Findings and Conclusions of the NDE Expert Panel

1.0 INTRODUCTION

Industry events in recent years associated with performance demonstrated ultrasonic testing (UT) techniques have called into question a number of aspects of UT that may impact its effectiveness and reliability, as implemented in the field.

Some of the recent events have common or recurring nondestructive examinations (NDE) issues. This observation led to the formation of an expert panel to discuss the potential effect these issues may be having on overall NDE reliability, to consider improvements to address these issues, and to raise the level of confidence in NDE results. The makeup of the panel was as follows.

- Michael Anderson, PNNL, Member
- Doug Hansen, Arizona Public Service Company, Member
- Mark Lozev, Ph.D., BP Products North America, Inc., Member
- Clarisse Poidevin, Commissariat à l'énergie atomique (CEA), Member
- William Prosser, NASA, Member
- Ward Rummel, D&W Enterprises, LTD, Member
- Greg Selby, EPRI, Member
- Wallace Norris, NRC, RES Liaison
- Edmund Sullivan, PNNL, Facilitator

The panel met by teleconference approximately once a month from May through December 2013 to discuss a series of NDE-related events and associated issues, including some recurring themes. The following sections contain a listing of findings and conclusions reached by the NDE Expert Panel (NEP).

A topic discussed by the Panel that relates to NDE is the difference in the flaw acceptance criteria in Sections III and XI. Some Panel members noted that the criteria should be consistent. The Panel recommends that the ASME Code work on an action to unify the approaches to flaw detection, characterization, and evaluation under Sections III and XI with full consideration of the differences in flaws of interest and examination techniques used. This subject is discussed further in Section 2.3

2.0 SUMMARIES OF EXPERT PANEL FINDINGS AND CONCLUSIONS

2.1 Encoded Data and Independent Data Review

- Enhances discrimination of service-induced flaws from fabrication flaws and geometrical reflectors and may enhance detection of flaws when signal-to-noise ratio is low.
- Review of encoded data has identified indications missed during examinations performed by non-encoded manual techniques.
- Independent review of encoded data has identified indications missed during primary analysis of the encoded data.

- Provides improved reliability by allowing indications present in examined volume to be properly categorized; reduces false call probability.
- Provides a means of assessing whether the expected examination volumetric coverage has been achieved.
- Allows data quality to be assessed independently and, if necessary, addressed through repeated examinations.
- Supports assessing results from historical examinations; for example, flaw growth trending, repeated detection of non-crack indications, etc. Supports a probable or root cause determination if an indication is missed or misinterpreted.
- Independent review of encoded data should be required.
- Encoded data should be acquired. The panel recognizes that a place should be retained for manual non-encoded examinations in low-risk situations where the conditions will lead to reliable examinations; for example, thickness measurements for flow-accelerated corrosion.
- Guidelines on use of encoded data have been developed by the industry NDE Improvement Focus Group (NIFG). With these guidelines as a starting point, conditions should be established for when spatially-encoded UT data needs to be acquired.

2.2 Modeling

- Models provide useful insights into potential strengths and weaknesses of examinations, such as expected sound field densities in the examination areas of interest and flaw responses in areas where degradation commonly exists.
- Models support validation of focal laws, scanning area, Code-required volumetric coverage, and overall essential and non-essential examination parameters.
- Models can assist in determining which UT technique to apply and in understanding technique limitations. Modeling can be used to assist in procedure assessment. For instance, procedures may be enhanced or optimized by varying parameters over a permissible range and by taking into account that more than one parameter may be varied at the same time.
- Models are currently used by many organizations to provide useful information for evaluating probe design parameters.
- Models may be able to be used for training on discrimination of flaws (i.e., planar versus volumetric flaws, surface-connected versus embedded cracks) to assess the robustness of flaw characterization criteria and help with data interpretation.
- Models may eventually provide alternatives to developing expensive mockups for every application. For example, modeling may have a beneficial role in expanding an existing qualification to include a little broader scope in component or equipment configuration, with limited use of expensive mockups.
- Modeling should be used to influence the decision when results are encountered that conflict with the independent data review or historical information.
- Model limits, parametric features, and algorithms need to be validated by measurements that encompass the configurations to be examined and the modeling purposes intended.
- Procedures must be developed for using models to reach conclusions about the adequacy of examination techniques. The procedures should be agreed upon by stakeholders.

- Guidelines must be developed to establish the conditions for which a model is considered adequately validated for a specific application. The guidelines should be agreed upon by stakeholders.
- Conditions should be established for when models need to be utilized.

2.3 Approach to Discrimination of Flaws

2.3.1 Background

- ASME rules for performance demonstration specimens require no, or only a limited number of, fabrication flaws because the focus is on testing of systems for service degradation; that is, crack-like defects.
- Industry protocols guide the fabrication of test blocks to not include, or in some cases, remove realistic (albeit, acceptable) welding flaws in the same grading units as cracks.
- Individuals are tested for an ability to detect a minimum number of crack-like defects in specimens while not exceeding the acceptance criteria for false calls of non-crack-like defects; therefore, candidates are not asked to report anything except cracks, and false call acceptance criteria in the testing process discourages reporting of indications other than cracks.
- Based on excluding, or on including a very limited number of, fabrication flaws in the test blocks, individuals are not required to effectively demonstrate an ability to discriminate between service-induced and fabrication flaws.
- Discrimination of flaw types is not required training for individuals performing UT examinations.
- One panel member expressed the view that discrimination between fabrication and service-induced flaws that lead to false calls are an economic impact, not a safety impact. However, other members observed that if false calls lead to unnecessary repairs, the introduction of higher residual stresses could have a negative impact on component integrity.
- One panel member expressed an opinion that, similar to nearly all other NDE methods across multiple industries, UT examiners have to correctly interpret indirect information in order to make characterizations of relevant versus non-relevant responses. Thus, unless UT examiners are appropriately trained and tested to make these characterizations, those individuals should not be considered to be qualified.

2.3.2 Findings

Overall, the panel members were not able to reach consensus conclusions on this topic. The following bullets reflect the divergence of views on the topic of “Approach to Discrimination of Flaws.”

- Some panel members indicated that because examiners will encounter indications from reflectors other than cracks, examiners have to be able to deal with situations not covered in the industry performance demonstration protocols. These panel members saw the current approach to qualification and training as a weakness in the program.

- Two panel members indicated that the current approach to qualification and training may result in a safety concern.
- One panel member indicated experience has shown that the current approach has resulted in proper characterizations of flaws, although mobilization of additional resources in some cases has been necessary. The panel member's opinion is that the expectation of examiners is to not miss cracks and that teaching examiners not to call non-relevant indications cracks would introduce a weakness.
- Several panel members have indicated a concern that, with the current approach to qualification and training, the use of non-encoded examinations along with the application of potentially non-robust ultrasonic techniques,[1] service-induced flaws may go undetected or not be properly characterized (i.e., mistaken as welding flaws or other non-relevant indications), either of which could be a safety issue.
- One panel member indicated a concern that modifying the qualification would increase the likelihood that a crack would be mischaracterized.
- One panel member indicated that the root of this issue is the differences between Section III and XI examination techniques for detection and characterization and the differences in Section III and XI acceptance standards. The focus of Section III is on fabrication flaws and the focus of Section XI is on service-induced flaws. Examiners under Section XI encounter both types of flaws but do not have the "tools" to deal with both types of flaws. ASME should be tasked to address this issue.
- Until a more comprehensive resolution of this issue is developed, the Panel recommends that the industry develop guidelines for training on discrimination of flaws.

2.4 Training

2.4.1 Background

Non-nuclear NEP members avoided connecting issues to either human error and training or procedures. These members did not attribute issues to the examiners, because information presented did not indicate that the issues/problems identified were due to examiners failing to implement procedures or performing below expectations based on examiner certification. Likewise, the information presented did not clearly indicate that the issues/problems identified were caused by inadequate procedures. The non-nuclear NEP members saw some issues as arising from the techniques chosen. One panel member occasionally expressed the view that issues were related to human performance. More detailed (and probably unavailable) information on some of the events would be needed to clarify the extent to which procedures and human error and training gave rise to the issues discussed.

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[1] Non-robust ultrasonic techniques would include techniques utilizing poor, or non-optimized, sound field intensities within the areas of interest, insufficient number of beam angles to produce adequate volumetric coverage (especially in coarse-grained austenitic materials), and improper contouring of wedges restricting full coupling across the entire transmitting surfaces.

2.4.2 Conclusions

- Passing performance demonstration testing alone is not sufficient to ensure reliable examinations. The primary goal of the performance demonstration process has been to “screen out” poorly performing systems. Experience shows that, beyond meeting ASME Code demonstration requirements, examiners need sufficient training and experience to perform reliable NDE.
- Areas discussed where additional training and additional exposure to operational experience may have lessened the impact of some events:
    - Evaluate and recognize poor data quality and its contributors;
    - Understand limits of applied techniques, such as sound field characteristics; and
    - Improve ability to discriminate service-induced cracks from fabrication flaws.

2.5 Detection of Cracks in Welds Mitigated by Mechanical Stress Improvement Process

- Some panel members indicated that because examiners are expected to detect and size cracks in welds repaired by the mechanical stress improvement process (MSIP), the procedures/examiners should be demonstrated/tested on mockups with MSIP applied to the flaws.
    - If the object to be examined is changed mechanically, the examination procedures need to be revised/updated to reflect the mechanical change. Generally speaking, if the test object is modified, then the procedure must be ensured to match the component.
- One panel member disagreed with this recommendation indicating that if a flaw was present before MSIP was applied, then either:
    - A—the MSIP worked and the flaw is so compressed that it can’t grow and also is invisible; or
    - B—the MSIP didn’t work, the flaw isn’t compressed, and there’s no point in doing a separate demonstration on compressed flaws.
- The NRC Research Liaison and PNNL panel members support the panel recommendation in the first bullet above because:
    - Code Case N-770-1 contains requirements for examination of dissimilar metal welds in pressurized water reactors and is required by the NRC to be implemented. The Code Case allows MSIP to be applied to certain cold leg reactor vessel nozzle welds without prior UT examination provided a UT and a surface examination are conducted after MSIP. If a flaw is detected, for example by the surface examination, a flaw evaluation must be performed to satisfy ASME Code requirements to put the weld back in service. Demonstrated sizing techniques will be required to perform a valid flaw evaluation.

- MSIP could be misapplied to a weld with a crack deeper than allowed for application of MSIP while still compressing the inner region of the flaw. Analyses by Fredette and Scott (2010) showed that MSIP applied to such a flaw would increase the stress intensity at the crack tip, which could lead to a safety concern. The primary feature that is normally used for detection (corner-trap) may not be present, while detection of tip responses alone is not being demonstrated.

- The MSIP application causes ID/OD surface indentations adjacent to the targeted weld. In the case of a nearby field weld, future examinations could be affected because of this indentation; performance demonstrations should account for this surface irregularity.

2.6 Site-Specific Demonstration

- It was not feasible to construct mockups for all of the unique weld geometries that are addressed by the performance demonstration requirements of Appendix VIII. This situation necessitated site-specific demonstration (SSD).
- Current NFIG industry guidelines will be an appropriate starting point for ASME codification of SSD.
- Codification of SSD by ASME should be the industry's focus because of the importance of making the SSD adaptation acceptable to all parties.
- ASME should be tasked with revising Appendix VIII to include rules for SSD.

2.7 Team Scanning

- Team scanning is not ideal; but under the right conditions, it has the possibility of being effective.
- Without adequate controls, team scanning will not be repeatable.
- Some Panel members concluded that the team member manipulating the transducer should be required to be UT-qualified and perhaps certified under performance demonstration requirements. One panel member disagreed that the team member manipulating the transducer needs to be certified under performance demonstration requirements.
- The team member manipulating the transducer should receive training specific to team scanning.
- The team member manipulating the transducer should be able to view the monitor and be in direct communication with the NDE examiner interpreting the UT data.
- Under the industry guidelines, the decision to use team scanning will have to be a more "considered" decision.

2.8 Receipt Testing and Verification of Equipment Operation

- Steps should be taken to control and manage probes to ensure the probes will perform as intended.

3.0 REFERENCES

Fredette L and PM Scott. 2010. *Evaluation of Full Structural and Optimized Weld Overlays as Mitigation Strategies for Primary Water Stress Corrosion Cracking in Pressurized Water Reactors*. Battelle Columbus, Columbus, Ohio. ADAMS Accession No. ML101260540.