Attachment 5

Broadening Appendix VIII to Include Non-UT Inspection Processes

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Outline of Presentation

- Background
- Prescriptive Versus Performance Demonstration
- Performance Demonstration Design
- Issues Related to Expanding Appendix VIII
- Appendix VIII Modifications
- Specific Recommendation for Example Cases

Background

- Interest in addressing expansion of Appendix VIII for specific applications involving non-UT inspection processes
  - VC Summer use of ET for ID inspection of Dissimilar Metal Welds
  - PNNL research work on use of ET for the ID inspection of CSS
  - VT of nozzle inner radius
- NRC requested PNNL to develop a white paper on what strategy should be followed to expand Appendix VIII for these applications
  - How to get credit for non-UT inspections

Prescriptive Versus Performance Demonstration

- Appendix VIII design to produce requirements that are **performance-based** as opposed to **prescriptive**
- Prescriptive requirements specify the details of instrument operation, inspection steps and data interpretation
- Performance-based requirements describe what the inspection is to achieve and a practical test to verify that such performance is achieved
- A prescriptive requirement can not be applied to non-UT applications but a performance-based requirement can

Prescriptive Portions of Appendix VIII

- Examples – Assure good instrument operation
  - VIII-3130 Essential Variable Ranges
  - VIII-3140 Requalification
  - Article VIII-4000 Essential Variable Tolerances
  - Supplement 1 Evaluating Electronic Characteristics of Ultrasonic Systems
- These do not apply to non-UT NDE methods
- We do not recommend re-writing Appendix VIII
  - Well documented procedure
  - *Technical Justification Report*

Performance Demonstration Portions of Appendix VIII

- Supplements 2-13 all have similar structures
- Designed to assure suitably high POD or suitably low RMSE
- Statistical criteria used to develop pass/fail values such as in Table VIII-S2-1 or RMSE
- For POD a table provided to provide flexibility and trade offs with cost, number of test specimens, number of flaws based on POD should be above 50% at 95% confidence
- While RMSE value was chosen to assure performance was below value at 95% confidence.

Performance Demonstration Portions of Appendix VIII Cont'd

- If non-UT procedure or combined UT and non-UT procedure is to replace Appendix VIII procedure and goal is to detect the same kinds of flaws at the same POD – then the pass/fail criteria in Supplements can be applied as long as test flaws simulate NDE response for the non-UT method
- If a non-UT procedure is to replace a UT procedure, then use the original statistical criteria used to formulate the initial Appendix VIII tests
  - Review of demonstration objectives
  - Type of flaws in the test set
  - New pass/fail criteria (POD and False Calls)
  - New sizing error criteria

Appendix VIII Modifications

- Three ways to propose modifications
  - Complete Revision of Appendix VIII
    - Re-Write Appendix VIII for general NDE
    - Generic Requirements for all NDE
    - Specific Requirements for **Each** NDE Method
    - This would require many years to accomplish
  - Addition of Non-UT Section to Appendix VIII Covering
    - Requirements for Non-UT NDE Qualification
    - General Performance Demonstration for Each Non-UT NDE
  - Addition of Specific Supplements
    - Supplement for each new process/application
    - Will lead to inconsistency but is easiest to implement

Specific Recommendations Examples

- VT for Nozzles Inner Radius - Meet Supplement 5
- Only Conducting VT
- Flaws must be Appropriate for VT with Key Parameter being Crack Open Dimension
- Must have Realistic Surface Conditions
- Only Surface Breaking Flaws Detectable
  - Must Justify Why Non-Surface Connected Flaws Can be Ignored
- Will Require a Technical Justification Report
- No Depth Sizing only Length Sizing

Specific Recommendations Examples cont'd

- Combined UT and ET for CSS
- Supplement 9 not Developed
- Technical Justification Report
  - Technical requirements report
- Detection Test Acceptance Criteria
  - ID Inspection of Piping Using Supplement 2 and 3 requirements (8 Out of 10 Type of Test)
  - Crack Opening Dimension (COD) is a Key Parameter and Must have Realistic ID Conditions

Specific Recommendations Examples cont'd

- Detection Test Specimens
  - Since No Known Degradation - Base COD Values on Field Experience and Include Flaws with COD Values from a Few Microns to Greater Than 100 Microns
- Sizing Test Acceptance Criteria
  - Expected Degradation Processes will Result in ID Surface Breaking Cracks
  - For ET Can Only Measure Length Combine with UT Data and Meet RMSE of less than 0.75 inches
  - For Depth Sizing Determine What UT Is Capable of Doing – Given Good Conditions and Bad Conditions
  - If One can Only Measure Length then can Apply an Aspect Ratio for Analysis for Cases where there is a Known Correlation between the Length and Depth of the Flaw

What Next?

- Goal is to broaden Appendix VIII and get credit for inspections – Need Code Actions
- Since there is already a Task Group that is working on Re-writing Appendix VIII and this activity falls within that scope – seems logical to have them take the lead
- Having participation on this Task Group for Re-Writing App. VIII from WG on Personnel Qualification, Surface, Visual and ET would be important

Broadening Appendix VIII to Include Non-UT Inspection Processes

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1 Introduction

The general objective of this white-paper is to evaluate the changes being proposed to Appendix VIII of ASME Code Section XI. Currently, there is interest in replacing or augmenting ultrasonic testing (UT) inspection required by Appendix VIII with alternative (non-UT) inspections. This white paper evaluates how the performance demonstration methodology presented in Appendix VIII might be expanded to qualify such alternative NDE.

One specific inspection of interest is on the inner radius of nozzles; industry is proposing inspection processes to perform visual testing (VT) in lieu of UT. Another inspection of interest concerns the inspection of cast stainless steel (CSS) or dissimilar metal welds from the ID using eddy current (ET). Because CSS is part of Appendix VIII Supplement 9, what testing would be required for a qualified inspection process that included both ET and UT?

The strategy discussed for qualification incorporates some of the ideas developed in the ASME Joint Task Group between SC-V and PCC (Post Construction Committee). This Task Group was called the TGSCV and PCC and was concerned with applying the concept of performance demonstration to general NDE inspection problems and produced the draft Article 14 of Section V.

2 General Philosophy Behind Appendix VIII Performance Demonstration

The intention behind the Appendix VIII Performance Demonstration has been to produce requirements that are *performance-based* as opposed to *prescriptive* requirements. Prescriptive requirements specify in detail instrument operation and inspection steps, while performance based requirements describe what the inspection is to achieve, and use a practical test to verify that such performance is achieved.

Although the current version of Appendix VIII relies more heavily on performance-based testing than earlier versions, it is best described as a compromise between the two philosophies. These two philosophies have implications for any proposed broadening of Appendix VIII to include non-UT techniques: A prescriptive UT requirement cannot be applied to non-UT techniques, but a performance-based requirement can.

2.1 Prescriptive Portions of Appendix VIII

Article VIII-4000, "Essential Variable Tolerances" is a good example of a prescriptive portion of Appendix VIII; it presents prescriptive requirements for UT instrument operation in the form of tolerances on variables that influence operation of a typical UT instrument. For example, this article describes how a UT receiver spectrum should be measured and sets tolerances for the spectrum center frequency and bandwidth. Obviously, such requirements are irrelevant for non-UT NDE procedures (specifically visual testing or eddy current procedures).

A review of Appendix VIII yields the following list of sections which are prescriptive in nature;

VIII-3130 Essential Variable Ranges.

VIII-3140 Requalification.

Article VIII-4000 Essential Variable Tolerances.

Supplement 1 Evaluating Electronic Characteristics of Ultrasonic Systems.

As one can see from the list above, the UT prescriptive requirements are built upon the notion of a set of "essential variables[1]"; a set of variables which describe instrument operation, and that, if properly set, will assure good instrument operation. It would therefore be possible to apply the same general framework to other NDE systems, but it would have to be done on a procedure-by-procedure basis; there is no hope of producing a single set of "essential variables" for a general NDE method. If prescriptive requirements similar to the UT requirements are to be included for any new candidate NDE inspection process, a complete re-write of Appendix VIII will be the consequence.

We would therefore recommend that no attempt be made to duplicate the prescriptive requirements in Appendix VIII for new candidate NDE inspection processes. In place of the specific prescriptive requirements, one should require the candidate NDE inspection process to have a well-documented procedure (which would contain any prescriptive requirements relevant to that NDE inspection process). Another closely related alternative would be to have an applicant supply a *technical justification report,* as required in TGSCV and PCC draft report [2]. Such a report describes the procedure, the scientific basis for its effectiveness, what flaws it applies to, and the method's influential parameters (i.e. essential variables).

The section from TGSCV and PCC draft report [2] describing the "technical justification report" has been excerpted and is reproduced in Appendix A of this report. Appendix A is currently written to cover UT procedures only, but it could be easily modified to cover general NDE inspection processes and to be compatible with the performance demonstrations used in Appendix VIII.

[1] These are parameters that have an impact upon the effectiveness of the examination when changed.

2.2 Performance Demonstration Portions of Appendix VIII

Although there are several performance demonstrations described in Appendix VIII (Supplements 2 through 13 describe different performance demonstrations), all have similar structures. The performance demonstration test is either designed to assure (1) that the candidate's POD is suitably high, or (2) that the sizing error (usually measured by RMSE) is suitably low. Although not explicitly stated in Appendix VIII, the POD and sizing tests were originally designed from a set of statistical criteria, which are relevant to any candidate NDE inspection process.

2.2.1 POD Performance Demonstrations

The original criteria for a detection performance demonstration pipe test were that POD (for a suitably chosen flaw size) should be above 50% at approximately 95% confidence[1]. These statistical criteria resulted in the pass/fail values appearing in Table VIII-S2-1. For reactor pressure vessel tests a higher performance standard was needed, and this is reflected in the pass/fail values in Table VIII-S4-1, which assures that POD > 80% at 75% confidence. Such pass/fail tables allowed the test administrator the freedom to consider tests of different sizes and thus trade-off the cost of building test specimens, with the cost of failing good inspectors. It also allowed the test administrator to give tests with different numbers of flaws to reduce the potential of those taking the test to know how many flaws were in their test sets. It should be noted that the pass/fail tables appearing in the supplements are slightly altered versions of binomial tests produced from the above criteria. The tables also include a false call criterion to prevent using a strategy of making many calls to pass the test.

If one wants to replace an Appendix VIII UT-procedure with a non-UT procedure, *and the non-UT procedure is to detect the same kinds of flaws at the same POD*, then the relevant pass/fail table already in Appendix VIII can be applied to the non-UT procedure. The other details of the performance demonstration test would also be relevant but may need to be altered to reflect use of test flaws that simulate the NDE response for the non-UT procedure.

On the other hand, a non-UT procedure may be proposed as a replacement, because the inspection problem has changed. For example, a VT procedure might be proposed as a replacement for UT when surface connected flaws are considered to be more prevalent (or important) than internal flaws. Such a change in perspective should result in a corresponding change in the objectives of the performance demonstration test. The kinds of flaws in the test set should be altered and new pass/fail tables should be calculated from updated POD criteria. For example, the POD for a VT inspection would be based on crack opening dimension instead of crack depth, as employed in UT. Of course, any change in the inspection problem should be recorded and justified in an appropriate manner (i.e. a technical report in support of a code case or code change).

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[1]This implies that a candidate with POD below 50% will fail the test 5% of the time.

2.2.2 Sizing Performance Demonstrations

The original sizing tests for Appendix VIII performance demonstrations evolved from an agreement between the NRC, EPRI and the BWROG. These sizing test pass/fail criteria were based on a complex combination of mean absolute deviation, regression correlation, and regression slope. As data was acquired, it was decided to simplify the pass/fail criteria with a single parameter designed with the same type of statistical criteria as used for the detection tests: the sizing tests were to show that the RMSE was below a selected threshold at 95% confidence. This criterion resulted in pass/fail tables similar to those produced for detection. These tables were not included in Appendix VIII. The results from the tables were distilled into a single pass/fail threshold for each of the sizing tests. Consequently, the pass/fail criteria for the sizing tests included in Appendix VIII do not account for the effects of sample size as the detection tests do.

Generally speaking, the sizing tests in Appendix VIII are less directly related to a simple statistical design criteria than the detection tests. Currently, some of the ASME supplements use RMSE and others use the sizing test pass/fail criteria that was based on a complex combination of mean absolute deviation, regression correlation, and regression slope.

Nevertheless, the existing sizing tests can be applied to non-UT NDE procedures in exactly the same way that detection tests can. If a candidate non-UT process is to replace a UT-process, and is to achieve the same sizing performance, then the performance demonstration test currently in Appendix VIII is applicable.

If a non-UT process is to be qualified to sizing criteria that differ substantially from those already existing in Appendix VIII, it is recommended that the test be designed to the statistical criteria originally used to formulate the initial Appendix VIII tests. This means that the test should assure that the procedure RMSE is below a desired threshold level at 95% confidence.

3 Issues Related to a Candidate NDE Inspection Process

If Appendix VIII is to be revised so that candidate non-UT inspection processes can be qualified, there are several important issues that must be considered. First, is the new process simply a replacement for an existing UT process, or are the inspection objectives also being redefined? If the new non-UTprocess is to be an equivalent replacement to an existing process (i.e. detect/size the same types of flaws with same POD and RMSE), then existing code requirements can be easily adapted to the new process.

However in many cases, the non-UT process will not be entirely equivalent to existing UT processes. For example, the new process may be proposed because the inspection problem has changed. The new procedure may be able to detect types of flaws that are of higher safety significance than was previously thought. Conversely, certain types of flaws may now have lower safety significance than previously thought, so an NDE process that ignores the lower safety significance flaws might be considered appropriate. Also, the new NDE process might be much more effective (i.e. higher POD, lower RMSE) than the existing UT process, and there might be a desire to increase performance standards associated with the qualification test.

Obviously, such changes in inspection objectives need to be justified (but not in Appendix VIII). Appendix VIII should clearly identify any changes in performance objectives that have been made for the new candidate NDE inspection processes. When inspection objectives are altered, new performance demonstration tests will have to be created. As mentioned previously, they can be created by using the same statistical criteria employed for the original tests. Also the flaw sets required for testing would be impacted by changes in inspection objectives. The qualification organization may need to produce new flaws for the required tests.

It is also possible that the new candidate process is really being considered as a component of a hybrid system: a system composed of the new process and the old UT process. If data from the new non-UT and old UT process are combined to detect or size flaws, the combined process should be qualified as a system and not as individual components.

4 Appendix VIII Modifications

There are several ways that Appendix VIII could be modified to include non-UT qualifications. Three possible modifications are discussed below which range in degree of difficulty of implementation.

4.1 Complete Revision of Appendix VIII

The most logical way to incorporate non-UT NDE into Appendix VIII would be to change the focus of Appendix VIII from UT-based NDE to general NDE inspection for the components of concern. This would require the appendix to be entirely revised, most probably with important changes in the requirements for UT qualification.

A revised version of Appendix VIII should begin by enumerating general requirements that apply to all NDE inspection processes. Supplements, or subsections, should deal with requirements that are applicable to only one type of NDE (e.g. UT, VT, or ET). It is expected that most of the requirements involving performance demonstration tests would be placed in the "general requirements" section.

The UT-specific prescriptive requirements now in Appendix VIII would either be eliminated or placed in a supplement specific to UT-based NDE. To create a version of Appendix VIII that is broadly applicable to NDE, the prescriptive requirements should be replaced by the requirement for a "technical justification report" similar in nature to the requirement appearing in Appendix A.

A complete revision of Appendix VIII would produce requirements that are most consistent (i.e. equivalent requirements for all NDE) and most readable. However, such a revision would take years to develop and implement, and since revisions are done by committee, there is no assurance that the final product would be any more consistent than the current version.

4.2 Addition of a Non-UT Section in Appendix VIII

Another alternative would be to include a new section in Appendix VIII, one titled "Requirements for Non-UT NDE." Such a section would describe general requirements for qualification such as the submittal of a "technical justification report," or a process description covering certain specific topics.

The section would describe general performance demonstration requirements. For example, if the candidate non-UT process was being proposed as a replacement for an existing UT process, the existing performance demonstration could be used for qualification.

An addition of a new section to the existing code would be much more feasible than a complete revision. It might also serve as a good bridge to a comprehensive revision of Appendix VIII in the future.

4.3 Addition of Specific Supplements

The most limited way to incorporate new non-UT inspection processes into Appendix VIII is by constructing a supplement for each new process. Under this scheme, procedure-specific prescriptive requirements can be included without problem. When appropriate, requirements from other supplements can be referenced, so the new supplement need not describe entirely new performance demonstration tests.

Under this strategy, one does not attempt to formulate general requirements that all NDE inspection processes should obey. Consequently, if this strategy were implemented, one might find that the non-UT supplements were not entirely consistent with each other (or with the UT supplements).

This strategy, is the easiest strategy to implement, and we therefore recommend the changes be proposed as supplements.

5 Specific Recommendations

Let us now focus the discussion on the two non-UT procedures that are currently being considered for inclusion into Appendix VIII: visual examination of the nozzle inner radius, and eddy current testing for cast stainless steel (CSS) and dissimilar metal welds.

5.1 VT for Nozzles

Qualification for the nozzle inner radius is currently described in Supplement 5 of Appendix VIII. Visual testing is proposed to replace the existing UT inspection processes for this area. Since VT can only find surface-breaking flaws, some justification would have to be supplied for ignoring non-surface-connected flaws. Appropriate detection requirements for VT are presented in Table VIII-S4-1.

The sizing test should also be conducted separately from any other supplement. Consequently, a minimum of 10 flaws will be required for the inner-radius sizing test. The acceptance criteria for VT will only use length of flaws. The acceptance requirements found in Supplement 4 can be applied to VT on the inner radius.

The flaws currently used to qualify UT in nozzles may not be appropriate for VT; surface connected flaws with realistic surface-breaking features are required. The new supplement should require that a "technical justification report," as described in Appendix A, be submitted as part of the qualifications process.

5.2 Eddy Current Testing for Cast Stainless Steel

The supplement concerning UT inspection of cast stainless steel welds (i.e. Supplement 9) is not currently in force because no effective UT inspection process exists for CSS. Thus, qualification requirements for eddy current testing (ET) cannot simply be transferred from an existing supplement. Below are suggestions for qualification:

Technical Justification Report: A technical requirements report, similar in organization to that outlined in Appendix A, should be compiled as part of the qualification process.

Detection Test Acceptance Criteria: The detection test should be constructed so that the performance for CSS is similar to that for other piping as defined in Supplements 2 and 3. However, instead of using flaw depth as a flaw essential variable, for ET the crack opening dimension (COD) will be used with values of COD selected based on CODs associated with experience from inservice cracks. These requirements can be achieved by the pass/fail criteria in Table VIII-S2-1.

Detection Test Specimens: Cracks having COD's that range from a few microns to greater than 100 microns should be included in the specimens.

Sizing Test Acceptance Criteria: Since ET is only effective for detecting surface-breaking or near surface defects, it can not determine the depth of cracks. For the sizing test it is necessary to determine sizing performance as a function of crack length. A RMSE for length less than 0.75 inches at 95% confidence is desired. In addition, the approach is only useful for degradation mechanisms for which there is a known correlation between the length and depth of the flaw.

Sizing Test Specimens: The test specimens used for sizing should contain flaws representative of those expected in CSS.

References

[1] Appendix VIII, of the ASME Boiler and Pressure Vessel Code, "Performance Demonstration for Ultrasonic Examination Systems," 2001.

[2] "UT System Qualification by Performance Demonstration," Joint TGSCV & PCC Draft Report, March 2002.

[3] Section V Article 14, "Examination System Qualification," of the ASME Boiler and Pressure Vessel Code, July 2003, Addenda.

[4] Inspection Planning Guidance Standard for Post Construction Pressure Containing Equipment, Inspection Planning Subcommittee, Board on Pressure Technology Codes & Standards, Dec, 1999.

Appendix A

Technical Justification Report Requirement

This appendix contains the technical justification report section from the TGSCV & PCC draft report [2] and a few editorial notes by the authors of this white paper. Although the TGSCV and PCC draft report [2] is confined to UT inspection, the section detailing a "technical justification report" could be simplified to apply to a general NDE procedure. A requirement for a technical report could replace the prescriptive requirements now in Appendix VIII, at least for any new candidate NDE procedure.

"T-341 Technical Justification Report

Qualification of any examination system, regardless of the level of rigor, first requires presentation of a technical justification report to the owner and, if applicable, to the Jurisdiction, Authorized Inspection Agency (AIA), independent third party, examination vendor, or other user. Acceptance of this report is the only requirement for an examination system that is to be qualified to the lowest level of rigor. The report shall be approved by a Level III examiner, and address the following minimum topics:

T-341.1 Description of Component/Flaws to be Examined

The component design, range of sizes, fabrication flaw history, and expected in-service damage mechanisms of the component shall be determined by analysis to establish the scope of the examinations, the types of flaws to detect, and the likely location of defects. The scope of the procedure shall include the limits of the procedure applicability (e.g. materials, thickness, diameter, product form, access, scanning limitations, surface condition).

(a) The flaws of interest to be detected and their expected locations; minimum recordable flaw size; and the critical flaw size, orientation, and shape; shall be established, serving as a guideline for development of the procedure. Critical flaw sizes (calculated from fracture mechanics analysis) and crack growth rates are important considerations for determining flaw recording and evaluation criteria. Flaw evaluation ensures critical crack sizes are not reached during normal operation prior to the next inspection or object replacement. The recordable flaw size is smaller than the critical flaw size, and may be based on observed crack growth rates, the estimated remaining life of the component, or the observed quality of workmanship during the fabrication process.

(b) Geometry, scanning limitations, and metallurgical conditions may limit the accessibility to the component. Examination procedure or equipment modifications may be required to gain access to the entire surface or volume to be examined. Environmental conditions, weld crowns, surface contours, and component geometry may dictate that higher angle search units, robots, and/or scanners are necessary to complete the examination.

(c) The acceptance criteria to be applied to the demonstration shall be provided.

(d) Justification issues to consider include:

1. historical effectiveness of procedure [editorial note – this does not cover new procedures],
2. documentation for prior demonstrations,
3. extent of prior round robin tests,
4. observed flaw detection rates, probability of detection, and false call rates;
5. acceptable rejection/acceptance rates, and
6. sizing accuracy.
7. [editorial note – should also consider transportability]

T-341.2 Overview of Examination System

A general description of the examination system shall provide sufficient detail to distinguish it from other systems. The description shall include, as applicable, the search unit angles, frequencies, transducers, modes of vibration, cables, search unit motion, couplant, scanners, recording sensitivity, sizing techniques, analysis software, acquisition software, recording thresholds, and indication interpretation techniques to be used. If a combination of equipment is used, then conditions requiring specific equipment shall be adequately described.

T-341.3 Description of Influential Parameters

The influence of inspection parameters on the examination system shall be considered; including equipment selection, scanning sensitivities, instrument settings, data analysis, personnel qualifications, and search unit selection. The justification for parameter selections shall be based upon the flaws of interest, and include an explanation of why the selected parameters will be effective for the particular examination and expected flaws.

a) Essential variables are parameters that have an impact upon the effectiveness of the examination when changed. For example, search unit frequency and angle are obviously essential variables, but the specific revision level of equipment software used for data analysis may or not be an essential variable. Procedure requirements, including essential variables that should be considered, may be found in Article 4, or the referencing Code of construction.

b) Additional personnel requirements, in addition to routine Level II or III examiner certification, may be advisable under some conditions. When using established techniques for examination of more readily detected damage mechanisms, or where less critical components are involved, a routine Level II or III examiner certification is adequate. For critical examinations requiring a high degree of confidence, or when the probability of detection of the flaws of interest must be definitively known, additional personnel requirements shall be specified. This may include a quantitative risk based criteria for the selection of components to be examined, or completion of a blind performance demonstration. Examination techniques, which will be performed by a team of examiners, shall address the specific qualification requirements for each team member. Operators of the scanning device shall be qualified, even when NDE certification may not otherwise be required.

T-341.4 Description of Ultrasonic (UT) Techniques

A justification for the effectiveness of the selected UT Techniques in the procedure for detecting the flaws of interest shall be included. The scanning surfaces, flaw orientation, flaw size, beam paths, ultrasound/flaw interaction, and influence of metallurgical and geometric affects are also required to be included in the justification. A description of the method used to distinguish between relevant and non-relevant indications shall be included. The following shall be addressed in the description:

a) Criteria for indication interpretation.
b) Justification for sensitivity settings for recording flaws.
c) The criteria applied to characterize and size flaws.

T-341.5 Optional Topics for Technical Justification

The following topics may be addressed within the technical justification to improve the understanding of the techniques to be applied.

a) **Description of UT Modeling.** A description of the ultrasonic modeling used to develop procedures, select scan surfaces, plot indications, show angle of beam impingement on flaw, predict flaw responses, design mockups, show scan coverage, and qualify procedures may be included. Models are required to be validated before use. The referencing Code of construction shall establish the criteria for validating models. Models can be used with qualified procedures to prove the effectiveness of revised procedures when parameters such as geometry, angle, size, and access limitations are changed. The procedure can be qualified or re-qualified using a minimum number of mockups.

b) **Description of Procedure Experience.** Prior Experience with a procedure may be included in the technical justification, and used to make revisions to the procedure. Previous demonstration that are applicable to the examination may be included. Experimental evidence to show effect of applicable variables such as surface roughness, artificial vs. real flaw responses, defect morphology, etc. may also be considered when developing the procedure."