ELECTRIC POWER RESEARCH INSTITUTE

2009-073 BWR Vessel & Internals Project (BWRVIP) Project 704

March 3, 2009

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

Attention: Joseph Williams

Subject: BWRVIP Comments on NRC Draft Safety Evaluation on Treatment of Non-Destructive Examination Flaw Sizing Uncertainty

References:
1. Letter from Stacey L. Rosenberg (NRC) to Rick Libra (BWRVIP Chairman), "Draft Safety Evaluation (SE) for Electric Power Research Institute (EPRI) Boiling Water Reactor (BWR) Vessel and Internals Project (BWRVIP) on Treatment of Non-Destructive Examination (NDE) Flaw Sizing Uncertainty as Related to BWRVIP Topical Reports (TRs) – Open Item (OI) – Generic BWRVIP Issues (BWRVIP-63) (TAC NO. MD9656)," dated December 29, 2008.
2. Letter from Carl Terry (BWRVIP Chairman) to Document Control Desk (NRC), "Project 704 – BWR Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999," dated July 1, 1999.

The purpose of this letter is to respond to the request in the Reference 1 NRC letter identified above for the BWRVIP to comment on any factual errors or clarity concerns contained in the draft Safety Evaluation (SE) transmitted to the BWRVIP by that NRC letter.

Attachment 1 to this letter provides BWRVIP comments and clarity concerns regarding the subject draft SE. Due to the long time period over which this NDE uncertainty issue has been addressed and the numerous communications between the NRC staff and the BWRVIP, Section 1 of Attachment 1 contains background and historical information to put the BWRVIP comments and concerns in proper perspective. The key BWRVIP conclusions are in Section 5 of Attachment 1. The BWRVIP considers these comments and concerns to be significant and we look forward to continuing to work with the NRC staff to reach a mutually satisfactory resolution.

Please note that the enclosed Attachments 1 and 3 contain proprietary information. Therefore, the request to withhold the BWRVIP-63 report from public disclosure transmitted to the NRC by the Reference 2 letter identified above also applies to Attachments 1 and 3.

A004

Add: Joseph Williams to ERIDS

NRR

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.

Sincerely,

Rick Libra

Rick Libra
Exelon
Chairman, BWR Vessel and Internals Project

c: Matthew Mitchell, NRC
Simon Sheng, NRC
Chuck Wirtz, FirstEnergy
Randy Stark, EPRI

Attachment 2

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Nuclear Engineering and Design 195 (2000) 227–232

Nuclear Engineering and Design

www.elsevier.com/locate/nucengdes

Technical note

Experience with inspection qualifications for austentitic piping

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Accepted 16 September 1999

Abstract

The performance demonstration initiative (PDI) was formed in 1991 to address implementation of appendix VIII to Section XI of the ASME Boiler and Pressure Vessel Code. All US utilities and three foreign utilities are participating. Appendix VIII differs from previous Code approaches in that it does not specify a particular approach. It does require that the capabilities of the personnel, procedures, and equipment be demonstrated. Appendix VIII describes, in detail, the demonstration requirements and acceptance criteria for ultrasonic examinations. Piping demonstrations have been performed for 390 examiners since April 1994. The database of demonstration results includes 10 000 detection and length sizing data points and 5000 depth sizing data points, which are available for analysis. The performance of these candidates provides insight into the difficulties of the inspection process for austenitic piping. The length and depth sizing accuracy along with the detection rate as a function of false call rate will be presented. The results of recent investigations will also be described.

1. Background

Performance demonstration requirements were added to the ASME Code, Section XI in the 1991 Addenda. These requirements are described in appendix VIII, 'Performance Demonstration Requirements for Ultrasonic Examination Systems.' These requirements are applicable to ultrasonic examination of piping bolting and selected portions of the reactor pressure vessel (RPV). The RPV requirements exclude the shell-to-flange and head-to-flange welds. The appendix requires that procedure effectiveness and personnel proficiency must be demonstrated on realistic mockups containing real flaws.

Recognizing the importance and complexity of appendix VIII implementation, representatives from all US nuclear utilities have formed the performance demonstration initiative (PDI) to implement appendix VIII. All US utilities and one

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PII: S0029-5493(99)00249-6

foreign utility have joined the program. The objective of the PDI is to provide:

- A unified industry approach of high credibility;
- A generic program that minimizes the need for site-specific or repeated demonstrations by vendors or individual examiners;
- A basis for negotiating implementation approaches and dates with regulatory authorities;

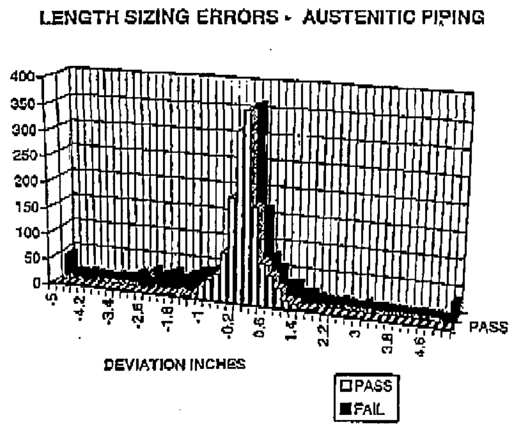

Fig. 1. Length sizing accuracy for flaws in austenitic piping.

Table 1
Length sizing errors

Austenitic piping	Mean (inches)	SD (inches)
Passed	0.025	0.498
Failed	−0.216	2.218
Ferritic piping		
Passed	0.017	0.464
Failed	−0.127	1.152

Table 2
Depth sizing accuracy

Austenitic piping	Mean (inches)	SD (inches)
Passed	0.007	0.096
Failed	−0.017	0.322
Ferritic piping		
Passed	0.007	0.078
Failed	0.061	0.351

- A lower cost alternative through the use of combined resources;
- A fair and competitive environment for ISI vendors by minimizing the up-front cost impact.

Uniformity of this approach is important to credibility, acceptability, and to ensure that qualifications earned at one location can be applied at another. This helps to avoid the substantial cost of repeating qualification demonstrations.

The PDI program was initiated in 1991 with the first demonstrations starting in April 1994. More than 300 piping samples are included in this program, including 30 that contain intergranular stress corrosion cracking (IGSCC) and were removed from service. Demonstration at the NDE Center for the detection and sizing of IGSCC has continued since 1982.

2. Discussion

More than 1000 separate piping demonstrations have been performed since initiation of the, program in 1994. The data offer an insight into the performance of piping examiners under a wide range of geometric and access conditions, flaw types, material thickness, and diameters.

This database is a component of the administration and grading program that is used at the NDE Center. The database contains more than 10 000 detection and length sizing data points. The database also includes 5000 through-wall sizing data points.

2.1. Sizing accuracy

2.1.1. Length sizing

Length sizing is performed in conjunction with detection. Each candidate must provide a length size with his detection results. The acceptance criterion in appendix VIII has now been revised from ± 1.0 inch to 0.75 inch RMS. The distribution of length sizing errors is shown in Fig. 1. These results represent the length sizing results from more than 10 000 individual measurements on austenitic and ferritic piping. Please note that the central portion of both the passed and failed

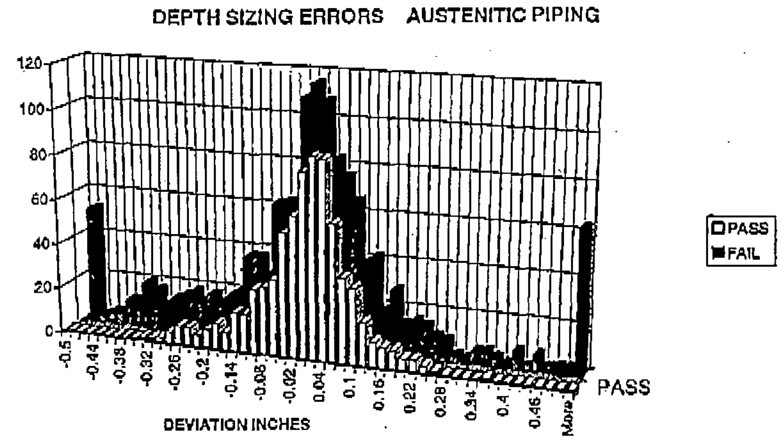

Fig. 2. Distribution of depth sizing errors for austenitic piping including both passed and failed candidates.

distributions are very nearly of the same shape. However, the unsuccessful candidates have substantial measurements exceeding 1.5 inches. The mean and standard deviation are shown in Table 1. The errors committed by the failed candidates does not appear to be related to the effectiveness of length measurement techniques. The problem appears to stem from an inability to discriminate between crack indications and other geometric indications. Considering this problem of discrimination, we believe that the actual length sizing should be included in any detection demonstration. This is to ensure that candidates are properly discriminating the cracks from other geometric indications.

2.1.2. Depth sizing

Appendix VIII depth sizing criteria is 0.125 inch RMS. The results presented here represent more than 3000 individual depth measurements. The database includes ferritic and austenitic piping, as well as passed and failed candidates. Table 2 lists the sizing accuracy for both passed and failed candidates. Results for austenitic and ferritic piping are provided. The distribution of depth sizing errors for austenitic piping, is shown in Fig. 2. The results from passed and failed candidates are provided separately. Please note that the central portion of the distribution is much wider than that for the passed candidates. It is our judgment that these sizing errors stem from the fundamental difficulty in operating the procedure, i.e. a lack of precision. Errors greater than ±0.2 inch are predominately the result of problems in discrimination. That is, the signal being sized is not the intended flaw. Both types of errors can lead to gross under and over sizing.

2.2. Detection versus false calls

Maximizing the detection rate is of little benefit without minimization of the false call rate. Detec-

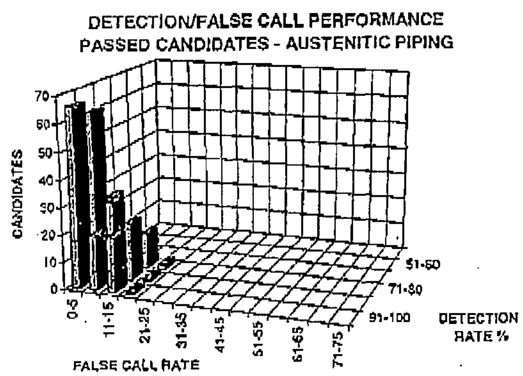

Fig. 3. Detection and false call rate for passed candidates.

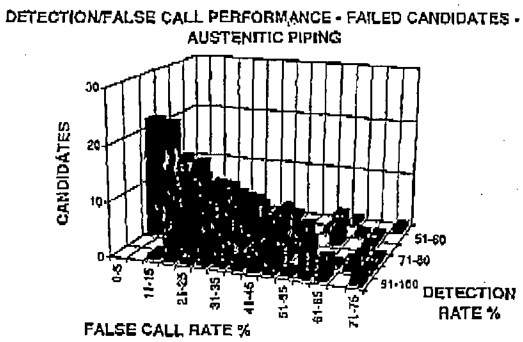

Fig. 4. Detection and false call rate for failed candidates.

Table 3
POD at 90% confidence for TWE ≥ 50%

	Near side access (%)	Far side access (%)
All candidates	93	70
Passed candidates only	96	74
All candidates, T > 0.5 inch	89	73
Passed candidates only, T > 0.5 inch	93	Insufficient data
Passed candidates, TWE > 57%	97	74

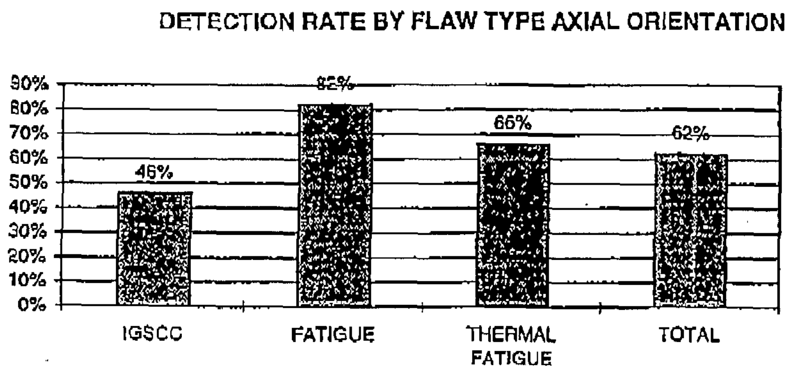

Fig. 5. Detection rate for axial flaws in austenitic piping by flaw type. Flaws are 5% TWE and larger.

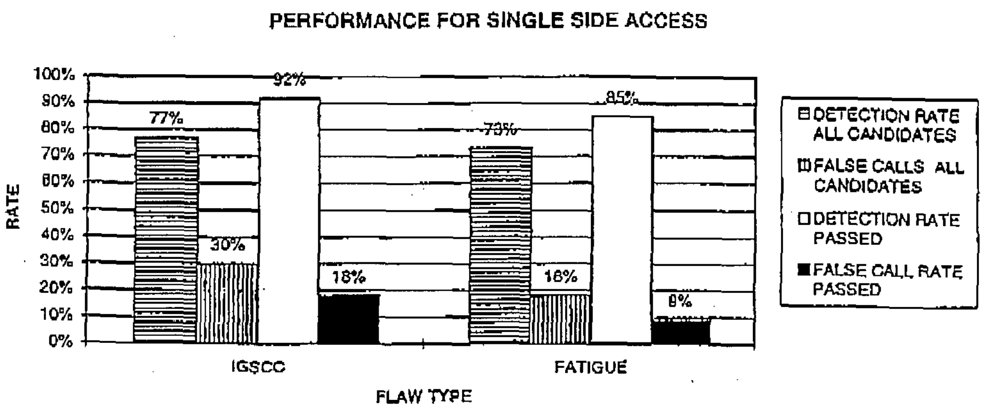

Fig. 6. Detection rate and false call rate for flaws located on the far side of the weld relative to the transducer.

tion data has little validity without also considering false calls, because a candidate could simply turn up the gain without demonstrating the ability to discriminate between real flaws and geometric signals. Appendix VIII considers both detection and false call rates as part of the acceptance criteria. Fig. 3 displays the results of successful detection candidates as a function of both rates. Fig. 4 displays similar results for failed candidates. There are twice as many entries in Fig. 4 (failed candidates) than in Fig. 3 (passed candidates).

2.3. Field removed IGSCC versus other flaw types

It is always desirable to use field removed flaw samples for training and qualification of NDE examiners. This is particularly true when considering IGSCC. A limited number of field removed IGSCC samples suitable for performance demonstrations are available. Approximately 50 such samples are available at the EPRI NDE Center. In training and testing of examiners over the past 15 years, it is apparent that IGSCC is the most difficult flaw type to detect and resolve. Fig. 5 shows the relative success rate of PDI candidates for three common flaw types. These include field removed IGSCC and mechanical and thermal fatigue flaw types. As shown in Fig. 5, IGSCC flaws are considerably more difficult than the other flaw types.

IGSCC flaws occur in both the axial and circumferential directions. Fig. 6 depicts the relative degree of difficulty for axial oriented IGSCC relative to fatigue and thermal fatigue of the same orientation. Clearly the field removed IGSCC flaws are the most difficult to correctly detect and resolve.

2.4. Single side access

The testing matrix includes 'single side access,' that is, access is only allowed from the side of the weld that is opposite to the flaw and the ultrasonic beam must pass through the weld. It has been known for many years that propagation of ultrasound through the dendritic structure of austenitic welds was extremely difficult. However, in many instances that is the only method of achieving the required coverage. The NDE Center has taken the position that examination, particularly for IGSCC, was not sufficiently reliable to claim credit for full coverage. Reliability, in this instance, is defined as 80% or greater detection with less than 20% false calls. Fig. 6 reports the detection rate and false call rate for flaws located on the far side of the weld. At first glance the higher detection rate for IGSCC might seem inconsistent with previous information. However, the IGSCC flaws selected for far side personnel qualifications are selected from a larger group of flaws based on the their detectability.

To address this condition, PDI qualifications indicate that detection for flaws on the far side of the weld are not adequately detectable and examinations are prone to high levels of false calls. Therefore, where access to both sides of the weld is not possible, it is recommended that the weld be examined using the personnel and procedures that have been qualified to this more limited standard. It is the position of the PDI that, while it might be possible to examine through some austenitic welds, there is substantial evidence that it is not always possible to examine through all austenitic welds. In addition, examination through the weld using standard techniques is prone to false calls.

2.5. Flaw of relevant sizes

It has long been recognized that the acceptance standards tables of ASME Section XI, EWB-3500 are extremely conservative and the probability of piping weld failures are very low. In evaluating the safety of a piping system, we are often asked what is the largest flaw that could be missed. There is always some minute possibility that any flaw might be missed. A more reasonable approach is to evaluate the probability of detecting flaws that would be significant to safety. If we select, for purposes of discussion, a value of $\geq$ 50% of the pipe wall thickness as the actual size of concern, a high reliability could be demonstrated. Table 3 lists calculated probabilities of detection

(POD) at the 90% confidence level for flaws with through-wall extent (TWE) > 50%. The data represent 1668 attempts on 147 different flaws for the near side, and 512 attempts from the far side. Failure to detect a large flaw is not a criterion of appendix VIII. However, it can be seen from the data that it is a rare occurrence for near side access. It is noteworthy that the POD for passed candidates does not improve for larger wall thickness. The largest flaw that was missed by a successful candidate was 57% in a pipe wall thickness of 0.69 inches.

3. Conclusions

The PDI database of candidate performance is extremely valuable in describing the capabilities and performance levels of ultrasonic piping examiners. A key result is the 96% POD that has been demonstrated for flaws of 50% TWE and greater. The length and depth sizing performance also appears to be adequate for the intended purpose. Overall, the results should provide confidence in examinations performed by qualified individuals using qualified procedures.