

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
OFFICE OF NEW REACTORS
WASHINGTON, DC 20555-0001

April 5, 2010

NRC INFORMATION NOTICE 2010-07: WELDING DEFECTS IN REPLACEMENT STEAM GENERATORS

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of or applicants for an early site permit, standard design certification, standard design approval, manufacturing license, or combined license issued under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

All holders of or applicants for a license for a fuel cycle facility issued pursuant to 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material."

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees to the problem of welding defects that were associated with the manufacturing of replacement steam generators (RSGs). The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

The licensee, Southern California Edison (SCE), contracted Mitsubishi Heavy Industries (MHI), to manufacture four RSGs in Japan for installation at San Onofre Nuclear Generating Station (SONGS) Units 2 and 3. MHI completed manufacturing and testing of the first two RSGs in 2008 and shipped them to SONGS Unit 2 for scheduled installation in October 2009. MHI was scheduled to complete manufacturing and testing of the two RSGs for SONGS Unit 3 in 2009.

On March 18, 2009, MHI conducted a routine visual inspection after completion of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section III primary and secondary side hydrostatic pressure test on the SONGS Unit 3 "B" RSG and discovered a 5-inch long surface flaw (crack) in the dissimilar metal weld between the divider plate, made from Alloy 690, and the channel head, made from low-alloy steel (LAS). The flaw

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formed between the LAS and the Alloy 152 butter. A photograph of flaw and a schematic diagram of the weld joint are shown in the enclosure.

After discovering this weld flaw, MHI conducted additional inspections with dye penetrant test (PT) and ultrasonic test (UT) examinations on all the divider plate to channel head welds in both SONGS Unit 3 RSGs. With the expanded inspections, MHI found several small surface flaws in the Unit 3 "A" RSG that was being manufactured at the same time. In addition, in both Unit 3 RSGs, UT examinations revealed that almost all of the Alloy 152 butter under the divider plate and some stainless steel cladding adjacent to the divider plate had separated from the LAS substrate. SCE performed the same PT and UT examinations on the two RSGs made for SONGS Unit 2 by MHI in 2008 and did not find any indication of flaws.

SCE and MHI investigated the root cause of the cracking in the SONGS Unit 3 RSGs. SCE and MHI determined that the separation in the SONGS Unit 3 RSGs followed the fusion line between the Alloy 152 butter/stainless steel cladding and the LAS substrate. The weld joint was prepared by removing the stainless steel cladding from the RSG surface using air carbon-arc gouging (ACAG) and surface grinding to prepare for the deposition of Alloy 152 as a butter pass. The root cause of the separation was associated with the ACAG technique. The ACAG resulted in higher carbon content and areas of higher hardness in the vicinity of the fusion line between the butter pass and the LAS substrate. During subsequent surface preparation by grinding, MHI did not ensure that all of the surface carbonized material was removed. The regions of higher hardness and variations in surface conditions led to unfavorable metallurgical properties at the interface between the Alloy 152 butter and LAS substrate. Separation between the Alloy 152 butter and LAS was subsequently identified during the inspections following the primary side hydrostatic testing of the SONGS Unit 3 RSGs. The cladding in the SONGS Unit 2 RSGs was removed by machining without using ACAG. As a result, the RSGs for SONGS Unit 2 passed the ASME Code Section III secondary side hydrostatic pressure test without any inspection issues.

SCE and MHI presented the results of their root cause investigation at a public meeting with the NRC on September 15, 2009. The presentation slides are available through the NRC's Agencywide Documents Access and Management System, under Accession No. ML092590470.

DISCUSSION

The welding defects identified at the fabrication facility on the RSGs for SONGS Unit 3 are unlike the weldability issues that are typically observed in the welding of nickel-based alloys. For the SONGS Unit 3 RSGs, surface preparation for the Alloy 152 butter was inadequate. Contamination from the ACAG, used to remove the stainless steel cladding, resulted in elevated hardness of the material adjacent to the fusion line that remained on the surface after the grinding step. When the butter pass was applied, the metallurgical bond between the LAS and Alloy 152 butter weld pass was not as strong as it should have been.

The fabricator followed approved welding procedures for dissimilar metal welding of Alloy 690 to LAS and had recently built two RSGs for SONGS Unit 2 according to these procedures without problems. However, for the SONGS Unit 3 RSGs, the fabricator requested and the licensee approved a deviation to allow using an alternative method (in this case ACAG) to prepare the

LAS surface for butter application. According to the ASME Code, Section IX, this deviation did not require the requalification of the welding procedure because this aspect of the weld joint preparation was not considered an essential variable.

ACAG could be used in the manufacturing or repair of any ASME Code Class 1, 2, or 3 component. The ACAG technique is an accepted procedure for removing metal. American Welding Society (AWS) C5.3:2000, "Recommended Practices for Air Carbon Arc Gouging and Cutting," states that welding on a surface after ACAG "may generally be performed with a minimum of grinding or cleaning." However, the standard also notes the limitation that the process "increases the surface hardness on cast iron and air hardenable metals. This may be objectionable."

ACAG is not specifically covered in Section III of the ASME Code; however, ASME Code, Section XI, IWA-4461 covers the qualification and use of a thermal removal process like ACAG. In addition, 10 CFR 50.55a(b)(2)(xxiii) states:

The use of provisions to eliminate the mechanical processing of thermally cut surfaces in IWA-4461.4.2 of Section XI, 2001 Edition through the latest edition and addenda incorporated by reference in paragraph (b)(2) of 10 CFR 50.55a are prohibited.

Although all specific requirements or standards were met, this event illustrates that control over all aspects of welding ASME Code Class 1, 2, and 3 components can prevent welding defects like those found in the RSGs for SONGS Unit 3 from occurring.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

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Enclosure: San Onofre Nuclear Generating Station (SONGS)
Replacement Steam Generator Welding Defects

Note: NRC generic communications may be found on the NRC public Website,
<http://www.nrc.gov>, under Electronic Reading Room/Document Collections.

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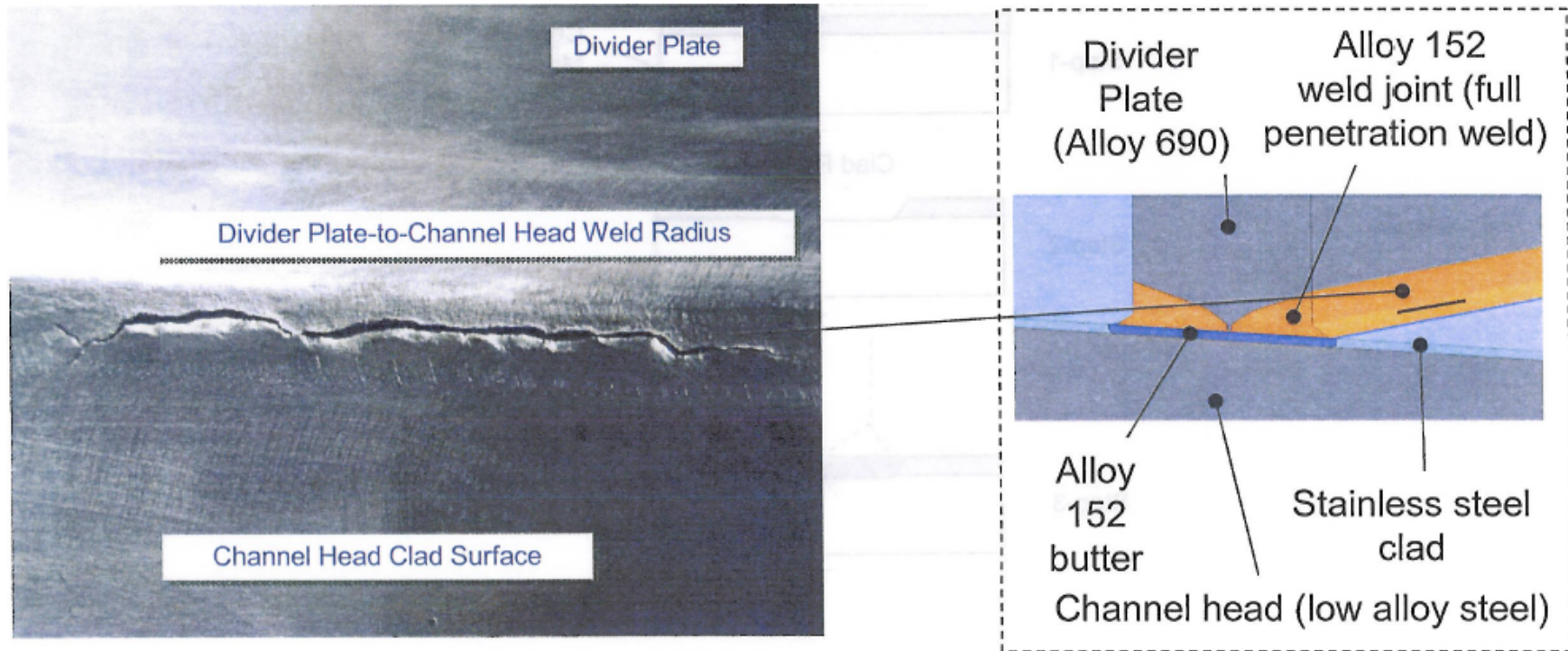
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San Onofre Nuclear Generating Station (SONGS)
Replacement Steam Generator Welding Defects



SONGS Unit 3 "B" Replacement Steam Generator
Cold-Side Crack in Divider Plate-to-Channel Head Weld