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2007-371 BWR Vessel & Internals Project (BWRVIP)

December 7, 2007

Document Control Desk
U. S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

PROJ 704

Attention: Matt Mitchell

Subject: BWRVIP Recommendations Regarding Dissimilar Metal Weld Examinations

The purpose of this letter is to inform the NRC staff of the recommendations that the BWR Vessel and Internals Project (BWRVIP) is making in response to recent inspections and indications observed in BWR dissimilar metal (DM) welds.

The BWRVIP has been monitoring inspections performed on BWR DM welds since anomalous examination results were observed in early 2007. Most recently, anomalous weld examination results were noted by the Hope Creek plant. As a result of these recent observations, the BWRVIP transmitted the enclosed letter to the BWRVIP Executive Committee recommending that BWR plants review previous examination records for specific DM welds and evaluate their future inspection plans in light of this recent Hope Creek experience.

The BWRVIP will continue to communicate with the NRC staff as additional information becomes available and as additional recommendations are developed.

If you have any questions on this subject please Chuck Wirtz (FirstEnergy, BWRVIP Integration Committee Technical Chairman) by telephone at 440.280.7665 or by e-mail at cjwirtz@firstenergycorp.com.

Sincerely,

Rick Libra

Rick Libra
Exelon
Chairman, BWR Vessel and Internals Project

c: Holly Cruz, NRC
Chuck Wirtz, FirstEnergy
Randy Stark, EPRI

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2007-367 BWR Vessel & Internals Project (BWRVIP)

NOTE: THIS LETTER CONTAINS A "NEEDED" REQUIREMENT AS DEFINED IN NEI-03-08 AND BWRVIP-94, REVISION 1

December 4, 2007

TO: BWRVIP Executive Committee

Rick Libra

FROM: Rick Libra
Exelon
Chairman, BWR Vessel and Internals Project

SUBJECT: Recommendations Regarding Dissimilar Metal Weld Examinations (Includes Needed Requirement per NEI 03-08)

The purpose of this letter is to provide new recommendations regarding dissimilar metal (DM) weld examinations based on recent results of such examinations. Note that this letter contains a "Needed" requirement as defined in NEI 03-08 and BWRVIP-94, Revision 1. The "Needed" requirement is provide in **bold type** below.

Several previous BWRVIP letters transmitted information regarding anomalous DM weld examinations performed at BWRs. On October 26, 2007 BWRVIP issued letter 2007-321 that described anomalous Category C DM weld examination results at Hope Creek (included as Attachment 1). It is important to note that Hope Creek demonstrated a strong safety culture in following BWRVIP recommendations to review previous examination data for DM welds and, upon finding suspect data, acted upon it by scheduling the subject weld for examination in their upcoming outage.

Previous BWRVIP correspondence and recommendations on this subject concentrated on Category D DM welds as defined in BWRVIP-75-A. Category D welds are those made of susceptible material with no identified flaws that are not stress improved. Based on recent results of both Category C and D weld examinations, the BWRVIP is issuing the following "Needed" requirement (as defined in NEI 03-08 and BWRVIP-94, Revision 1):

> **For all Category D DM welds (regardless of material), and for all Category C DM welds with 82/182 metal exposed to the environment, plants shall review previous examination records and determine those welds that do not have examinations that were qualified in accordance with the requirements of ASME Code Section XI, Appendix VIII, Supplement 10.**

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For plants with refueling outages in the second half of 2008, the data review shall be completed no later than August 15, 2008. For all remaining plants, the data review shall be completed no later than December 31, 2008.

Records of the data review and evaluation(s) performed shall be maintained in the event additional information is needed based on results of the industry review requested by this letter.

In addition to the "Needed" requirements provided above, the following Good Practice / Recommendations are also provided:

For plants with refueling outages in the first half of 2008, it is recommended that the data review defined above should be completed before the start of their outage.

For the applicable DM welds, the examination data should be reviewed and evaluated for adequacy using the guidelines outlined in Attachment 2.

Based on the results from the review and evaluation required above, plants with Category D DM welds (regardless of material) or Category C DM welds with 82/182 metal exposed to the environment, and whose weld examinations were not qualified in accordance with Supplement 10 should evaluate their inspection plans in light of the recent Hope Creek experience.

The BWRVIP is also assembling a team to review BWRVIP guidance (e.g., BWRVIP-75-A), recommendations, evaluations, etc. to determine if any changes are warranted.

The BWRVIP will continue to keep you informed as additional information becomes available and as additional recommendations are developed.

If you have any questions on this subject please contact Chuck Wirtz (FirstEnergy, BWRVIP Integration Committee Technical Chairman) by telephone at 440.280.7665 or by e-mail at cjwirtz@firstenergycorp.com or Randy Stark at EPRI by telephone at 650.855.2122 or by e-mail at rstark@epri.com.

c: All BWRVIP Committee Members
Alex Marion – NEI
Rick Jacobs – INPO

October 26, 2007

TO: BWRVIP Executive Committee

Rick Libra

FROM: Rick Libra
Exelon
Chairman, BWR Vessel and Internals Project

SUBJECT: Recent Operating Experience (OE) Regarding Dissimilar Metal Weld Examinations

The purpose of this letter is to provide information on recent OE regarding inspections and indications observed in BWR dissimilar metal (DM) welds.

Several previous BWRVIP letters transmitted information regarding DM weld examinations performed at BWRs, resulting indications, results of a DM weld examination survey, related communications with the NRC, and recommendations. In accordance with BWRVIP recommendations, Hope Creek reviewed previous DM weld examination data and identified a suspect indication in one of their Reactor Recirculation inlet nozzle-to-safe-end welds. Although not previously scheduled, Hope Creek scheduled the weld for examination in their current outage. During examination, Hope Creek found the suspect indication to be ID connected. The nozzle-to-safe-end weld is approximately 14" in diameter and is a Category C weld. As defined in BWRVIP-75-A, Category C welds are welds made of IGSCC susceptible materials that have been stress improved after two years of operation. The indication is circumferentially oriented, approximately 13 inches long, and ID connected with a maximum depth of greater than 80% of the nominal wall thickness. This weld received a mechanical stress improvement in 1999 and has no history of repair. Hope Creek has been tracking this indication as a mid-wall flaw and has three sets of previous automated examination data (1996, 1999 and 2000) that show it was essentially the same depth at each of those examinations. However, the previous examinations were not performed as Supplement 10 exams. The examination performed this outage was performed to Supplement 10 requirements, including grinding the weld flush prior to examination. The Supplement 10 examination found that the indication was ID connected and likely IGSCC as opposed to the previous belief that the indication was a mid-wall fabrication defect. Hope Creek is proceeding with a weld overlay repair of the weld and has performed expanded scope examinations on two other Category C DM welds (another Reactor Recirculation inlet nozzle and a capped Control Rod Drive Return nozzle). No ID connected flaws were identified in the expanded scope exams.

Previous BWRVIP correspondence and recommendations on this subject concentrated on Category D DM welds as defined in BWRVIP-75-A. Category D welds are those made of susceptible materials that have not been stress improved.

The BWRVIP will continue to keep you informed as additional information becomes available and will likely provide recommendations in the near future following review and evaluation of all available information.

If you have any questions on this subject please contact Chuck Wirtz (FirstEnergy, BWRVIP Integration Committee Technical Chairman) by telephone at 440.280.7665 or by e-mail at cjwirtz@firstenergycorp.com or Randy Stark at EPRI by telephone at 650.855.2122 or by e-mail at rstark@epri.com.

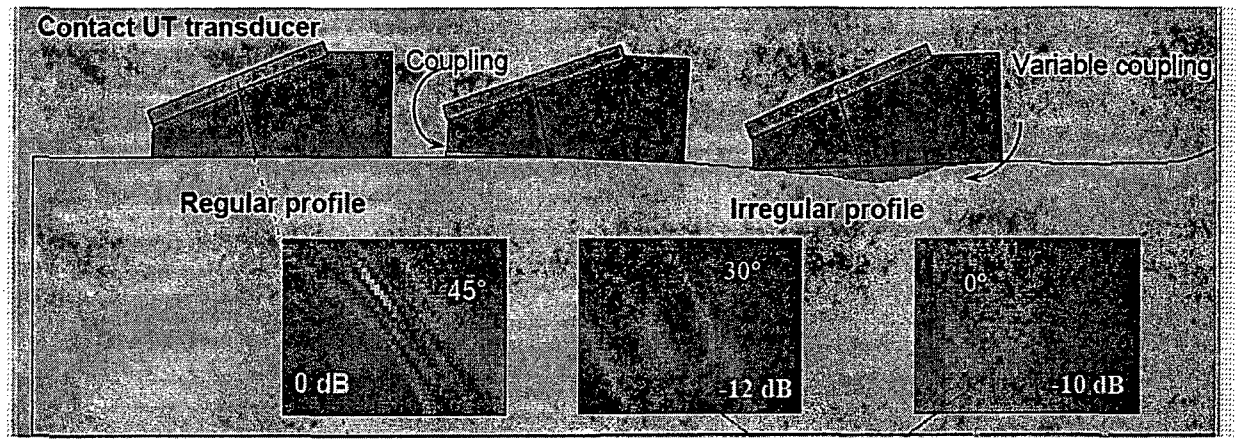
c: All BWRVIP Committee Members

1. General Information

For examinations that were not qualified in accordance with ASME Code Section XI, Appendix VIII, Supplement 10, the examination data shall be reviewed and evaluated for adequacy using the following guidelines. The intent of the information presented here is to provide guidance related to assessing the surface condition of dissimilar metal (DM) welds with regard to previous and future ultrasonic (UT) inspections. The information is also intended to provide a general understanding of the negative effects which poor surface conditions can have on the results of UT examinations as well as provide visual examples that may assist in identifying areas of concern during the review of existing data.

The effects of surface geometry on the results of UT examinations are well known and documented. UT contact testing relies on the contact efficiency between the ultrasonic transducer and the component being examined to provide optimal results. Even relatively minor interruptions in transducer contact can have an adverse effect on the quality of the examination. The presence of weld crowns or radial shrinkage near the weld are examples of conditions that will reduce transducer contact efficiency, thereby potentially reducing the effectiveness of the examination. Figure 1 was created using an ultrasonic beam modeling program and depicts this condition.

Figure 1



As can be seen in Figure 1 above, when the UT transducer is in optimum contact with the surface (far left) a well formed UT beam is induced in the material under examination. This condition will provide the best examination results. As the transducer is moved towards the right side of the illustration, surface conditions are present that distort the UT beam and would have a negative impact on the examination. These adverse surface conditions are indicative of radial shrinkage and weld crowns.

Figure 2 depicts the UT responses from a series of ID connected notches. As the transducer encounters a weld crown and experiences a "lift-off" condition a dramatic reduction in the UT responses can be seen in the upper right hand image.

Figure 2

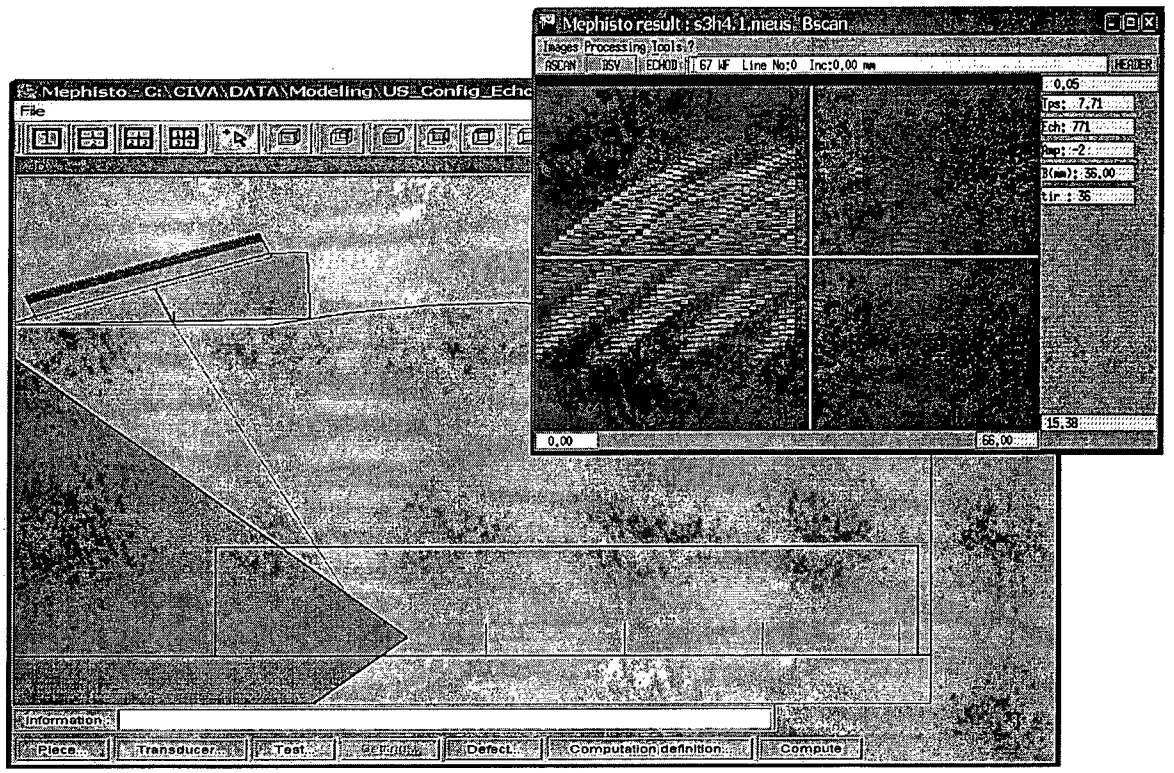
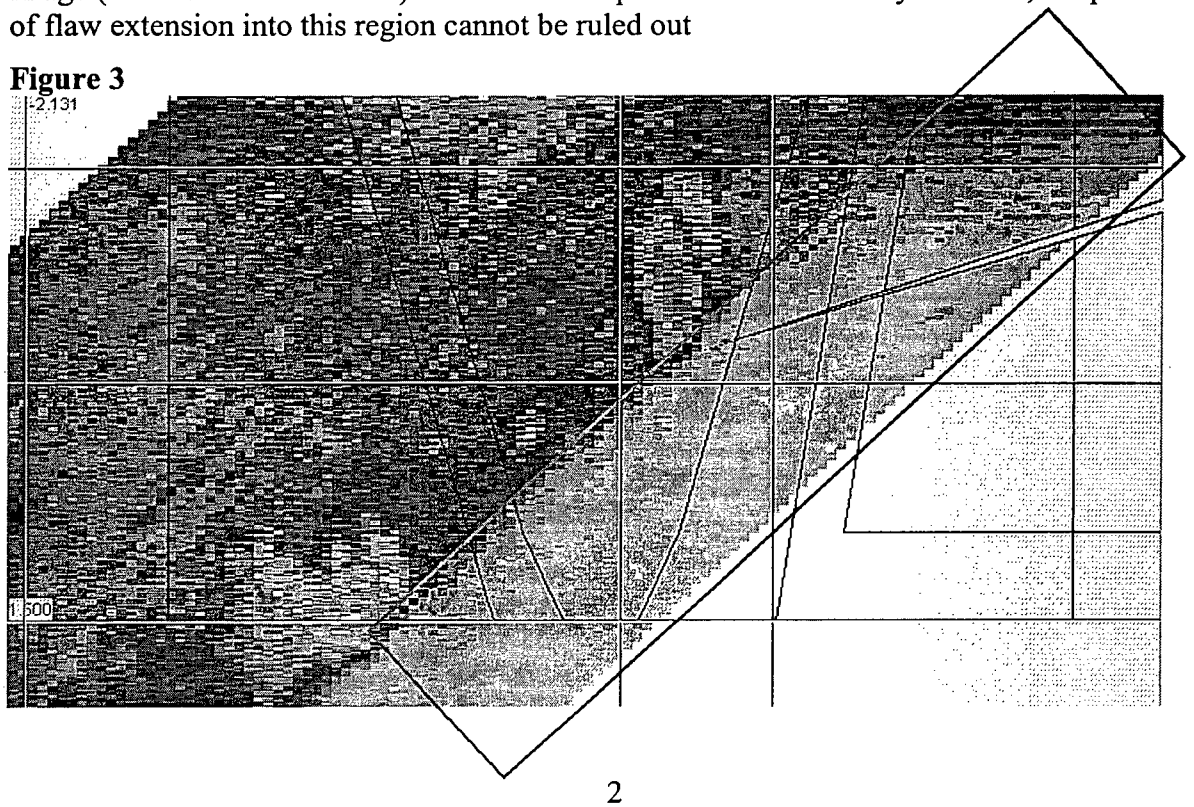


Figure 3 below is UT data collected with an automated acquisition system and shows a similar reduction in UT responses as the preceding illustration (Figure 2). The lighter blue area of the image (outlined in the red box) is indicative of poor contact efficiency and thus, the presence of flaw extension into this region cannot be ruled out

Figure 3



The following two images, Figures 4 & 5, were taken from UT examinations performed on the same weld. Figure 4 is from data acquired when the weld had a moderate weld crown condition. The second image, Figure 5, is of data acquired after surface conditioning was performed to remove the weld crown condition. The lighter blue/white areas present in the middle and top of Figure 4 are indicative of reduced contact due to the weld crown. These lighter areas are essentially devoid of meaningful data. After surface conditioning was performed the general background color in the data is far more consistent, as can be seen in Figure 5. This consistent background is an indicator that contact has been greatly improved by surface conditioning. Additionally, Figure 5 shows a significant and unique reflector present in the data (the yellow to red pattern in the middle region of the image). A similar, but greatly reduced, pattern can be seen in Figure 4 as well. As can be deduced from comparing the two images, the poor surface condition present in Figure 4 had a detrimental effect on the overall quality of the examination. Also present in the first image, Figure 4, are areas of high amplitude "noise" in the data (the yellow to red areas scattered throughout the image). This noise is also indicative of poor contact during the examination and is frequently related to gaps under the transducer from radial shrinkage and/or the presence of weld crowns. It is important to realize that the surface condition which was present in Figure 4 would not comply with current procedure requirements qualified in accordance with ASME Appendix VIII, Supplement 10. The surface preparation related to the second image, Figure 5, does meet the current requirements and the difference in data quality can easily be recognized as significantly improved.

Figure 4

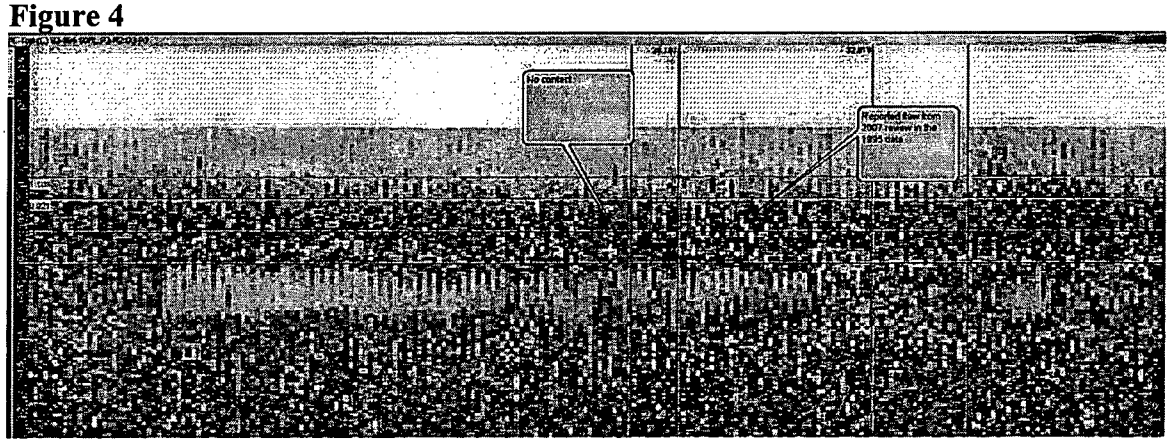
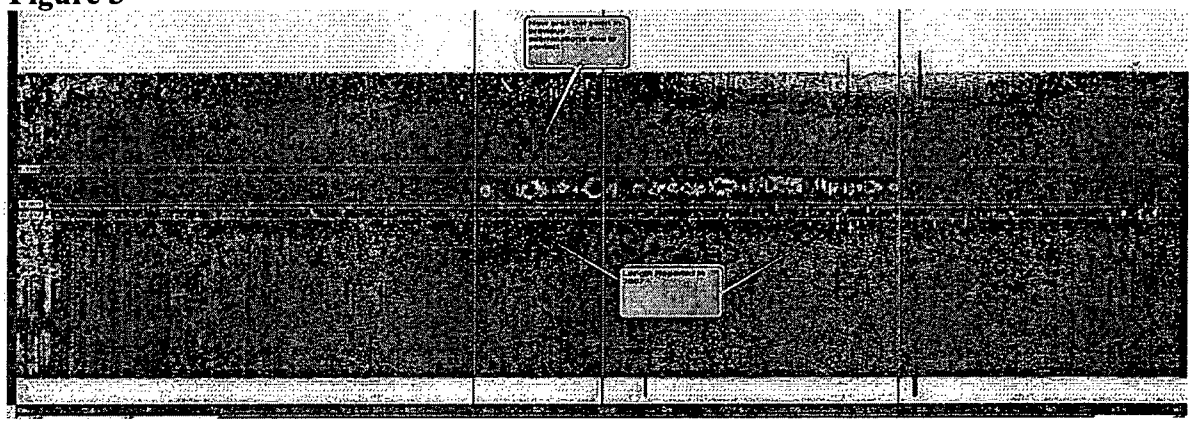


Figure 5



2. Data Review Criteria – General

The following information is intended to provide general guidance related to the review process of previously collected data on DM welds. Additionally, key points are presented that should be considered prior to performing future examinations.

The data review process should initially focus on identifying poor or questionable data quality and the presence of embedded flaws. Poor or questionable data quality refers to conditions that could have a negative impact on the quality of the examination and the ability to determine the integrity of the weld. Items to be considered when evaluating data quality should include but are not limited to the following:

- The presence of weld crowns
- Radial shrinkage near the weld
- Overall poor surface condition
- Transducer lift-off
- Inadequate transducer coupling

The review should begin with the most recent examination data and, if necessary, continue to previous examinations, as appropriate, to determine the adequacy of existing data. If the most recent examination was performed with an Appendix VIII, Supplement 10 qualified procedure and this procedure followed the guidance provided in a EPRI report titled *"Dissimilar Metal Piping Weld Examination Guidance: Volume 3 1009961"* Technical Update, November 2005, which contained additional guidance including a strong affirmation of the necessity for flatness/roughness requirements of less than 1/32 in. (0.03125 in. [0.794 mm]) over the length of the search unit., the findings should be documented and the review may be considered complete. If evidence of poor or questionable data is discovered, an attempt shall be made to ascertain the cause. If surface conditions appear to be a contributing factor, a surface conditioning plan should be developed and implemented prior to any required future examinations. If the data contains evidence of embedded flaws, the data from the next prior examination should be evaluated in an effort to ensure no connection to inside surface is evident. If surface conditions appear to limit the thorough evaluation of an embedded flaw, surface conditioning should be planned prior to any future examinations and the results of the data review should be documented in the utility's Corrective Action Program and dispositioned accordingly.

Poor or questionable data quality within the Code required examination volume should be documented as a coverage limitation. If the data review identifies surface conditions that might not meet the current requirements, a surface conditioning plan should be developed and implemented prior to any required future examination. In the event that adequate surface profiles are not available, or surface conditions cannot be determined from the available data, this information should be gathered at the first opportunity.

Additionally, previous UT examination techniques should be compared to the current Appendix VIII qualified techniques. Generally, UT transducer selection would be of primary concern during this review. Items to consider during this comparison should include:

- Transducer angle

- Transducer focal length or depth
- Transducer frequency (MHz)
- Transducer contouring

When available, weld repair history should also be reviewed in an effort to identify the source of any suspect areas, or the nature of any previously reported indications.

3. Data Review Criteria – Automated Examinations

Review of previously collected automated inspection data should be performed by a data analyst qualified for the examination in accordance with Appendix VIII.

The following information is provided as guidance to be considered during the review of previously collected automated UT data. This information is not intended to be all inclusive, but should be considered during the review process.

Initially, general observations should be made of the entire scan area. This general review should attempt to identify areas which exhibit evidence of reduced contact; Figures 3 & 4 show examples of reduced contact. Typically, weld crown or radial shrink interference will appear as a band of reduced contact near the weld. This band might or might not be present throughout the entire length of the scan, due to varying conditions around the component circumference. These areas might also be accompanied by high amplitude noise signals generated when transducer lift-off occurs. After the initial review, a more detailed evaluation should be performed on areas where potential reduced contact efficiency has been noted. A suggested approach to this evaluation would involve reviewing the A-scan data in the suspect areas compared to areas that appear to have good contact. Most procedures define that scanning sensitivity be established in a manner that will produce an inside surface response or "ID roll" between 10% and 20% of the maximum A-scan presentation. Therefore, based on the procedure requirements, the A-scan responses from the ID in the suspect areas should be evaluated against other areas of the scan and against the procedure requirements in an effort to identify a reduction in ID response that could be attributed to poor contact. Data collected on horizontal components might also have contact issues near the bottom where the effects of gravity may contribute to contact difficulties.

If the review process identifies characteristics that could be resulting from weld crown or radial shrink, detailed evaluation of the actual component should be made, and surface conditioning should be performed as required prior to any required future examination. Areas within the examination volume that exhibit reduced contact that can not be attributed to weld crown or shrinkage should be documented as coverage limitations.

4. Data Review Criteria – Manual Examinations

The review of manual data is more limited than that for automated data since the review is primarily limited to the paper report generated during previous examinations. In light of this, the review needs to be more critical in some respects. Components where embedded indications have been previously recorded should warrant additional scrutiny during the review process.

The evaluation of surface condition, in many cases, will be limited to one or two surface profiles. The traditional method of acquiring a surface profile utilizes a pin gauge similar to

those that may be purchased at a local hardware store. The pin gauge is pressed against the component surface and the resulting profile is traced onto a piece of paper. This method inherently results in some reduction of resolution in regard to the actual component surface. Due to this situation, and the lack of digitized data to review, extra scrutiny must be applied when reviewing these surface contours. Even slight surface conditions present in the previous data packages could in fact be more significant than they appear. Additionally, the surface profiles available for review might not have been taken in an area representative of the most adverse surface condition around the component circumference. Figure 6 provides an example of a surface profile that would most likely adhere to a qualified procedure's surface requirements. Figure 7 depicts an example of a surface profile that should be regarded as questionable and probably would not meet the current surface condition requirements. However, even if a surface profile appears to be consistent with Figure 6 it is no guarantee that the rest of the component circumference will possess the same profile conditions.

Figure 6

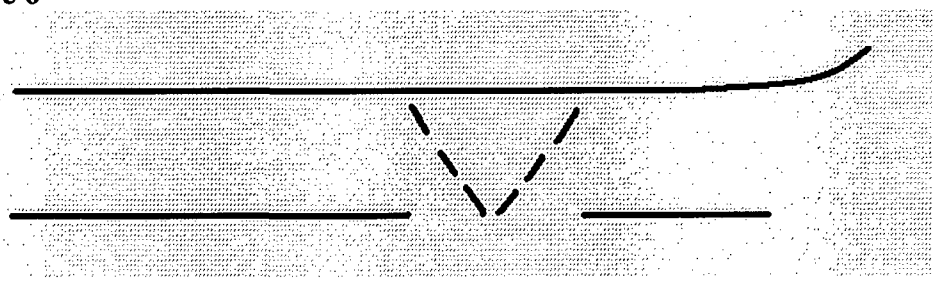
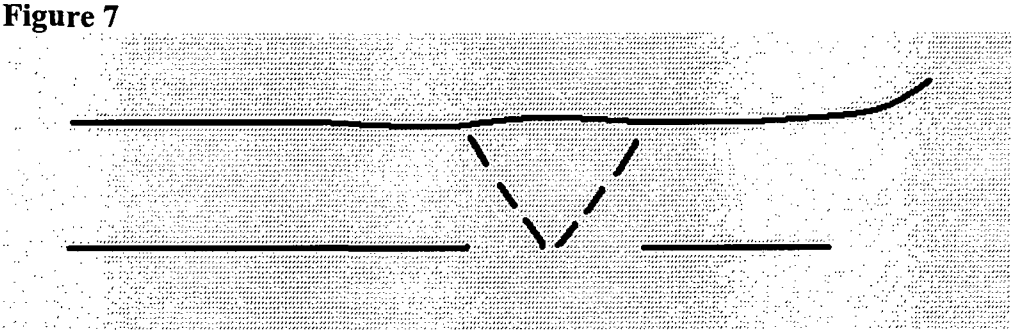


Figure 7



In addition to review of surface profile information, a thorough review of previous transducer selections should be made. In many cases, the transducers used for DM weld examinations prior to Appendix VIII qualifications do not meet the current requirements. Often these transducers were too small, too high in frequency or focused too shallow to provide effective interrogation of the inside surface.

5. Summary

The effects of reduced contact efficiency on the results of UT examinations are well known and documented. Recent industry experience has emphasized the importance of proper surface preparation prior to UT examinations. The inherent structure of a DM weld creates challenges for UT inspections; these challenges are compounded when component surface conditions are less than ideal.

The four major contributors to a successful ultrasonic DM weld inspection are

- Sufficient access to the examination volume,
- Adequate surface condition for transducer coupling,
- Proper inspection technique, and
- Proper application of a qualified procedure.

Recognition of these major contributors and the implementation of actions to address them will significantly increase the quality and accuracy of DM weld examinations.