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MRP 2003-039

Subject: Recommendation for Inspection of Alloy 600/82/182 Pressure Boundary Components

During recent years, there have been a number of leaks in the PWR primary system pressure boundary due to cracks in Alloy 600/82/182 components and welds. Examples include the hot leg nozzle weld at V. C. Summer, a steam generator bowl drain line at Catawba, the top-of-pressurizer safety/relief valve nozzle welds at Palisades and Tsuruga, the bottom mounted instrument nozzles (BMIs) at South Texas Project Unit 1, numerous small bore lines in the CE fleet, and numerous vessel head penetrations. In addition, some cracks or indications have been discovered by volumetric and/or surface NDE before growing through-wall. These include cracks in Ringhals 3 & 4 hot leg nozzle welds, the Tihange surge line nozzle weld, V. C. Summer hot and cold leg nozzle welds, and numerous vessel head penetrations. With the exception of the BMIs (currently being analyzed), breaks or leaks associated with PWSCC of Alloy 600/182/82 are typically analyzed and bounded by a plant's design basis accident analyses. A significant line break at one plant would, however, represent an economic concern for the entire US PWR fleet. Because Alloy 600/82/182 is used as a transition material between low alloy steel and stainless steel, leakage from these locations represents a threat to the associated carbon steel material through boric acid corrosion degradation. Such leakage at Davis-Besse resulted in the most significant wastage to date of the carbon steel reactor vessel pressure boundary.

Most of the through-wall cracks have been discovered by evidence of leakage (boric acid residue), but in many cases this evidence has not manifested itself outside the insulation. Additionally, in the steam space, the extent of boric acid residue is limited, and evidence of leakage may only manifest itself in a visible spray pattern or rust streaks. Visual examination of borated systems is often the best way to detect leaks, but if the leak rate is very low, as has been the case for a number of the tight PWSCC cracks, examination of the component without removal of the insulation has been shown to be ineffective. Also, some boric acid deposits have been identified that appear to have been associated with leaks that may have been active for several years prior to discovery. This period is significantly longer than the 4-hour hold required by the ASME B&PV Code to inspect insulation for evidence of leakage during pressure tests, which is additional evidence that the Code inspection may not be fully adequate to detect PWSCC leakage from these components and welds.

Each plant will ultimately need to develop a planned inspection program for Alloy 600/82/182 taking into account the relative likelihood of leakage and the safety and economic risk of leakage. In the long term, these plans should be based on the industry recommended programs resulting from ongoing safety assessments and the plant's own assessments of safety and economic risks. The Butt Weld Working Group of the Alloy 600 Issues Task Group is finalizing safety assessments for Alloy 82/182 butt welds and is considering some form of augmented volumetric inspection recommendations, over and above the normal ASME B&PV Code or Risk Informed ISI required inspections. The need for such augmented volumetric inspection is driven by the PWSCC crack growth rate in these weld metals and the desire to prevent or minimize leakage events discovered by visual inspections. **In the interim, until those recommendations are finalized, the MRP recommends that a direct visual inspection of the bare metal (either through removal of insulation or remote visual examination inside the insulation) or equivalent alternative examination be performed at**

all Alloy 600/182/82 pressure boundary locations normally operated at greater than or equal to 350°F in the primary system within the next 2 refueling outages at each plant, unless performed during your most recent refueling outage.

For Alloy 600/82/182 locations in water space, visually inspect for evidence of leakage as much of the circumference and the surrounding areas as reasonably achievable. For Alloy 600/82/182 locations in steam space, this inspection should be essentially 100% of the surface because of the limited deposits that may be present.

For plants that have already developed comprehensive inspection programs, the program should evaluate operating experience, as it becomes available, to ensure the bases for inspection type and frequency remain valid.

In planning upcoming outages, priority should be given to the hottest locations (such as the pressurizer and hot leg weld locations) during the next refueling outage. Plants whose design significantly impedes access to perform the recommended examinations should initiate expedited actions, up to and including physical modifications, to allow implementation of the recommendation at the earliest possible scheduled outage opportunity. These recommendations are not intended to modify inspection programs for upper heads per the NRC Order EA-03-009, or the recent MRP recommendation for bare metal visual inspections of bottom mounted instruments (Ref. MRP 2003-17). Alternatives to the recommendations contained in this letter should be documented at the individual plant sites and be reflective of recent operating experience.

While implementation of these recommendations does not relieve any plant of their obligations to implement volumetric examinations in accordance with the ASME B&PV Code, Appendix VIII[1], and NRC regulations, it will ensure early detection of any existing leaks and will provide the utility and the industry an assessment of the condition of the plants.

In light of leakage and cracking events discussed earlier in this letter, non-visual NDE may ultimately be a prudent and necessary component in a comprehensive inspection plan to fully evaluate the condition of the Alloy 600/82/182 materials in the primary loop, particularly following visual detection of a leak.

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[1] These bare metal examinations can also enable the gathering of useful plant-specific information on joint configurations and access to prepare for future volumetric examinations. This is because weld geometric and access conditions present at some locations may limit the applicability of existing qualified UT procedures. In particular, existing dissimilar metal weld qualifications to ASME Section XI, Appendix VIII, Supplement 10 have limitations on detection or sizing that depend upon joint contour, crown condition, tapers, etc. Some of the critical locations for PWSCC susceptibility are at high temperature locations (e.g. pressurizer spray, relief, and surge lines) that may have to be examined manually, which also has limitations with respect to existing qualified procedures. Thus, it will also be important to determine which welds can be inspected with automated versus manual techniques. Finally, since some as-built configurations are not covered in the PDI DM qualifications set, some sites may need to develop site-specific mockups. Availability of the above information will enable licensees to adequately prepare for future volumetric examinations.