March 4, 1997 Attachment 1

MEMORANDUM TO: Ashok C. Thadani, Associate Director for Technical Review
Office of Nuclear Reactor Regulation

FROM: Brian W. Sheron, Director
Division of Engineering
Office of Nuclear Reactor Regulation

SUBJECT: REQUEST FOR APPROVAL FOR PUBLICATION OF A PAPER

Robert W. Hermann is approved to the attend the Joint EC OECD IAEA Specialists Meeting on NDE Techniques Capability Demonstration and Inspection Qualification in Petten, the Netherlands, on March 11-13, 1997. At this conference he is planning to present the attached paper entitled: "U.S. Nuclear Regulatory Commission Perspective on Performance Demonstration of Ultrasonic Testing Systems." This paper will also be published in the conference proceeding. We are requesting your approval for him to present this paper and have it published. A completed NRC Form 426, Release to Publish Unclassified NRC Staff Publications is attached for your signature.

Approval: ORIGINAL SIGNED BY:
Ashok C. Thadani

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U.S. Nuclear Regulatory Commission Perspective on Performance Demonstaration of Ultrasonic Testing Systems

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Abstract

In the mid-1980's, the Nuclear Regulatory Commission staff and the U.S. nuclear industry recognized that the reliability of ultrasonic examinations (UT) used in inservice inspection programs could be significantly improved through performance demonstration qualifications of non-destructive examination (NDE) equipment, procedures, and examiners. The efforts of the industry to develop performance-based qualification criteria culminated in the publication of Appendix VIII to the ASME Boiler and Pressure Vessel Code, Section XI, in the 1989 Addenda. The NRC has been developing a rule to make Appendix VIII a regulatory requirement.

This paper discusses the regulatory perspective on the need for performance-based methods to qualify UT systems for inspecting U.S. reactor vessels and piping systems.

Background

In the 1970s, the U.S. nuclear power regulatory authority observed from operating experience and industry tests that there was a need for improving UT procedures to consistently and reliably detect and characterize flaws during ISI of reactor vessel welds. Also noted was the need for more definitive reporting of results and for more descriptive requirements for essential variables associated with ultrasonic examinations. In response, Regulatory Guide (RG) 1.150, Revision 1, "Ultrasonic Testing of Reactor Vessel Welds During Preservice and Inservice Examinations," was issued in February 1983. RG

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Abstract

In the mid-1980s, the U.S. Nuclear Regulatory Commission (NRC) staff and the U.S. nuclear industry recognized that the reliability of ultrasonic testing (UT) used in inservice inspection (ISI) programs could be significantly improved through performance demonstration qualification of nondestructive examination (NDE) equipment, procedures, and examiners. The efforts of the industry to develop performance-based qualification criteria culminated in the publication of Appendix VIII to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, in the 1989 Addenda. The NRC has been developing a rule to make Appendix VIII a regulatory requirement.

This paper discusses the regulatory perspective on the need for performance-based methods to qualify UT systems for inspecting U.S. reactor vessels and piping systems.

Background

In the 1970s, the U.S. nuclear power regulatory authority observed from operating experience and industry tests that there was a need for improving UT procedures to consistently and reliably detect and characterize flaws during ISI of reactor vessel welds. Also noted was the need for more definitive reporting of results and for more descriptive requirements for essential variables associated with ultrasonic examinations. In response, Regulatory Guide (RG) 1.150, Revision 1, "Ultrasonic Testing of Reactor Vessel Welds During Preservice and Inservice Examinations," was issued in February 1983. RG 1.150 was incorporated into the technical specifications of many plants.

As the nuclear industry gained more operating experience, the need for

further improvements in ISI capabilities became apparent. For example, in the late 1970s, thermal fatigue cracks were found on the inner-blend radius of nozzle-to-vessel surfaces in boiling-water reactor (BWR) feedwater and control rod drive return line nozzles. The NRC staff recommended in NUREG-0619, "BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking," dated November 1980, that licensees develop ISI programs to search for cracks in the inner-blend radii using dye-penetrant, visual, and ultrasonic examinations. The NRC staff recognized the potential for improvements to UT systems and stated in NUREG-0619 that demonstrated improvements could be used as the basis for modifying the inspection criteria.

Also in the late 1970s, intergranular stress-corrosion cracking (IGSCC) was identified in austenitic stainless steel piping. The NRC staff recommended in NUREG-0313, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," dated July 1977, and in subsequent revisions thereto published in July 1980 and January 1988, that a program be established to conduct formal IGSCC performance demonstration testing for UT examiners.

In 1984, the NRC entered into an agreement, known as the IGSCC Coordination Plan, with the Boiling Water Reactor Owners' Group and the Electric Power Research Institute (EPRI) to coordinate selected activities in regard to training and qualification of personnel using UT to examine piping welds. As part of the IGSCC Coordination Plan, EPRI administered IGSCC performance demonstration tests to personnel seeking UT qualification in IGSCC detection and characterization in piping systems.

The need for additional guidance related to performing UT in ISI programs that were based on requirements in Section XI of the ASME Code, prompted a reexamination of the effectiveness of UT as it was being applied through the ASME Code. The conventional (amplitude-based) UT requirements in the ASME Code establish minimum acceptable inspection standards. In the 1970s and 1980s, the nuclear industry tested UT systems extensively to identify the critical aspects of an effective UT inspection program that would provide a high reliability for detection and characterization of flaws. In the mid-1980s, the NRC and the nuclear industry recognized that the reliability of UT in ISI programs could be significantly improved through performance demonstration qualification of NDE equipment, procedures, and examiners.

ASME Code, Section XI, Appendix VIII

The nuclear industry set about changing ASME Code requirements for UT from the current minimum inspection standards to inspection standards with performance-based qualifications. The performance-based qualifications would also produce uniform acceptance criteria for evaluating new technology and addressing new forms of degradation. The efforts of the industry to develop performance-based qualification criteria culminated with the publication of Appendix VIII to Section XI of the ASME Code, which was published in the 1989 Addenda. Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems," contains detailed requirements for UT performance demonstrations that include statistically based acceptance criteria to detect and size flaws. At this time, the rules of Appendix VIII have not yet become NRC requirements.

Appendix VIII is based on the qualification of equipment, procedures, and examiners using performance demonstrations; whereas existing requirements in the 1989 (and earlier) Edition of Section XI of the ASME Code are

prescriptive, minimum inspection standards. A performance-based qualification program encourages development of improved methods for detecting and characterizing flaws and facilitates implementing the methods with a defined testing curriculum.

The performance demonstrations require that equipment, procedures, and examiners be tested on flawed and notched materials and configurations similar to those found in actual plant conditions. The nuclear industry created the Performance Demonstration Initiative (PDI) ... to manage implementation of the performance demonstration criteria of Appendix VIII.

The PDI activities have been assessed by the NRC staff, as described in the letter from J. Strosnider (NRC) to B. Sheffel (PDI) dated March 6, 1996, and have been found to provide a significantly improved method for qualification of equipment, procedures, and examiners. Overall, the NRC staff found that PDI has established and is in the process of executing a well-planned and effective program to test UT technicians on selected portions of Appendix VIII. Accordingly, the NRC staff found that UT procedures qualified under the PDI program using performance demonstration methods provide an acceptable level of quality and safety.

Because performance demonstrations test the ability of equipment, procedures, and examiners to detect and size flaws, the demonstrations raise the performance threshold for examiners conducting ultrasonic inspections. For example, a sampling of individuals tested in the different piping examinations under the PDI program revealed that 22 percent of them did not satisfy the screening criteria for detection of flaws; 41 percent did not satisfy the screening criteria for length-sizing; 67 percent did not satisfy the screening criteria for depth measurement; and 49 percent did not satisfy the screening criteria for IGSCC. These percentages are based on a sampling that included retests. The PDI tests ensure that the equipment must have adequate sensitivity, the procedures must have sufficient detail, and the individuals must be sufficiently skilled in order to successfully qualify under the PDI program.

The improvements in UT techniques performed using Appendix VIII criteria became apparent in 1993 during the augmented examination of the reactor pressure vessel shell weld at the Browns Ferry Nuclear Power Plant, Unit 3, and in 1995 during the inspection of piping systems for IGSCC at the Millstone Nuclear Power Station, Unit 1. At Browns Ferry, the equipment, procedures, and examiners were qualified consistent with the objectives of Appendix VIII. The examination revealed 15 flaws that did not meet the ASME Code, Section XI, Subarticle IWB-3500, acceptance criteria and that required further evaluation. Of the 15 flaws, only 3 would have been recordable using conventional Section XI minimum inspection standards and RG 1.150 criteria, and only 2 of the 3 flaws would have required an analytical evaluation in accordance with Section XI, Subarticle IWB-3600. This experience indicates that flaws large enough to require analytical evaluation might not be detected using current UT standards.

Millstone Unit 1 inspectors performed an augmented UT examination for IGSCC in the welds in the reactor system piping. The licensee used a newly developed ultrasonic transducer technology to supplement the original examinations. Before the examination, UT examiners from Millstone who were qualified under the IGSCC Coordination Plan demonstrated the adequacy of the new transducer technology by successfully passing the Appendix VIII performance demonstration test administered through the PDI program. During

the augmented examination, the UT inspection personnel examined 264 of the 411 pipe welds and found that 35 welds had cracks. A review of examination records from 1984 through 1994 revealed 211 indications that were previously considered by Level III inspectors to be nonmetallurgical or geometric indications. During the 1995 inspection, 14 of the indications previously identified as nonmetallurgical or geometric were identified as flaws; 3 of these flaws developed through-wall leaks when they were mechanically buffed in preparation for repair by the NRC-approved overlay process. The Appendix VIII qualification by Millstone inspectors using normal IGSCC UT procedures increased the licensee's reliability in the detection of IGSCC. The additionally demonstrated capability of the new transducer technology under the PDI-administered program clearly increased the level of confidence in the new transducer technology used to identify previous errors made in flaw disposition.

The staff has been requiring for some time now that selected inspections be performed using performance-based qualification techniques (e.g., IGSCC piping inspections). The success in improved plant availability for BWRs by eliminating forced outages due to leakage in primary piping demonstrated that improved inspections not only are cost effective in terms of availability but also improve safety by limiting start ups and shut downs.

The above-mentioned experiences clearly depict the need for improvement by using performance demonstration methods in performing UT examinations of reactor vessels and piping. The NRC has initiated rulemaking to amend the codes and standards rule in paragraph 50.55a of Title 10 of the Code of Federal Regulations (10 CFR 50.55a). The rulemaking would result in updating the reference to Section XI of the ASME Code to include references up through the 1995 Edition. After completion of rulemaking, Appendix VIII to Section XI will become a requirement for all licensees. The process of amending 10 CFR 50.55a has become more complex than originally anticipated. The final rule incorporating Appendix VIII is not expected to be issued until mid-1998. As a result, the NRC is proposing to a generic letter to the U.S. nuclear industry as an interim approach for addressing concerns regarding performance demonstration of UT systems.

Discussion

The qualification statistics from the PDI discussed previously and the issuance of the regulatory guide and staff reports highlight the fact that some UT systems satisfying ASME Code, Section XI, amplitude-based UT requirements are less effective in identifying and characterizing certain types of flaws. The experiences at Browns Ferry Unit 3 and Millstone Unit 1 highlight the significant improvements in the effectiveness of UT systems when equipment, procedures, and examiners are qualified through a performance demonstration program. Therefore, a significant improvement is gained in the effectiveness of UT systems qualified through performance demonstrations (e.g., Appendix VIII) over those satisfying conventional Section XI amplitude-based UT requirements.

The early and accurate detection of flaws in plants is important for maintaining the structural integrity and ensuring the safety function of safety-related systems and components. As plants age, improved reliability in inspection methods, more flexibility in utilizing advanced technology, and a better ability to detect new forms of degradation gain increased importance in

ISI programs. The nuclear industry recognizes Appendix VIII as an improvement over the current ISI requirements, and the NRC staff finds that Appendix VIII criteria, as implemented by the PDI program, provide UT results that generally are superior to those of the 1989 (and earlier) Edition of Section XI of the ASME Code. The NRC staff finds that implementation of Appendix VIII criteria enhances the reliability of inspections and provides a significant improvement in the methods used to satisfy existing regulatory requirements and ensure plant safety.

Some licensees have already submitted requests to utilize Appendix VIII performance demonstrations as an alternative examination for selective ASME Code, Section XI, requirements. Licensees have also submitted requests to the staff to use Appendix VIII criteria in lieu of criteria in RG 1.150. Some licensees are using Appendix VIII concepts in developing alternatives to the IGSCC Coordination Plan, and the NRC staff has already approved the use of either the PDI program or the original IGSCC program for IGSCC qualification of examiners.

The NRC staff has determined that using only existing ISI requirements for performing UT examinations might not provide reasonable assurance that flaws can be reliably detected and sized in certain areas. The staff considers cracks and flaws in the reactor vessel and other safety-related components to be a concern when the possibility exists for flaws exceeding the ASME Code, Section XI, allowable flaw sizes not being reliably detected or sized. Adequate safety exists through defense-in-depth measures, leakage monitoring systems, and ASME Code margins in component design; however, significant improvement in the ability to reliably detect and size flaws in reactor vessels and piping can be achieved using performance demonstration methods. To assess whether the margins required by the ASME Code, Section XI, are adequately maintained and to ensure compliance with the applicable existing requirements previously identified, the NRC has concluded that it is appropriate to request certain actions and information from U.S. licensees.

The NRC staff is proposing to request this information through the issuance of a generic letter addressed to all U.S. licensees. The generic letter has been issued in draft form and is expected to be finalized within the next few months after allowing for public comments. In consideration of the information and concerns previously addressed, the proposed generic letter will request that each licensee perform an evaluation to determine whether its current ISI program ensures that flaws in the reactor vessel and safety-related piping are reliably detected and sized. If it is determined that flaws in the reactor vessel and safety-related piping cannot be reliably detected and sized, each licensee will be expected to take appropriate corrective action in future inspections to improve the capability to reliably detect and size flaws.

Conclusions

It is clear from a variety of experiences, including the PISC program, IGSCC inspections in BWR piping, the PDI, and Appendix VIII type reactor vessel inspection, that using only existing U.S. regulatory requirements on UT might not be adequate to ensure flaws in reactor vessels and piping can be reliably detected and sized. However, significant improvement in the ability to reliably detect and size flaws in reactor vessels and piping can be achieved using performance demonstration methods.

NRC FORM 426 (3-89) NRCM 3201

U.S. NUCLEAR REGULATORY COMMISSION

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Paper, Petten, etnerlands, March 11-13, 19.

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Ashok C. Thadani, Associate Director, NRR

SIGNATURE: A. Thadani — DATE: 3/6/97

Attachment 2

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NDE Conference

11 - 13 March 1997

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11 - 13 March 1997

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NDE Conference

11 - 13 March 1997

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Attachment 3

EPRI

US Piping Failure Data Base Program

Alan Chockie

Presented at:

International Cooperative Group on Piping Performance

March 13, 1997

Pettin, The Netherlands

EPRI Program Objectives

Objectives

- Develop a comprehensive and validated data base and statistical analyses of piping failures, non-leaking cracks, and fabrication defects at US nuclear power plants.

- To support US and international activities such as:
  - PSA Applications
  - Risk-Based (Informed) ISI
  - Risk -Based (Informed) IST
  - Reliability Centered Maintenance
  - Piping System Analysis

Products

- An electronic data base of piping failures and non-leaking cracks for:
  - each utility's plant
  - all other US plants (plant confidentiality maintained)
- A report of the data base and a statistical summary (similar to that in SKI 96:20)
- For EPRI members, an appendix on the statistical evaluation processes to allow plants to perform their own evaluation

Activities & Schedule

• Review publicly available records	9/96 - 1/97
• Review NPRDS records	11/96 - 3/97
• Conduct Pilot Plant Tests – Hatch 1 & 2 – Surry 1 & 2	3/97 - 4/97
• Distribute Finalize Survey Packages	4/97
• Revise Data Base based on responses	6/97 - 7/97
• Distribute Report and Data Base	9/97

Data Base

Number of Events (to date)

- Leaks & Ruptures -- 1800
- Non-Leaking Cracks -- 3000

Contents (from public records)

- Date
- Systems
- Pipe Size
- Failure Type
- Failure Mechanism
- Reference
- Comments

Additional Data Base Fields

Plan s will be asked to:

- review the data base
- make any corrections
- add additional events from their records
- add information if available on:
  - material
  - safety class
  - plant operating mode
  - component operating status

Report of Leaks

Plant Name	Date (mo/da/yr)	Seq #	System Name	Pipe Size (inches)	Break Definition	References	Failure Mechanism	Comments
Correct? Yes No	2/22/96	1	RHR	6	Leak	LER-96-001	IGSCC	Thru-wall leak (small); Check LER 94-003, 91-019, 89-042, 89-011 (E19)
Correct? Yes No	12/15/92	1	Containment heat removal	2	Leak	92-008	Construction Defect/Errors	Fitting failure, construction defects/errors (S687)
Correct? Yes No	2/13/87	1	Service water	6	Leak	PNO-II-87-011A	Unknown	Leaked fiberglass line, unknown cause (S1272)
Correct? Yes No	2/9/86	1	Feedwater	18	Rupture	86-020	Erosion/Corrosion	Erosion/corrosion (S686)

Basic Definitions

- Pipe > 1/2 inch NPS
- Tube < 1/2 inch
- Failure Type
  - Leak < 50 gallons per minute
  - Rupture (Large Break) > 50 gallons per minute
  - Non-leaks
    - Cracks
    - Wear/Wall Thinning

Failure Mechanisms

- Stress Corrosion Cracking
- Thermal Fatigue
- Vibration Fatigue
- Erosion Corrosion
- Local Corrosion (MIC, O2 pitting, etc.)
- Erosion Cavitation
- Construction/Fabrication Defect
- Design Defect
- Water Hammer
- Frozen Pipe
- Other
- Unknown

Attachment - 4

Attendance List
International Cooperative Group on
Piping Performance Meeting

O. J. Victor Chapman, UK (Rolls-Royce and Associates Limited)

Alan Chockie, USA (Chockie Group International, Inc.)

Jose M. Figueras Clavijo, Spain (Consejo De Seguridad Nuclear)

Damien Couplet, Belgium (Tractabel)

Robert Gerard, Belgium (Tractabel)

Ian M. Grant, Canada (Atomic Energy Control Board)

Markus Gribi, Switzerland (Swiss Association for Technical Inspections)

Gert Hedner, Sweden (Swiss Nuclear Power Inspectorate)

Ladislav Horacek, Czech Republic (Nuclear Research Institute)

Alfred Höfler, Germany (Gesellschaft fur Anlagen-und Reaktorsichereit)

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