《特别寄稿》

INSPECTION OF NUCLEAR POWER PLANTS

Joseph M. Varela

IAEA Expert, Korrea Advanced Energy Research Institute Cheng Ryang P. O.Box 7, Seeoul, Korea

(Received : April 26, 1982)

The inspection of nuclear power plants differs considerably from the inspection of fossil fueled plants, bridges or high rise buildings, principally because of three factors, which are; RADIATION, REMOTENESS, and RELIABILITY. I call this, the three R's.

Early in nuclear reactor construction we constructed in accordance with existing codes which were The Uniform Building Code, Standard Plumbing and Electrical Codes and local safety codes, however, after several malfunctions of the early research and development nuclear reactors, we were forced to add new requirements, for some but not all of the following reasons: Entry into the proximity of the reactor vessel (The heat producing "boiler") was limited by radiation and time of occupation, some remote critical components which required repair or removal were in high radiation areas and had not been designed for accessability, and generally, decontamination was often near impossible. Because of the many new problems facing this new industry, we at Atomics International, in the early 1950's formulated and specified our own standards for design modification, and inspection of the reactors which we constructed for university training of future nuclear engineers, and for the introduction and training of this new industry to many countries including Germany, Japan, Denmark, Italy etc. In the late 1950's the US industry was anxious to try this new power source, and I was recruited to join the US Atomic Energy Commission as their first construction inspector.

My first observation was the lack of adequate codes and inspection requirements for the utilities, their constructors or for the AEC inspectors, to invoke.

After a series of meetings the ASME Nuclear Code was drafted and shortly after the AEC "re-invented the wheel" and produced the 18 Criteria which was a modified copy of existing Military and Navy Criteria.

Section III of the ASME Code increased in its demands weekly, until now it overshadows all Codes, followed by inclusions into the Safety Analysis Report, 26 joint ASME and ANSI Standards, the US Nuclear Regulatory Commission's Regulatory Guides, ASME Section XI(Inservice Inspection)etc., with Quality Assurance / Quality Control as a dominating and obviously, necessary requirements, which is imposed on the utility from deisgn thru manufacturing of components, assembly, and construction, and thru operation, to the entire life of the nuclear electric generating facility.

So, we in the business of inspection have come a long way since the days when we performed NDE by striking a weld under hydrostatic pressure with a "calibrated" hammer, until one of my associates was seriously injured. But, before going into further detalis consider the introduction of the 18 criteria of Appendix B, as it is referred to :

INTRODUCTION, "Every applicant for a construction permit is required by the provisions of the Criteria (50.34) to include in its Preliminary Safety Analysis Report (SAR) a description of the Quality Assurance Program, to be applied to the design, fabrication, construction, and testing of the structures, systems, and components of the facility. The applicant is required in its SAR, information pertaining to the managerial and administrative controls to be used to assure safe operation.

Nuclear power plants include structures, systems, and components that prevent or mitigate the consequences of POSTULATED ACCIDENTS Viz.

What happens to the power plant when a tsunami, an earth-quake, or a telephone pole being propelled by a hurricane, strikes the plant ?

The introduction continues; This appendix establishes quality assurance requirements for the design, construction, and operation of those structures, systems, and components. The pertinent requirements of this appendix apply to all activities affecting the safety-related functions of those structures, systems, and components; these activities include designing, purchasing, fabrication, handling, shipping, storing, cleaning, erecting, installing, testing, operating, maintaining, repairing, refueling, and modifying. AND in a not too subtle a way, Quality Control or Inspection IS THE KEYSTONE THAT PROVIDES THIS ASSURANCE.

In NDE the visual observation of the inspector (QA / QC) is foremost, BUT his daily activities must be planned. The QC plans are formulated from the construction and fabrication plans and procedures from which the QC supervisor determines the critical or most important fabrication or construction steps which are classified as Hold Points.

The following is a condensed example of QC record keeping in relation to non-conformances:

NO. **ENTRY INFORMATION**

1. If the nonconformance was found during an in-process inspection being performed with a QC Field Inspection plan, enter the Inspection Plan number.
2. Check the block indicating whether or not the nonconformance involves an ASME Code Item.
3. Signature of the individual preparing the NCR and date of signature.
4. Signature of the Project Field Quality Control Engineer (PFQCE) or his delegate validating the nonconforming condition and concurring in the preparation of the NCR and date of signature.
5. Enter the NCR number taken from the Nonconformance Report Log and Status Book.
6. If the nonconforming item is removed from its installed location and replaced with another like item, record the part number and revision.

7. If the nonconforming item is serialized and removed its installed location and replaced with another like item, record the serial number.
8. Enter the source of the NCR. (Engineering, Construction, Procurement, Supplier, Contractor, Subcontractor, etc.)
9. The person validating the NCR shall indicate routing of the NCR for disposition.
10. Enter a concise and complete description of the nonconformance. Include serial numbers of serialized items and all dimensional or specification deviations. Define the activity when the nonconformance was noted, i.e. Receiving Inspection, Installation or testing. If a sketch would help to explain the condition, prepare one and attach it to the NCR.
NOTE: If sufficient space is not available to complete this block entry, a Continuation Sheet, QC-G3-3, Figure 2, shall be used completing block numbers 1 and 14 in accordance with this instruction. Indicate which block from the previous page is THE ENTIRE PROCEDURE AND INSTRUCTIONS IS 20 PAGES LONG.

Records are constantly audited by Quality Assurance as is the performance of Quality Control. The records must be maintained in a fire-proof locked vault for the life of the plant.

In addition to the Utilities, the contractors, sub-contractors and manufacturing companies QA/QC organizations, there is required by ASME the verification of designated HOLD POINTS to be witnessed by another independent inspector, known as the AUTHORIZED INSPECTOR (A. I.)

The requirements for, and the responsibilities of, The Authorized Inspector, are included in the Nuclear Code-ASME Section III, and it is the responsibility and obligation of the manufacturer and installer to see that the (A. I.) has the opportunity to perform his duties as required of him by law (Reference NA-5120 of ASME Sect. III) The (A. I.) and his survey team carefully consider how the manufacturer or installer (contractor), within his system, has provided for inspection and inspeciton documentation. Space for documentation of this must be made available by the manufacturer for the inspector, on in-process forms and controls, and in other check lists and documentation used by the manufacturer or installer in his system.

A Company must promptly arrange with an AUTHORIZED INSPECTION AGENCY for the Agency to review and accept the Quality System before the company requests review by the American Society of Mechanical Engineers (ASME).

NOTE: The court decree that opened the ASME certfiication to FOREIGN manufacturers, that all principal documents, be in the English language and in U. S. units of measure.

NDT Pre-Service Inspection (PSI) and In-Service Inspection (ISI)

PSI and ISI is another unique feature of nuclear component inspection in addition to all previous NDE inspections. This special final and inservice inspection is REQUIRED of all critical component weldments, classified as Class 1, 2 and 3, pressure retaining components.

All NDE methods are employed, however due to the remoteness and radiation levels of these components, ISI work is conducted thru ultrasonic and eddy current methods thru the use of specially designed remote controlled equipment. For the examination of weldments, all reflectors which produce a response greater than 100% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such reflectors, in terms of the acceptance - rejection standards specified, Secondly, the length of reflectors shall be measured between points which give amplitudes equal to 100% of the reference level. Personnel performing these NDE examinations shall be qualified with a written procedure prepared in accordance with SNT-TC-1A.

Frequency of ISI testing shall be performed on each pump, nominally once a month during normal plant operation.

Instrument Location, Transmitters, Computers: Instruments shall be located at their input source and read directly or via video transmission, or transmitters may be used. Instrument outputs may be fed directly into a computer for processing and indication or digital print-out.

Considering Code acceptance standards for radiography, there are certain restrictions on weld surface irregularities and film density; radiographs are required to have a "sensitivity" capable of showing a "Penetrameter" actually an image quality indicator not a defect simulator.

The ASME Code required sensitivity is usually considered to be 2 percent; but the equivalent sensitivity approaches 5 or 10 percent in thickness less then 1 / 4 inch; it is about 2 percent in thickness from 3 / 4 to about 2 inches, and is about 1 percent for thicknesses over 4 inches.

With selected equipment, fine grain film, improved techniques, and competent radiographers, it is not dificult to achieve a sensitivity as low as 1 / 2 percent, particularly for the thick sections of pressurized water cooled nuclear reactors. This achieved sensitivity is an acceptance standard, since marginal sensitivity places a practical limit on the size and quantity of tight cracks and fine porosity and inclusions which can be detected and rejected. ASME Code rejectability standards also include any type of crack or zone of incomplete fusion or penetration; elongated or intermittent aligned slag or inclusions within certain measured limits of length and spacing; and the size, quantity and distribution of porosity, frequency as represented by dots on a printed chart. Evaluation of these standards should consider the ability of the radiographic techniques to present an image which does represent the flaws, and the significance of flaws or combination of flaws detected (or not detected) on the ability of a welded joint to perform under the rigorous temperatures and pressures and service environment of a nuclear reacto .