INSERVICE INSPECTION PROCEDURES AND TRAINING ACCORDING TO THE ASME CODE

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ABSTRACT

Mandatory training of the technical staff at a nuclear power plant is of paramount importance if we are to avoid costly plant shutdowns. This training should include the requirements for both Preservice and Inservice Inspection, in addition to Quality Assurance procedures as required by the American Society of Mechanical Engineers (ASME) Code. The training is best accomplished by utilizing instructors who are thoroughly familiar with plant operations and the ASME Code, as well as serving on one of the Code committees. This paper focuses on the Inservice Inspection procedures and the results of an intensive training effort to implement such procedures.

THE ASME CODE

Emphasis should be placed on the word "Code" since in the United States, when rules are adopted by the legal jurisdictions and regulatory agencies of the government, the rules then become mandatory. The ASME Boiler and Pressure Vessel Code is an example of such a set of rules, and have been adopted by both the states in the United States, the Nuclear Regulatory Commission (NRC) of the Federal Government, as well as by the provinces in Canada. The ASME Code, as developed by the consensus committees of the American Society of Mechanical Engineers, is a group of administrative and technical rules and standards covering any combination of materials, designs, construction, installation, inspection and operation of equipment which rules are prepared for ready adoption into the laws of the governmental jurisdiction.

Section XI of the ASME Code, "Rules for Inservice Inspection of Nuclear Power Plant Components" is mandatory, having been adopted by the NRC, the jurisdictional authorities and voluntarily adopted by the utilities for the older "grandfather" nuclear power plants. Section XI provides the rules for the examination, testing and inspection of the Class 1, 2, and 3 components and systems in a nuclear power plant. Application of the mandatory requirements in Section XI begins when the requirements of the construction codes have been completed, including construction according to Section III of the ASME Boiler and Pressure Vessel Code, "Rules for Construction of Nuclear Power Plant Components".

RULES FOR INSERVICE INSPECTION

The rules are separated into three divisions covering the inservice inspection and testing of components of light water cooled plants, gas cooled plants and liquid metal cooled plants. The format and philosophy developed for the water cooled systems, outlined below, is modified only as necessary to adapt to the other systems. These rules detail:

- *Owner Responsibilities*
  The Owner is assigned the responsibility to determine the appropriate classification for each component or system in the plant and to design an arrangement and clearance adequate to conduct the required examinations.

- *Inspector's Duties*
  Section XI rules for inservice inspection of nuclear power plants are mandatory and the Authorized Inspector is assigned the duty to verify, to assure, or to witness that the responsibilities of the Owner and the requirements of Section XI are met.

- *Examination and Inspection*
  Examination denotes the performance of all visual observations and nondestructive tests and is detailed to the type of examination, the area to be examined and the frequency for each component and specific portions thereto. Examination personnel may be employed by the Owner.

  Inspection denotes verifying the act of performing the examinations by an Inspector representing a state or municipality of the United States, Canadian Province, Authorized Inspection Agency or other enforcement authority having jurisdiction over the nuclear power plant.

- *Standard for Acceptance*
  Indications of flaws detected during any inservice examination must be evaluated to determine acceptability by comparison to tabulated limits on flaw sizes or to the results of a detailed analysis.

- *Pumps and Valve Testing*
  The rules for testing pumps and valves represent a major addition to the original philosophy of inspecting the

pressure boundary in that emphasis is placed upon operating characteristics to improve assurance that the pumps and valves will perform as required when needed.

- *Repair Procedures*
  A direct consequence of exceeding the permissible acceptance standards is the need for in situ repair procedures. To provide the maximum flexibility in making in situ repairs, seven repair procedures were developed for Section XI.

- *Hydrostatic Test Requirements*
  Hydrostatic tests or pressure tests are required at the end of each inspection interval and following any repair or replacement.

- *Data Report*
  A Data Report is included to provide the official documentation that the requirements in Section XI have been met.

SYSTEM CLASSIFICATION

Classification of the systems in a nuclear plant is a mandatory requirement of the NRC regulations, published in Title 10, Code of Federal Regulations, Part 50 (10CFR50) and are divided into three classifications beginning with the systems most important to safety; that is Class 1. Classification of the systems, and their associated boundaries are extremely important, since the classification dictates which codes or standards are to be applied to both the construction of the components in the system and the Inservice Inspection and Inservice Testing of both the components in the system as well as the functional ability of the system itself.

Class 1 Systems

Class 1 systems are the primary systems containing the nuclear reactor pressure vessel and other components connected to the nuclear reactor pressure vessel whose function is to produce the steam by nuclear heat. Other components which are not capable of being isolated from the vessel itself are also required to be in the Class 1 classification by 10CFR50.

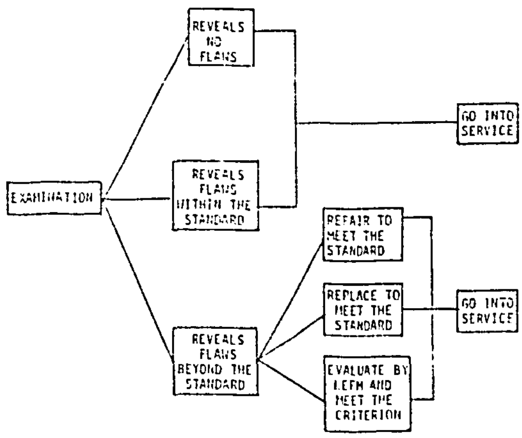
Class 2 Systems

Class 2 systems are those engineered safety and safeguard systems in a nuclear plant necessary to protect the Class 1 primary system, to mitigate the consequences of an accident and to shut the plant down safely, and to maintain the plant in a safe shut down condition. The containment system is, of course, Class 2 and includes vessels which would be normally constructed to the rules of Section III, either Class MC vessels for metal containment structures, or Class CC vessels for concrete containment structures.

Class 3 Systems

Class 3 systems are those systems essential to the safety of the nuclear power installation, but are isolated from either the Class 1 or Class 2 systems, and provide such functions as cooling water to the reactor coolant pumps, water to the containment spray system, etc.

INSERVICE ACCEPTANCE STANDARDS



INSPECTION REQUIREMENTS

The inspection requirements for the Class 1 components and the Class 1 systems are the most comprehensive in terms of the number of examinations to be performed, the equipment to be examined, and the number of times during the lifetime of the plant that the examinations are to be performed. All pressure retaining components and their supports are subject to inservice inspection due to the impact that a postulated failure would have on the safety of the plant. Some exemptions to the rigorous inspection of the Class 1 components are provided by their size or as a result of the minimal impact on safety should a failure occur. A preservice examination must be conducted on all Class 1 components and systems, even though the particular component or portion of the component would never require further examination during the normal life time of the plant.

The other systems in the plant require less rigorous examinations, and only those Class 2 systems scheduled for subsequent examinations are required to be examined prior to the operation of the plant.

Class 3 examinations are quite minimal, only a visual examination of the systems and their supports is required once at the end of each ten year period of time during a complete hydrostatic testing of the systems.

REPAIR & REPLACEMENT PROGRAM

A repair or replacement in a nuclear facility becomes necessary when the Section XI inservice inspection or some other event identifies a condition which is unacceptable for placing the unit or the part into service or for returning the unit or the part to service. This requirement applies to: 1) Systems and components and their supports constructed under ASME Section III Code Class 1, 2 and 3. 2) Systems and components and their supports classified as Class 1, 2 and 3 under 10CFR50 and USNRC Regulatory Guide 1.26, and 3) containments constructed or under construction.

Rules for repairs and replacements in nuclear power plants are contained in the ASME Section XI Code. These rules were prepared in order to provide a standard and acceptable method of accomplishing these tasks. The Nuclear Regulatory Commission has adopted these rules which makes them applicable to all nuclear power generating plants under their jurisdiction. These rules apply to all repair or replacements performed on the ASME Code Class 1, 2, and 3 pressure boundaries and their supports. It should be recognized that repairs include all metal removal and metal replacement activities. Replacements include alterations, modifications, backfits, retrofits, rerouting of piping, pump and valve replacement, system changes, and other activities.

The possession of an ASME certification or symbol stamp is not required or prohibited for Section XI repairs and replacement installations. The repair may be accomplished under the owners or repair organizations quality assurance program. However the owner, not the repair organization is ultimately responsible for a finished repair. An initial step in making a repair or replacement is to prepare a program that is subject for review by the enforcement and regulatory authorities having jurisdiction at the plant site. Standardized or generic repair/replacement programs may be prepared and submitted for routine maintenance type operations (such as replacement of pressurizer heaters and instrument line repairs). The services of an Authorized Inspection Agency are required for repairs. This includes metal removal as well as metal replacement by welding brazing or soldering. The inspector is responsible for assuring that the owner makes the repair in accordance with his repair program and for reviewing the owners Q.A. program.

TYPICAL REACTOR COOLANT REPAIR PROGRAM

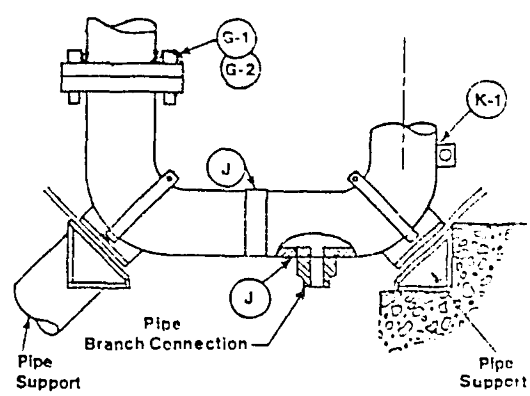
The inservice inspection program 2 is based upon the ASME Section XI code, including Summer 1975 Addendum. During inspection, liquid penetrant indications requiring repairs were located in the reactor coolant piping in the ASME Code Class 1 system. The indications were determined to be casting defects and will be repaired by grinding and/or welding as necessary to bring the piping back to design code requirements.

The reactor coolant piping was designed and fabricated in accordance with ANSI B31.1 1955 and ASME Section 1 1965 Edition with Nuclear Code Case N-10. The reactor coolant piping was installed in accordance with ASME Section III, 1971 Edition. Dye penetrant indications were found in the 2.55 inch min. wall ASTM A351-65 Grade CF8M cast elbow near a Weld 18 of the cold leg. The piping material is 2.335 inch min. thickness ASTM A312-65 Grade 316 seamless.

Repairs will be made in accordance with the following:

A. Defects will be removed in accordance with IWB 4100 of Section XI Summer 1978 Addendum.
B. Wall thickness measurements will be taken in repair areas to verify conformance with the original Design Specification and Construction Code requirements. Areas not in conformance with these requirements will be repaired by welding.
C. Welding procedures and welders will be qualified in accordance with the original installation code, ASME Section III, 1971 Edition. These welding procedures are suitable for welding the material.
D. All repair areas and repair welds will be examined by liquid penetrant method in accordance with ASME Section XI requirements. All repair welds will be examined by the radiographic method in accordance with original Construction Code requirements.
E. Pressure tests after repairs will be in accordance with Code Case N 210.
F. A new preservice inspection will be performed following the repair.
G. Quality assurance program will be in accordance with 10CFR50 Appendix B requirements.
H. Documentation will include all Section XI requirements and the completion of a NIS-2 Form.

INSERVICE INSPECTION PLAN PRIMARY COOLANT PIPE



COMPLIANCE WITH THE INSERVICE INSPECTION CODE

Even though it is mandatory to comply with the requirements stated in the ASME Code, there are many times when utilizing the provisions of the Section XI can lead to substantial savings in terms of both time and money during plant outages. Saving time during plant outages has always been a foremost consideration of the Committee, since it was never a desire that extended plant outages be attributed to the Code requirements. Although the main thrust of the Section XI code is to keep the plant in a safe operating condition, the program of inspections and tests can be accomplished during normal refueling outages and the plant can operate for another period of time — safely.

In a recent paper prepared by Larry Chockie for presentation at the A.F.I.A.P. Conference in Paris, October, 1986, emphasis was placed on the value contributed by the application of the rules for the analysis of flaws in Section XI. In this paper, it is stated that when the ASME formed the Boiler and Pressure Vessel Code Committee, over one hundred years ago, the goal was to reduce the number of steam boiler explosions. At the turn of the century boilers were exploding at a rate of more than one boiler per day in the United States. In the case of Section XI, and the operating nuclear power plants there can be no claim to reducing the number of explosions, but there are other benefits. An example of a real pay off was provided by C. V. Moore, a member of the committee, who analyzed the epidemic of intergranular stress corrosion cracking (IGSCC) of Boiling Water Reactor (BWR) piping and the program of measures which were taken nationally to cope with it.

Of the twenty three BWR plants then in service, twelve were reported to have cracked piping welds, with as many as thirty nine cracked welds in one plant. The remedies proposed varied from utilizing moisture sensitive tape or other local leak detection methods to induction heating to improve residual stresses, as well as weld overlays to replace lost effective wall thicknesses, shifts to hydrogen water chemistry and wholesale piping replacement. The significant feature of this program is that it was conducted in an orderly manner, as the plants were shut down for refueling - rather than by massive, across-the-board shutdowns such as occurred in the airline industry when problems were encountered following the introduction of commercial jet planes, and later wide-bodied jets.

The maintenance of these plants in service results from the ability of the plant owners and the Nuclear Regulatory Commission to provide assurance that they can be operated safely - an assurance which rests largely on the capabilities which the nuclear power industry has developed to meet the inservice inspection requirements of Section XI. These capabilities include: a) equipment, procedures and qualified personnel able to reliably detect and size IGSCC, b) the ability to evaluate the effect of IGSCC cracks of known size on structural performance with a reliability acceptable to the Nuclear Regulatory Commission, and d) trained insurance company inspectors to audit and certify the performance of examinations and repairs and thus provide assurance that requirements are being carried out, beyond the limited auditing capabilities of the Nuclear Regulatory Commission.

If these capabilities had not been in place and it had been necessary to shut down any significant fraction of these twenty three plants for times sufficient to either develop these capabilities or to replace the suspect piping, the costs to the economy would undoubtedly been orders of magnitude greater than all of the inservice inspection costs of all of the nuclear plants to date. By a rough calculation, if the shutdown of ten plants for an average of a year has been avoided, then the savings in replacement power alone would pay for inservice inspections for all plants for the next three hundred years. Alternatively, if this estimated savings-to-date were compared with the estimated costs-to-date of all of the inservice inspections performed on all nuclear plants the benefit-to-cost ratio is well over fifty.

To get this message of the advantages of using the provisions of the Code to the personnel involved in operating the plants, a series of publicly presented seminars was provided by members of the ASME committee, and later followed by more intensive training programs at the operating plants themselves.

INSERVICE INSPECTION SEMINARS

When only a few nuclear plants were in operation in the world, although many more were on order and were in the process of construction, a seminar open to the public was scheduled following the Third Conference on *Periodic Inspection of Pressure Vessels*, in London, September, 1976. The seminar was held in Manchester, England following the conference, and all the presentations were by officers of the ASME Section XI committee who had attended the Conference in London. Over one hundred and fifty individuals from many countries in Europe attended the seminar, and an additional audience of over a hundred had to be turned away due to the limitations on the size of the facilities in which the seminar was held.

The success of the seminar on Inservice Inspection, sponsored by the United Kingdom Atomic Energy Authority, led the members of the Section XI committee to schedule similar public seminars in the United States. These were quite successful from the standpoint of providing many participants who traveled to the various locations in the U.S. where the public seminars were scheduled. In fact, over nine hundred individuals have registered and attended these seminars over the following five years. These public seminars were being presented by the members, usually the officers, of the ASME Section XI member who was the chairman of that subgroup making up the committee, or a member most knowledge in that subject.

However, it was obvious that intensive training focusing on ASME Section XI was necessary if we were to assure continuing operation of our nuclear facilities. Because of this need, a cooperative effort to develop and present a series of seminars and training programs was begun by members of the ASME Section XI Committee and Technical Seminars, Inc. The seminars, of four to five days duration, were presented at popular hotel conference centers in the United States and Europe. Representatives from utilities, engineering organizations, material suppliers and government agencies attended one or more of these programs. They represented many countries including Great Britain, Belgium, Italy, France, Spain, Sweden, Federal Republic of Germany, Switzerland, Yugoslavia, and the United States.

The commonality of interests and interaction among peers was apparent if one observed the conduct of the seminars. Attendees had the opportunity, not only to absorb the formal material presented by the lecturers, but also to compare information with colleagues from organizations with different operational experiences. Course material for a typical seminar is presented in table 1.

TABLE I
Course Outline For Inservice Inspection Of Nuclear Plant Components

- Overview and application of the ASME Code including Addenda, Code Cases, and applicable Federal and State laws.
- General Requirements of Section XI, jurisdiction, owner's responsibilities, and personnel classification.
- Comparison of Class 1, 2 and 3 Systems including NDE, pressure tests and repair and replacements rules.
- Repair and Replacement programs including illustrative examples.
- Specialized examination Equipment for inside and outside inspection of Reactor Vessels, Steam Generators, and Reactor Coolant Pumps.
- Component Supports and their impact of ISI programs.
- NRC Documents including 10-CFR-50, Regulatory Guides, Standard Review Plans and Preparation.
- Standards and Flaw Evaluation.
- Pump and Valve Testing including the criteria for selection of pumps and valves.
- Mandatory Appendices including ultrasonic and eddy current NDE procedures.
- Summary of overall requirements of the Section XI and information on current changes and trends.
- Examination of Attendees.

Training Programs

The increasing demands for Inservice Inspection training coupled with the limitations on personnel away from the nuclear facility required that some training be performed at the plant site. Thus, in-house training programs were developed that would address the specific needs and priorities of a single power plant. This type of training provides a sense of esprit-de-corps and security that encourages discussion of critical problems unique to a single organization. In-House training is COST EFFECTIVE and is suited for organizations where large groups of employees cannot be away from the plant site for an extended period of time. Typically many sponsors of this type of training include Duke Power Co., Kansas Gas & Electric, Pacific Gas & Electric. Commonwealth Edison, Southern Company Services and Virginia Power Co.

Results

During the past three years, approximately 1000 engineering and technical personnel have completed Inservice Inspection training programs and were awarded Certificates of Completion and Continuing Education Units (CEU's). A sampling of job title classifications of approximately 300 attendees is detailed in table 2. An overview of the titles indicate that a broad range of plant personnel, from engineers to buyers and inspectors are involved in the Inservice Inspection process. At the conclusion of each seminar or training program, each attendee evaluates the performance of the instructors and the program in general. A sample of the responses in table 3 indicates an overall approval of this type of training activity.

TABLE 2
Training Program Attendees (1984 - 86)

Engineering		
Engineers	100	
Engineering Supervision & Management	8	
Engineering Technicians & Designers	13	
	121	40%
Quality Function		
QA Engineers	44	
Inspectors, Technicians, Auditors	85	
ISI Coordinators	18	
Supervisors	14	
	161	53%
Maintenance		
Engineers	6	
Technical Personnel	7	
Supervisors	2	
	15	5%
Miscellaneous		
Procurement	2	
Training	4	
	6	2%
SAMPLE TOTAL	303	100%

Conclusion

Effective training of the technical staff at nuclear facilities is best accomplished by state of the art intensive training programs that emphasizes current procedures in addition to changing codes and government regulations. The complexities of a nuclear power plant coupled with the large and highly specialized technical staff require several training programs that focus on their areas of interest. Thus additional programs that reflect these specialized needs and priorities have been developed or are in the development stages. They include Containments, Repairs, Replacements and Modifications, Retrofitting of Piping Systems, Replacement of Qualified Equipment and Procurement of Spare Parts.

TABLE 3
Course Evaluation andAttendee Comments

- "Industry overview by leaders of the ASME Code Committee."
- "Meetings with peers from various utilities and discussion of common ISI problems."
- "Larry Chockie's extensive understanding of the function of Section XI and style of teaching provide a comprehensive course."
- "Clarified the basic meaning and accepted interpretation of Code Statements."
- "The instructors knowledge and their ability to present this information to the studnents."
- "The course was well balanced, informative, and enjoyable."
- "Each instructor took pains to outline the basic philosophy behind the code rules. This is of great value where the letter of the Code is imprecise."

TYPICAL EXAMINATION QUESTIONS

1. In ASME Code Class 3 Systems
   A. There are exemption to visual examination of supports based on pipe size, service pressure, and service temperature.
   B. One-inch and smaller nominal pipe size is exempt.
   C. Two-inch and smaller nominal pipe size is exempt.
   D. "High Pressure" components require surface or volumetric examination.

2. The manway-to-vessel welds in manways in ASME Code Class 1 Systems
   A. Require volumetric examination
   B. Require volumetric and surface examinations
   C. Is exempt from examination
   D. Require Eddy Current examination

3. On steam generators there are
   A. ASME Code Class 1 welds only
   B. ASME Code Class 1, 2 and 3 welds
   C. ASME Code Class 2 welds only
   D. ASME Code Class 1 and 2 welds

4. The ASME Section XI Inspector
   A. Must carry ASNT Certificates in volumetric and surface methods
   B. Certifies all ASNT Level II personnel
   C. Witnesses or otherwise verifies that tests and examinations are performed
   D. Calibrates examination equipment

5. The half-bead repair welding technique
   A. Must be followed by a hydrostatic pressure test
   B. Requires no procedure qualification because it is prequalified in accordance with ASME Section IX
   C. Is applied to stainless steel welds only
   D. Requires a low temperature fast temperature rise stress relief.

6. When making an ASME Section XI repair
   A. A repair program is helpful and good practice
   B. The repair program is subject to review by the regulatory and enforcement authorities having jurisdiction at the plant site
   C. The repair program requires only the Corporate Quality Assurance Manager approval
   D. The repair program must include radiography of all welds

7. Modifications in operating Nuclear Power Plants
   A. Are exempted from of ASME Section XI rules
   B. Are always made to current ASME Section III rules
   C. Are under the overall jurisdiction of ASME Section XI
   D. Are under the total jurisdiction of the original code for the component being modified

8. An ASME Section XI repair requires
   A. An "N" stamp holder
   B. Radiographing of all repair welds
   C. A repair program
   D. The supervision of a registered professional engineer

9. The owner of a nuclear power plant
   A. Is responsible for the plant only after commercial operation begins
   B. Must maintain the ultrasonic calibration blocks used for examinations
   C. Is responsible for code classification of systems only if he has a registered engineer sign an approval document
   D. May delegate responsibility for inservice inspection to a vendor

10. In ASME Code Class 1 systems the inner radius section of pressure vessel nozzles
    A. Is an optional examination
    B. Is a required examination
    C. Is a required examination only if it is weld metal
    D. Is a required examination for NPS $\geqslant$ 4 in nozzles

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