it is recommended that visual inspection of these local areas also be performed.

NOTE: (a) It is recognized that access limitations at the H7 weld may preclude the possibility of identifying sufficient uncracked material to positively demonstrate structural margin through limit load/LEFM analysis. Should this prove to be the case, a conclusion as to the integrity of the weld may be based upon the results of the examinations performed.

4.0 REFERENCES

[1] GENE-523-05-0194, Revision 0, "Evaluation and Screening Criteria for the Dresden 2 and 3 Shrouds," W.F. Weitze, GE Nuclear Energy, San Jose, CA, March 1994.

[2] GENE-771-05-0194, Revision 0, "Shroud Fabrication and Operational History Data, Dresden 3," G. L. Hodson, GE Nuclear Energy, San Jose, CA, March 1994.

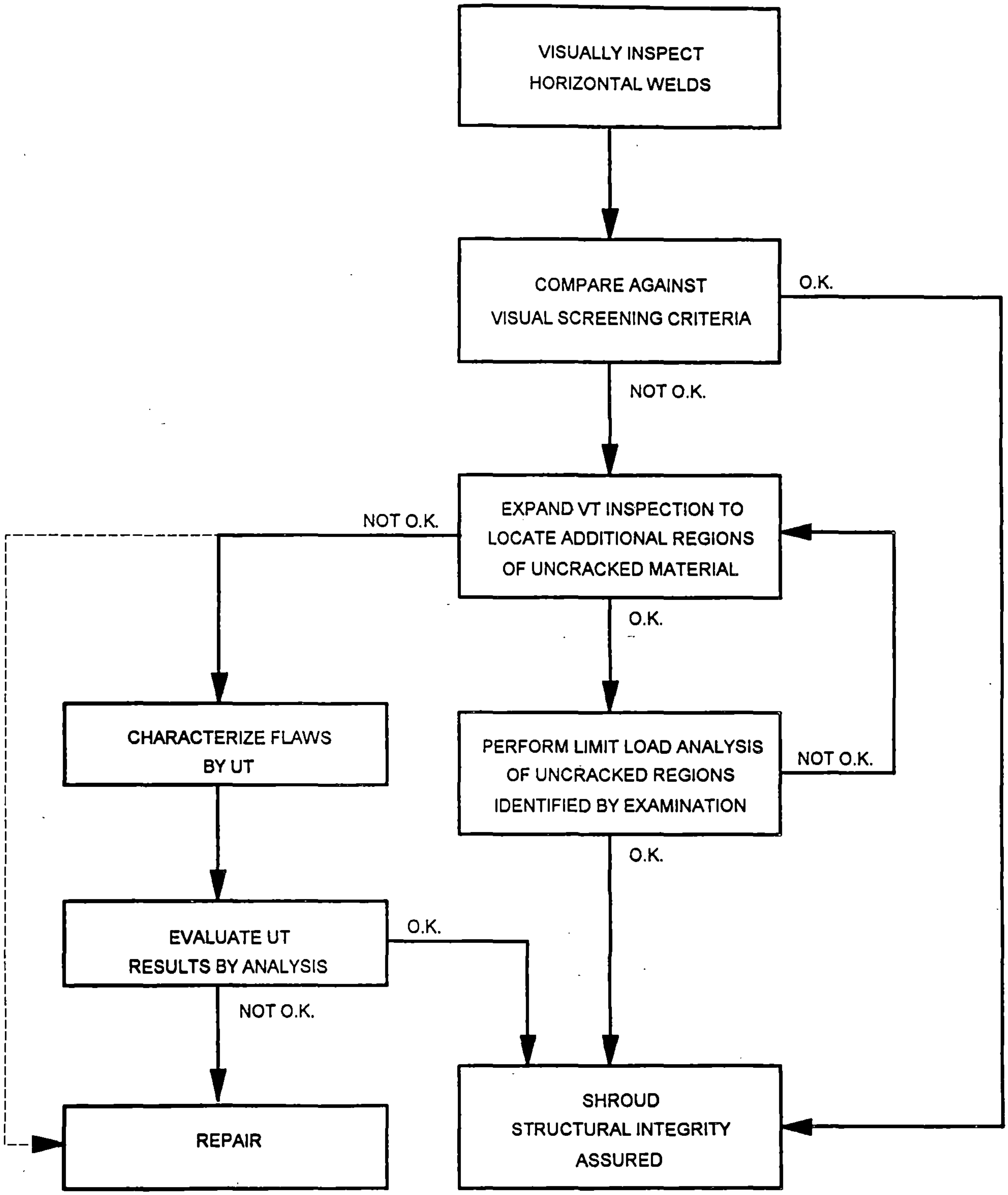

Figure 1: Shroud Inspection Flow Diagram

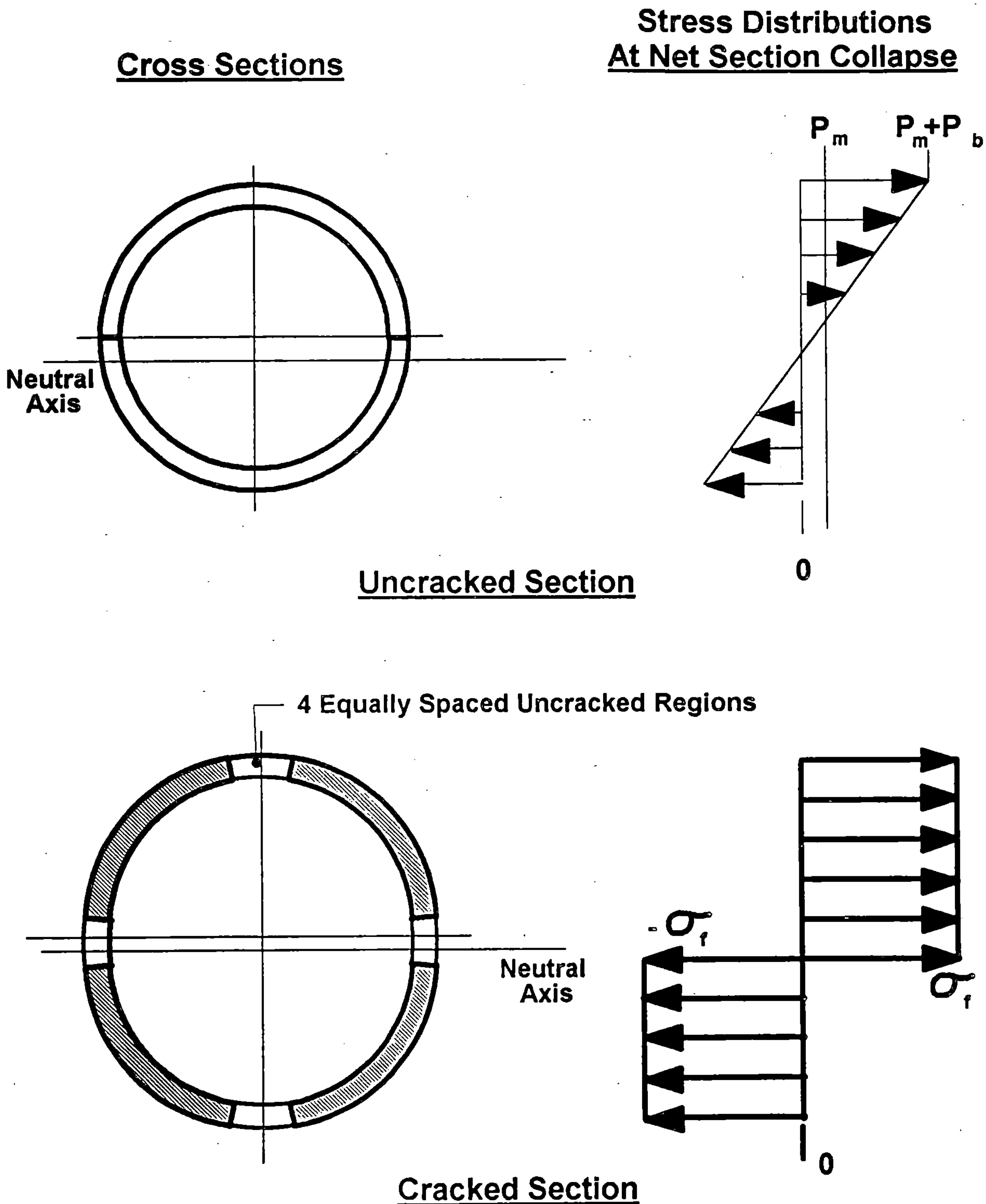

Figure 2: Limit Load Approach