

# **NRC Bulletin on Inspection of Alloy 82/182/600 Pressurizer Penetrations and Steam-Space Piping Connections**

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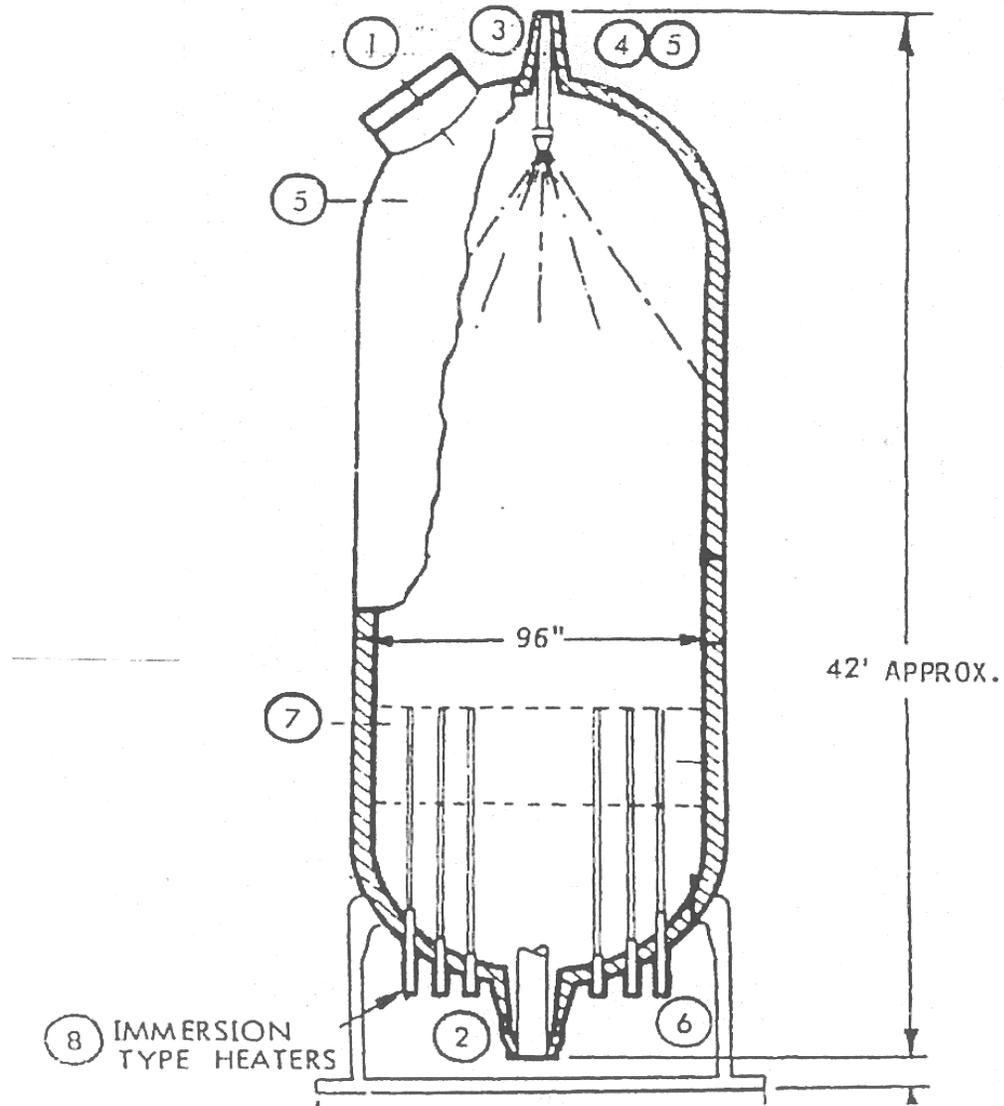
# Public Meeting Purpose and Objectives

- The NRC staff issued a bulletin regarding the inspection of Alloy 82/182/600 locations in or near the pressurizer boundary and susceptible to primary water stress corrosion cracking on April xx, 2004. The complete text of the bulletin may be found at <http://www.nrc.gov/reactors/operating/ops-experience/pressure-boundary-integrity.html>.
- The NRC staff issued the bulletin to request information from pressurized water reactor licensees regarding their past, present, and future inspection plans for the subject locations and their basis for concluding that their planned inspection program is adequate.
- The purpose of this public meeting is to provide an opportunity for recipients of the bulletin and members of the general public to ask questions of the NRC staff in order to receive clarification about the content of the bulletin.

# Operational Experience

- Extensive facility operating experience has demonstrated that Alloy 82/182/600 materials exposed to the environment present in the pressurizer of pressurized water reactors can lead to primary water stress corrosion cracking (PWSCC) of these materials
  - Alloy 600 pressurizer heater sleeves at Combustion Engineering-designed facilities
  - Alloy 600 diaphragm plates in pressurizer heater bundles at Babcock and Wilcox-designed facilities
  - Alloy 82/182 weld connections for pressurizer instrument lines
  - Alloy 82/182 butt welded connections in spray lines and safety and relief valve lines
- This is should be expected since the environment of the pressurizer consists of water and steam at a temperature of about 650 °F, approximately 50 °F warmer than reactor pressure vessel (RPV) upper heads and 100 °F warmer than RPV lower heads, where PWSCC has also been observed

# Pressurizer Diagram



# Recent Operational Experience

- Recent operational experience at both domestic and foreign facilities has caused the staff to focus on the inspection of these pressurizer penetrations and steam-space piping connections.
  - In Fall 2003, leakage was observed from pressurizer heater sleeves at Millstone 2 and Waterford 3 and confirmed to be the result of axially-oriented PWSCC in the pressure boundary portion of the heater sleeves
  - In October 2003, Palo Verde 2 discovered circumferentially-oriented PWSCC in the non-pressure boundary portion of five pressurizer heater sleeves during a planned activity to replace the pressure boundary portion of the unit's heater sleeves with Inconel Alloy 690 half-nozzles
  - In September 2003, inspections at Tsuruga Unit 2 in Japan found evidence of axially-oriented PWSCC in the nozzle-to-safe end butt welds in lines leading to the facility's safety and relief valves. Similar to circumferentially-oriented PWSCC found in lines at Palisades in 1993.
  - In November 2003, TMI 1 found PWSCC in heat affected zone of seal weld of pressurizer heater bundle diaphragm plate

# Initial NRC Actions

- The NRC staff engaged the industry about the potential implications of the Palo Verde 2 experience and the management of PWSCC in pressurizer heater sleeves at CE-designed facilities

Requested that Owners Group provide:

- Operability assessment to justify continued operation of the facilities over the near term
- Long-term inspection program for addressing this issue which must provide the staff with assurance that:
  - (1) unacceptable degradation of the heater sleeves or of the pressurizer head will be identified, characterized, and corrected, and
  - (2) the extent of degradation of the pressurizer heater penetrations at the affected facility will be adequately understood

# Industry Response

- Operability assessment submitted to NRC on December 23, 2003
  - Proposed a basis upon which to conclude that continued operation of the CE-designed fleet is justified (similar to RPV head analyses)
  - Documented inspections which are currently performed by licensees, not all of whom have been performing bare metal visual (BMV) inspections
- Final Owners Group proposal on inspection program submitted by letter dated January 30, 2004
  - 100 percent BMV of all heater sleeves every refueling outage
  - Followup NDE to characterize flaw orientation during refueling outage when leakage is observed by BMV
  - Expansion of NDE (to be determined through discussion with the NRC) if circumferentially-oriented cracking observed in pressure boundary portion of the leaking heater sleeve

# Development of the Bulletin

- Upon presenting the issue of PWSCC of pressurizer heater sleeves at CE-designed facilities to the NRR management, the staff was directed to develop a bulletin which would address the broader issue of Alloy 82/182/600 materials exposed to the pressurizer environment
- As addressed in the bulletin, an acceptable degradation management program would include:
  - Performing bare metal visual examinations of all Alloy 82/182 pressurizer heater penetrations and connections every refueling outage
  - If leakage is found, before returning to service, perform NDE to characterize the degradation present in the leaking penetration/connection and determine if circumferentially oriented flaws are present
  - If circumferential cracking is found, NDE examination of additional non-leaking penetrations or connections should be discussed with NRC staff in regards to support an extent of condition determination

# Bulletin 2004-xx Information Request

- Bulletin 2004-xx specifically requests:
  - (1)(a) A description of the pressurizer penetrations and steam space piping connections at your plant. At a minimum, this description should include materials of construction (e.g., stainless steel piping and/or weld metal, Alloy 600 piping/sleeves, Alloy 82/182 weld metal or buttering, etc.), joint design (e.g., partial penetration welds, full penetration welds, bolted connections, etc.), and, in the case of welded joints, whether or not the weld was stress-relieved prior to being put into service. Additional information relevant with respect to determining the susceptibility of your plant's pressurizer penetrations and steam space piping connections to PWSCC should also be included.

# Bulletin 2004-xx Information Request

- Bulletin 2004-xx specifically requests:
  - (1)(b) A description of the inspection program for Alloy 82/182/600 pressurizer penetrations and steam space piping connections that has been implemented at your plant. The description should include when the inspections were performed; the areas, penetrations and steam space piping connections inspected; the extent (percentage) of coverage achieved for each location which was inspected; the inspection methods used; the process used to resolve any inspection findings; the quality of the documentation of the inspections (e.g., written report, video record, photographs); and, the basis for concluding that your plant satisfies applicable regulatory requirements related to the integrity of pressurizer penetrations and steam space piping connections. If leaking pressurizer penetrations or steam space piping connections were found, indicate what followup NDE was performed to characterize flaws in the leaking penetrations.

# Bulletin 2004-xx Information Request

- Bulletin 2004-xx specifically requests:
  - (1)(c) A description of the Alloy 82/182/600 pressurizer penetration and steam space piping connection inspection program that will be implemented at your plant during the next and subsequent refueling outages. The description should include the areas, penetrations and steam space piping connections to be inspected; the extent (percentage) of coverage to be achieved for each location; inspection methods to be used; qualification standards for the inspection methods and personnel; the process used to resolve any inspection indications; the inspection documentation to be generated; and the basis for concluding that your plant will satisfy applicable regulatory requirements related to the structural and leakage integrity of pressurizer penetrations and steam space piping connections. If leaking pressurizer penetrations or steam space piping connections are found, indicate what followup NDE will be performed to characterize flaws in the leaking penetrations. Provide your plans for expansion of the scope of NDE to be performed if circumferential flaws are found in any portion of the leaking pressurizer penetrations or steam space piping connections.

# Bulletin 2004-xx Information Request

- Bulletin 2004-xx specifically requests:
  - (1)(d) In light of the information discussed in this bulletin and your understanding of the relevance of recent industry operating experience to your facility, explain why the inspection program identified in your response to item (1)(c) above is adequate for the purpose of maintaining the integrity of your facility's RCPB and for meeting all applicable regulatory requirements which pertain to your facility.

# Bulletin 2004-xx Information Request

- Bulletin 2004-xx specifically requests:
  - (2) Within 60 days of plant restart following the next inspection of the Alloy 82/182/600 pressurizer penetrations and steam space piping connections, the subject PWR licensees should either:
    - (a) submit to the NRC a statement indicating that the inspections described in the licensee's response to item (1)(c) of this bulletin were completed, and a description of the as-found condition of the pressurizer shell, any findings of relevant indications of through-wall leakage, followup NDE performed to characterize flaws in leaking penetrations or steam space piping connections, a summary of all relevant indications found by NDE, a summary of the disposition of any findings of boric acid, and any corrective actions taken and/or repairs made as a result of the indications found, **or**

# Bulletin 2004-xx Information Request

- Bulletin 2004-xx specifically requests:
  - (2) Within 60 days of plant restart following the next inspection of the Alloy 82/182/600 pressurizer penetrations and steam space piping connections, the subject PWR licensees should either:
    - (b) if the licensee was unable to complete the inspections described in response to item (1)(c) of this bulletin, submit to the NRC a summary of the inspections performed, the extent of the inspections, the methods used, a description of the as-found condition of the pressurizer shell, any findings of relevant indications of through-wall leakage, followup NDE performed to characterize flaws in leaking penetrations or steam space piping connections, a summary of all relevant indications found by NDE, a summary of the disposition of any findings of boric acid, and any corrective actions taken and/or repairs made as a result of the indications found. In addition, supplement the answer which you provided to item (1)(d) above to explain why the inspections that you completed were adequate for the purpose of maintaining the integrity of your facility's RCPB and for meeting all applicable regulatory requirements which pertain to your facility.

# Bulletin 2004-xx Information Request

- Bulletin 2004-xx specifically requests:

For lines attached directly to the pressurizer, with the exception of the surge line, the information requested in (1) and (2) above should be provided for any locations, including those remote from the pressurizer shell, which contain Alloy 82/182/600 materials which are exposed to conditions similar to those of the pressurizer environment.

# Conclusions

- The high operating temperatures associated with pressurizer penetrations and connections make them highly susceptible to PWSCC
- Adequate inspections for the purpose of identifying deposits resulting from PWSCC flaws may include performing bare metal visual examinations
- Adequate inspections of the subject locations are necessary to promptly identify and correct failures of the reactor coolant pressure boundary, operation with which is contradictory to facility technical specifications
- The information requested by the bulletin is necessary for the staff to determine if additional regulatory action is required