PNNL-26157, Rev. 1

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Summary of Literature Search of Relief Requests on ASME Code, Section XI, Volumetric Examination Coverage Requirements for Piping Butt Welds

October 2017

EJ Sullivan
TL Moran
MT Anderson

Prepared for the U.S. Nuclear Regulatory Commission
under a Related Services Agreement with the U.S. Department of Energy
CONTRACT DE-AC05-76RL01830

U.S. DEPARTMENT OF ENERGY

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service
5301 Shawnee Rd., Alexandria, VA 22312
ph: (800) 553-NTIS (6847)
email: orders@ntis.gov <http://www.ntis.gov/about/form.aspx>
Online ordering: http://www.ntis.gov

PNNL-26157, Rev. 1

Summary of Literature Search of Relief Requests on ASME Code, Section XI, Volumetric Examination Coverage Requirements for Piping Butt Welds

EJ Sullivan
TL Moran
MT Anderson

October 2017

Prepared for
the U.S. Nuclear Regulatory Commission
under a Related Services Agreement
with the U.S. Department of Energy
Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Acronyms and Abbreviations

ADAMS	Agencywide Documents Access and Management System
ANO-1	Arkansas Nuclear One Unit 1
ANO-2	Arkansas Nuclear One Unit 2
ASME	American Society of Mechanical Engineers
B&W	Babcock and Wilcox
BWR	boiling water reactor
CASS	cast austenitic stainless steel
CC	Code Case
CE	Combustion Engineering
CL	cold leg
CS	carbon steel
DMW	dissimilar metal weld
HAZ	heat-affected zone
HL	hot leg
ID	inside diameter/inner diameter
HPSI	high pressure safety injection
ISI	inservice inspection
LTOP	low temperature overpressure protection
NRC	U.S. Nuclear Regulatory Commission
OD	outside diameter/outer diameter
PAUT	phased array ultrasonic testing
PNNL	Pacific Northwest National Laboratory
PWR	pressurized water reactor
PWSCC	pressurized water stress corrosion cracking
PZR	pressurizer
RAI	requests for additional information
RCP	reactor coolant pump
RPV	reactor pressure vessel
SE	safe-end (only in appendices when referring to weld numbers)
SE	safety evaluation
SG	steam generator
SI	safety injection
SS	stainless steel
UT	ultrasonic testing

Contents

Figures

Tables

1.0 Introduction

Pacific Northwest National Laboratory (PNNL) performed a limited literature search of requests for relief from the American Society of Mechanical Engineers (ASME) Code, Section XI requirements that had been approved in Safety Evaluations (SE) by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation. One purpose of this literature review was to identify candidate weld configurations for future empirical research studies on improving examination coverage using advanced ultrasonic testing (UT) techniques and procedures. These empirical studies are intended to use measurements on mockups with different UT techniques as well as comparisons with results of UT modeling simulations. It is expected that the empirical portion of this work will likely be focused on welds made of materials that are known to be susceptible to degradation.

An additional purpose of the literature search was to generally characterize and assess the current limitations encountered in examining piping and nozzle butt welds that contribute to incomplete UT examination coverage. In this phase, an assessment of relief requests was made to develop recommendations for achieving improved ASME Code volumetric examination coverage. The assessment concentrated on configurations that are frequently the focus of relief requests where changes to requirements or practices have the potential to lead to a reduction in the number of these requests without compromising safety, or to enhance safety with more meaningful examinations.

The literature search pertains to requests for relief from volumetric examination coverage requirements for ASME Code Class 1 and 2 circumferential butt welds. The welds of interest in this search included a sampling of Code examination Categories B-J, B-F, and C F-1, and, in the case of risk-informed inservice inspection (ISI) programs, Examination Category R-A. Category C-F-2 welds were not included in this search as these welds are made of carbon and low-alloy steel. Studies have shown that inspections conducted through carbon and low-alloy steel are equally effective whether the UT sound fields have only to propagate through the base metal, or have to also propagate through the carbon steel weldment (Heasler and Doctor 1996). Further, ASME rules permit examination of these welds from either (one) side. Alternatively, the evaluation herein focused on stainless steel and Alloy 600/182/82 welds, which are more difficult to examine.

Separate searches were performed for the categories of welds indicated below.

- Pressurized Water Reactor (PWR) Dissimilar Metal Welds (DMWs) with Limited Coverage
  - ASME Code Case N-770-1 DMWs in PWRs
  - Pressurizer Nozzle DMWs (not covered by Code Case N-770-1)
  - Steam Generator Nozzle DMWs (not covered by Code Case N-770-1)
- PWR Reactor Coolant System Stainless Steel Welds with Limited Coverage
  - Reactor Coolant Pump Cast Austenitic Stainless Steel (CASS) Nozzle Stainless Steel Welds
  - Steam Generator Stainless Steel Safe-End-to-CASS Elbow Stainless Steel Welds
- PWR Stainless Steel Examination Categories B-J, C-F-1, and R-A Welds and Alloy 600/182/82 C-F-1 Welds (not covered by the preceding categories)
- Boiling Water Reactor (BWR) Examination Categories B-F, B-J, C-F-1, and R-A Welds.

2.0 Volumetric Examination Coverage Background

The volumetric examination requirements for ASME Code, Section XI, Examination Category B-F welds, Pressure-Retaining Dissimilar Metal Welds in Vessel Nozzles, and Category B-J welds, Pressure-Retaining Welds in Piping, are contained in Section XI, Table IWB-2500-1. The examination requirements for Category C-F-1 welds, Pressure-Retaining Welds in Austenitic Stainless Steel or High Alloy Piping, are contained in Section XI, Table IWC-2500-1. Similar requirements for Category R-A welds, Risk Informed Piping Examinations, are contained in ASME Section XI, Table R-2500-1, in Non-mandatory Appendix R.

These tables, as supplemented by notes and figures, specify the required volumetric coverage that has to be achieved during each examination, and the extent and frequency of examinations, as well as other related requirements. This study addresses circumferential butt welds in Tables IWB-2500-1, IWC-2500-1, and Table R-2500-1 in these four examination categories.

ASME Code Case N-460, “Alternative Examination Coverage for Class 1 and Class 2 Welds,” has been approved for use by the NRC in Regulatory Guide 1.147, *Inservice Inspection Code Case Acceptability*, and states that a reduction in examination coverage due to part geometry or interference for any Class 1 and 2 weld is acceptable provided that the reduction is less than 10 percent, that is, greater than 90 percent coverage is obtained. All commercial U.S. licensees invoke this Code Case for application during ISI.

Currently, there are no mandated requirements or definitive guidance for how to calculate the total coverage for volumetric (or surface) examination; this absence of requirements has led to inconsistent coverage calculations by licensees. The NRC has been addressing this inconsistency during safety evaluations of licensee requests for relief by asking licensees to submit cross-sectional drawings or sketches that depict angles of inspection and overall coverage achieved (Cumblidge 2015, ML15013A266).

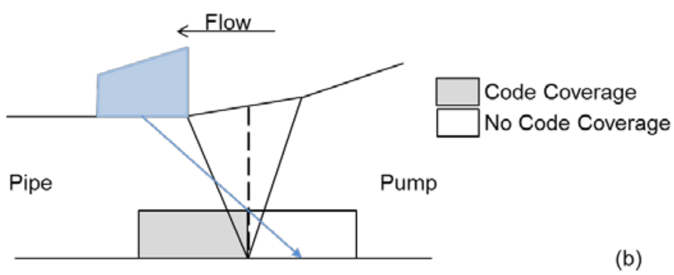
For example, similar reactor coolant pump (RCP) nozzle-to-piping welds from the same plant designs have been submitted for relief with widely varying claimed coverage (37.5 to 75 percent). Based on the three diagrams submitted by the licensees in support of their requests for relief, each of these welds was examined with essentially the same coverage. Though the inspection of these welds requires examination from two directions for both the axial (probe scanning toward the weld) and circumferential (probe scanning parallel to the weld) scans, due to configuration limitations, all three welds received only single-sided examinations from the pipe side. One weld had a stated coverage of 50 percent, while in a different loop of the same plant, the coverage was reported as 75 percent. The coverage for the third weld was reported to be 37.5 percent. Though the coverage stated for these welds should essentially be identical, they varied due to differences in coverage calculations as shown in the three scenarios depicted in Figure 1. Scenario 1: 50 percent coverage was calculated from inspecting 100 percent of both axial and circumferential directions from one side of the weld. No coverage could be claimed for the far side of the weld since there are no demonstrated procedures for single-sided examinations. Scenario 2: 37.5 percent coverage was calculated using 50 percent coverage for the axial scans and 100 percent coverage for the circumferential scans performed from one side of the weld. Scenario 3: 75 percent coverage was calculated using 100 percent coverage for the axial scans and 50 percent coverage for the circumferential scans.

Scenario 1: $\% \, coverage = \frac{100+100+0+0}{4}$ = 50.0 %

Scenario 2: $\% \, coverage = \frac{50+100+0+0}{4}$ = 37.5 %

Scenario 3: $\% \, coverage = \frac{100+50}{2}$ = 75.0 %

(a)



(b)

Figure 1. (a) Coverage Calculation Scenarios and (b) Coverage Diagram for a Single-Sided Examination of a RCP Nozzle-to-Pipe Weld

3.0 Literature Survey Methodology

In this literature survey, PNNL relied solely upon the NRC Agencywide Documents Access and Management System (ADAMS) for performing searches. Searches were generally begun using the content search feature. The document properties typically included a “document type” of safety evaluation and “document date” between 2007 and October 2015. Entries in the “document content” field included specified combinations of terms such as relief request, ASME Code, Section XI, volumetric, coverage, reactor, reactor coolant pump, pressurizer, and steam generator. Searches using these terms were sometimes narrowed down by also including terms such as “CC N-770-1” or “cast” in the document content field. Searches were made using different combinations of document field entries to ascertain whether the selection of document field entries was inadvertently limiting search results or excluding documents of interest.

“Safety evaluation” was chosen under document type as a starting point for most searches because SEs reflect NRC staff assessments of licensee requests for relief, contain information needed to determine whether the request is of interest for the subject literature search, and contain references to the licensees’ initial requests as well as responses to NRC staff requests for additional information (RAI). The ADAMS advanced search feature was generally used to locate documents of interest that were referenced in SEs. Relief requests for a particular search were summarized and applicable documents referenced in tables constructed for each of the four main categories of searches performed. These tables can be found in Appendices A, B, C, and D. However, while searches targeting each of the weld categories described in Section 2 above were separately performed, comprehensive searches that included all of the categories for each licensee identified during the initial searches were not performed. Consequently, all welds in all categories for each SE are not necessarily accounted for in the summary.

Appendices A, B, C, and D provide ADAMS reference numbers to licensee submittals, and page numbers within those submittals, to locate weld configurations and scan plans evaluated in this report. Each appendix also provides ADAMS reference numbers to the associated NRC Safety Evaluations and general descriptions for PWR or BWR coverage limitations, as applicable.

The main coverage limitation designations are Component Configuration, Weld Geometry, CASS Material, no qualified single-sided procedure (Single-Sided), and proximity to adjacent component or structures (Adjacent Component). Each of these general designations are defined below.

- Component Configuration – includes tapers or transition regions from valves, elbows, pumps, nozzles, weld-o-lets, flued heads, penetrations, sweep-o-lets, branch connections or tees, and too narrow a width of safe-end or too close proximity to adjacent welds; all/any of which may limit the available scan surface to part or all of one side of the weld. As can be seen, this designation category encompasses many conditions requiring individual analyses to determine if advanced UT methods or component modifications could be applied to increase meaningful coverage.
- Weld Geometry – weld crown presence, diametrical weld shrinkage, surface depressions or waviness. This designation also includes licensee statements concerning weld crowns not removed in order to meet minimum nominal wall thickness. Note that nominal wall thickness is not identical to critical wall thickness.
- CASS Material – no performance demonstration requirements defined in ASME Code, Section XI, Appendix VIII, Supplement 9 and no demonstrated single-sided procedures are available. Thus, no credit for volumetric coverage was claimed from the CASS side.
- Single-Sided – no existing ASME Code, Section XI, Appendix VIII, Supplement 2 performance-demonstrated procedures for single-sided examinations of austenitic stainless steels.
- Adjacent Components – proximity to adjacent piping, nozzles, structural restraints, and instrumentation limits scan area.

Typically, in order to achieve 100 percent coverage, a weld must be examined in four directions—two perpendicular to the weld called axial scans and two parallel to the weld called circumferential scans. Thus, when one of the above-described limitations is present, full coverage of the examination volume may not be achieved by one or more of the required scans.

4.0 Dissimilar Metal Welds in PWRs

The 94 welds discussed in this section are summarized according to configuration types as shown in Table 1 and Appendix A. Section 4.1 pertains to welds covered by ASME Code Case (CC) N-770-1, “Alternative Examination Requirements and Acceptance Standards for Class 1 PWR Piping and Vessel Nozzle Butt Welds Fabricated with UNS N06082 or UNS W86182 Weld Filler Material With or Without the Application of Listed Mitigation Activities, Section XI, Division 1.” Section 4.2 addresses pressurizer nozzle stainless steel DMWs not covered by CC N-770-1. Section 4.3 covers steam generator nozzle DMWs not covered by CC N-770-1. The requirements of CC N-770-1 were incorporated into 10 CFR 50.55a with an implementation date of the first refueling outage after August 22, 2011.

Table 1. PWR Limited Coverage Welds in Appendix A by Weld Configuration

Component Description	Number of Welds	Examination Description	Percent Coverage Claimed	Range of Diameters, inches
RCP nozzle CASS safe–end-to-CS elbow[(b)]	24	Single-sided from CS elbow side	(a)	30 and 36
RCP nozzle CASS safe–end-to-CS pipe[(b)]	24	Single-sided from CS pipe side	(a)	30 and 36
CASS safe–end-to-CS nozzle[(b)]	18	Single-sided from CS nozzle side	(a)	12
CS nozzle-to-SS safe-end with SS weld	2	Single-sided from SS safe-end side	26 to75	4 and 14
CS nozzle-to-SS safe-end with Alloy 52 weld	4	Single-sided from SS safe-end side	24 to 26	(c)
CS nozzle-to-SS safe-end with Alloy 52/152	2	Axial scan from nozzle side. Circumferential scan from safe-end side.	40.5 and 42	38
CS nozzle-to-CASS elbow with SS weld	6	Single-sided from CASS elbow side	49 to 65	34 and 38
CS nozzle-to-SS safe-end with Inconel weld	4	Single-sided from SS safe-end side	75	42
CASS safe–end-to-CS nozzle[(b)]	4	Two sided	(a)	12
CS nozzle to SS safe-end with Alloy 82/182 weld with Alloy 52 inlay[(b)]	2	Two sided	(a)	29 and 31
CS nozzle-to-SS safe-end with SS weld	4	Two sided	37 to 86	6 and 15

(a) Licensee's reported volumetric examination coverage in various ways, including ASME Code, Section XI-required coverage; MRP-139 recommended coverage; susceptible material coverage; Code-required coverage taking credit for examination of the CASS material; and Code-required coverage not including the CASS material. Percent coverage claimed will not be reported for these welds.
(b) Code Case N-770-1 welds.
(c) The diameters of some welds were not provided.

4.1 ASME Code Case N-770-1 DMWs

The initial focus of the literature survey of relief requests in PWRs was on welds within the scope of NRC requirements related to CC N-770-1. Searches on requests for relief from CC N-770-1 requirements for 32 of the 46 operating Westinghouse design plants were performed. Few requests for relief from CC N-770-1 requirements were identified; thus, searching on a relatively large percentage of the 46 Westinghouse plants was considered necessary to characterize CC N-770-1 relief requests for the Westinghouse fleet of plants.

Within the Westinghouse plants surveyed, only two requested relief from UT volumetric coverage requirements. One request pertained to less than the ASME Code-required coverage of a reactor pressure vessel (RPV) cold leg (CL) nozzle to safe-end weld for the baseline examination (Markey 2012). This nozzle was examined from the outside and coverage of 100 percent of the susceptible (non-stainless steel) material was claimed. This was the only relief request found for a RPV nozzle. As this literature search was focused on limitations of a more generic nature, this weld was not summarized in a table. The other request pertained to relief from circumferential scan coverage of the “C” steam generator (SG) CL and hot leg (HL) nozzle to safe-end welds because of surface contour as a result of repairs (Pascarelli 2013). No similar relief requests for SG welds covered by CC N-770-1 were identified, although relief requests on other dissimilar metal SG welds were identified and are discussed in Section 4.3. Other requests for relief related to CC N-770-1 requirements submitted by owners of Westinghouse-designed plants pertained to requests for approval of: weld overlays; an alternative to the ASME Code, Section XI, Appendix VIII root mean square sizing error requirements; alternative surface examination requirements; and an extended inspection interval for CL reactor vessel nozzle to safe-end welds.

Searches for requests for relief from NRC requirements on CC N-770-1 were conducted for all Combustion Engineering (CE) design plants. The results of these searches are shown in some detail in Appendix A and discussed in Sections 4.1.1 and 4.1.2 below. Searches for requests for relief from NRC requirements on CC N-770-1 were conducted for all Babcock and Wilcox (B&W) design plants. No requests for relief from UT volumetric coverage requirements were identified. Requests for relief from NRC requirements on CC N-770-1 pertained to examination interval extension for core flood nozzles and weld overlays.

4.1.1 Combustion Engineering Limited Coverage RCP CC N-770-1 Welds

Relief requests for RCP inlet and outlet nozzle CASS safe-end to carbon steel (CS) elbow or pipe welds were identified for seven CE-designed plants. The CASS safe-ends in these configurations are attached on one side to CASS pump nozzles by a stainless steel (SS) weld. The RCP nozzle safe-ends are attached on the other side to CS elbows or pipe sections with an Alloy 82/182 weld. Examples of selected configurations are shown in Figure 2. The examinations of the CE RCP CC N-770-1 welds were performed with phased array UT (PAUT). These welds were generally only examined from the CS side of the weld. Licensees report volumetric examination coverage for Alloy 82/182 welds in various ways, including: ASME Code Section XI required coverage; MRP-139 (EPRI 2008) recommended coverage; susceptible material coverage [(a)]; Code required coverage taking credit for examination of the CASS material; and Code required coverage not including the CASS material. In some cases, the manner of reporting coverage for the welds at a given plant for the initial submittal differed from the coverage reported in subsequent responses to NRC RAIs. For example, for the RCP nozzle welds, the coverage reported below is for the susceptible plus the ferritic material volumes.

(a) Susceptible material as defined by CC-N-770-1 is non-stainless steel material that is susceptible to primary water stress corrosion cracking and includes the weld, butter, and base material, as applicable. Susceptible materials are generally considered to be Alloy 600 base materials and Alloy 82/182 weld metal. The examination volume coverage for MRP-139 included the susceptible material plus ferritic materials.

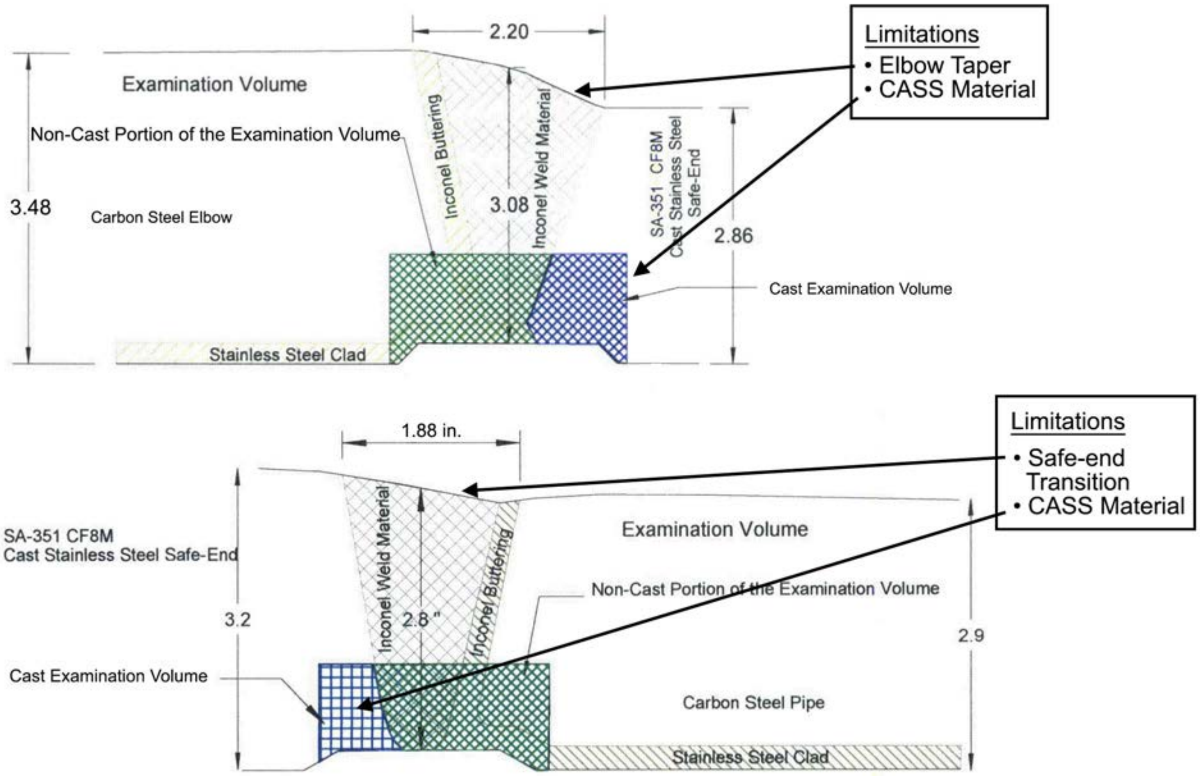


Figure 2. Examples of RCP CASS Nozzle-to-CASS Safe-End-to (a) CS Elbow (b) CS Pipe (Sartain 2014, ML14051A109)

For CE Plant A inlet and outlet DMWs, the axial scans achieved 100 percent of the Code required volume excluding the CASS material; that is, the susceptible plus ferritic materials. The circumferential scan achieved from between 74 and nearly 90 percent of the susceptible plus ferritic material volume. These examinations were single-sided examinations from the CS side. The SE for the CE Plant A RCP nozzle baseline examination of the RCP DMWs relied on UT modeling performed by PNNL (PNNL 2013a, ML13113A218) and a primary water stress corrosion cracking (PWSCC) flaw growth evaluation to provide a basis for an approved interval until the next inspection.

For the CE Plant B RCP inlet and outlet DMWs, the baseline axial scan achieved between 98 and 100 percent coverage of the susceptible plus ferritic material volumes. The baseline circumferential scan achieved between 79 and 85 percent coverage of the susceptible plus ferritic material volumes. For CE Plant C, the baseline axial scan coverages for these welds ranged from 94 to 100 percent coverage of the susceptible material plus ferritic material volumes. The baseline circumferential scans achieved between 82 and 85 percent coverage of the susceptible material plus ferritic material volumes. The SE for the CE Plant C RCP nozzle DMWs relied on UT modeling performed by PNNL (PNNL 2013b, ML13113A233) and PWSCC flaw growth evaluation to provide a basis for an approved interval until the next scheduled inspection. These examinations were single-sided examinations.

For CE Plant D RCP inlet and outlet DMWs, the axial scans achieved between 84 and 100 percent coverage of the susceptible plus ferritic material volumes. The circumferential scans achieved 100 percent coverage of the susceptible plus ferritic material volumes. These RCP weld examinations were also single-sided examinations.

For CE Plant E RCP inlet and outlet DMWs, the axial scans achieved between 66 and 71 percent coverage of the susceptible plus ferritic material volumes. The circumferential scans achieved between 92 and 100 percent coverage. The SE for the CE Plant E RCP nozzle DMWs relied on UT modeling performed by PNNL (PNNL 2013c, ML14149A195) and PWSCC flaw growth evaluation to provide a basis for an approved interval until the next inspection. The axial scans of the CE Plant F RCP nozzle DMWs achieved between 64 and 69 percent coverage of the susceptible plus ferritic material volumes. The circumferential scans achieved between 97 and 100 percent coverage of the susceptible plus ferritic material volumes. These examinations were single-sided examinations.

The axial scans of the CE Plant G (Mason 2012, ML12296A241) RCP nozzle DMWs achieved 100 percent coverage of the susceptible plus ferritic material volumes. The circumferential scans achieved between 76 and 83 percent coverage of the susceptible plus ferritic material volumes. These examinations were single-sided examinations.

Relief requests found in the literature search for RCP nozzle welds in the CE plants searched showed that axial scan coverage for the susceptible plus ferritic material volumes ranged between 64 and 100 percent. Circumferential scan coverage for the susceptible plus ferritic material volumes ranged between 74 and 100 percent. As indicated in Appendix A, these RCP DMWs were examined with manual non-encoded techniques except for CE Plant D, which was planning to employ automated encoded phased array probes for the CC N-770-1 baseline examination of these welds.

Examination limitations were caused by inspection through CASS material and other geometry and appurtenances such as outside diameter (OD) taper, welded structural steel insulation supports, and spray nozzle interferences on the CS side of the weld. Some DMWs are predicted to have less than full coverage at the inside diameter (ID) of the susceptible material; for example, the circumferential scan for axial flaws in the CE Plant G RCP DMWs (Mason 2012, ML12296A241, Figures 1–8). A DMW predicted to have less than full coverage of the ID for circumferential flaws over a short segment of the circumference is 30-RC-21B-10 at CE Plant C (Stanley 2012, ML12164A372, page 16). This limitation is due to an insulation support.

As noted above, a request for relief from the baseline examination requirements of CC N-770-1 was submitted for CE Plant A. The examination technique for the baseline examinations of the eight RCP DMWs was manual non-encoded PAUT. As indicated in Appendix A, the licensee also submitted a request for relief from the successive examination requirements of CC N-770-1 (Kalyanam 2013, ML13052A470). The examination technique for the successive examination is manual encoded PAUT. Under contract to the NRC, PNNL made a comparison of the estimated baseline coverage with manual non-encoded PAUT to the estimated coverage for the successive examination with encoded PAUT (PNNL 2013a, ML13113A218). The comparison showed that the coverage obtained by the encoded phased array successive examination achieved 6.3 percent higher coverage on average than estimated from the manual non-encoded PAUT for the baseline examinations. The main differences noted between the examinations are that the PAUT used for the successive examination also included shear wave circumferential scans and the skew angles for both the circumferential scan longitudinal and shear wave successive examinations were from −30° to +30°. For the baseline examinations the skew angles for the circumferential scan longitudinal waves were from −10° to +10°. Without completing a more detailed comparison through modeling both examinations, it would appear that slightly higher coverage was achieved in the successive examination than in the baseline examination through procedure and application changes, even though both procedures were based on PA technology.

4.1.2 Other Combustion Engineering Limited Coverage CC N-770-1 Welds

Relief requests on examination coverage were submitted for 12-inch diameter DMWs in the pressurizer surge, safety injection, and shutdown cooling systems in CE Plants A, B, C, and G. These 12-inch diameter welds consist of a CS nozzle welded to a CASS safe-end with an Alloy 82/182 weld. Examinations of these welds were performed from the CS side of the DMW, because Section XI requirements for examination of welds from the CASS side have not been prepared. An example of this configuration is provided in Figure 3, showing general coverage limitations caused by component configuration and CASS materials.

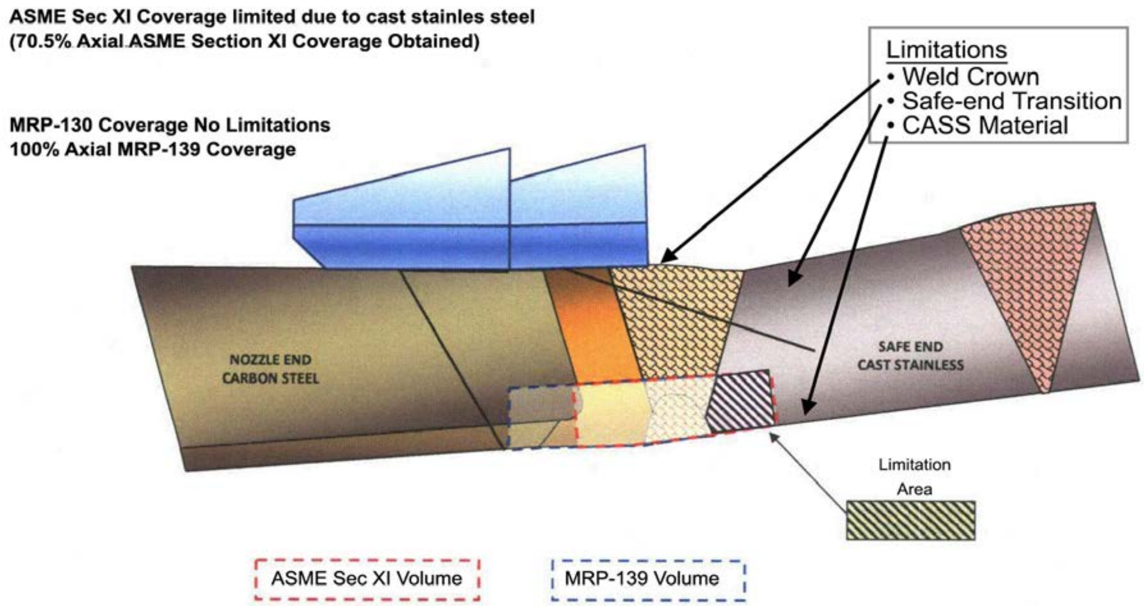


Figure 3. Example of PZR CS Nozzle-to-CASS Safe-End with Alloy 82/182 Weld (Stanley 2011, ML12009A073)

Manual non-encoded PAUT was used to examine the CE Plants B, C, and G 12-inch diameter welds summarized in Appendix A. The axial scans for all 22 of these 12-inch diameter welds achieved 100 percent coverage for the susceptible plus ferritic material. The circumferential scans achieved between 65 and 100 percent coverage for the susceptible plus ferritic material. For CE Plants A and C, there are no limitations that prevent examination of the ID of the susceptible plus ferritic material in these 12-inch diameter DMWs. For CE Plant B (Stanley 2011, ML12009A073) and CE Plant G (Mason 2012, ML12296A241), when performing circumferential scans there are geometric limitations that prevent examination of at least some portion of the ID of the susceptible material for eight of the eleven 12-inch diameter DMWs addressed in these relief requests. The regions of incomplete coverage at the ID of the susceptible material can be seen in the CE Plant B submittal (Stanley 2011) on pages 29, 35, 37, and 41 and in Figures 9–12 in the CE Plant G submittal (Mason 2012).

Information on smaller diameter DMWs at CE Plants B, C, and G is contained in Appendix A.

4.1.3 Findings of Literature Search on CC N-770-1 Welds

Based on the survey of relief requests PNNL conducted, it was shown with only two exceptions that requests for relief from the volumetric coverage requirements of CC N-770-1 were submitted for CE plants. The two exceptions are Westinghouse-designed plants discussed in Section 4.1. The general coverage limitations for these welds are component configuration, weld geometry, CASS material, no qualified single-sided procedure, and proximity to adjacent component or structures. A description of these general coverage limitations is defined in Section 3.0 above. Incomplete examination coverage occurred more frequently for the CE RCP DMWs than other weld types covered by ASME CC N-770-1 with the main coverage limitations being CASS material, component configuration, and weld geometry. The second most frequent CC N-770-1 welds that were the subject of incomplete coverage relief requests were CE 12-inch diameter CS nozzle to CASS safe-ends with the main coverage limitation being CASS material and component configuration. The coverage achieved for the RCP DMWs, in general, was lower than in the 12-inch diameter welds. PNNL concludes that should mockups be built for the empirical studies mentioned previously, the first mockup should be based upon CE-designed RCP safe-end to pipe welds. Such a mockup should be constructed to have coverage limitations for both the axial and circumferential scans. It is also recommended to consider including geometric limitations that prevent examination of at least some portion of the ID of the susceptible material when performing circumferential scans.

4.2 Pressurizer Nozzle Stainless Steel Dissimilar Metal Welds

A second category of DMWs in PWRs that was identified through the relief request literature search is pressurizer CS nozzles welded with SS-to-SS safe-ends.

Pressurizer DMWs with SS welds were identified in relief requests addressing six welds at four plants. The six welds are at a 4-inch pressurizer spray, three 6-inch relief, and 14-inch and 15-inch pressurizer surge nozzles. Dual-sided examinations were performed on the three relief nozzle welds and the 15-inch pressurizer surge nozzle weld. Volumetric coverages achieved for the dual-sided examinations were 37, 68, and 86 percent for the three relief nozzles and 83 percent for the 15-inch surge nozzle welds. The limitations to obtaining full coverage of the four welds that received dual-sided examinations were caused by nozzle and safe-end configurations and, in one case, the presence of lugs. These welds were examined with manual, non-encoded, conventional UT.

Single-sided examinations were performed on the 4-inch pressurizer spray nozzle and on the 14-inch pressurizer surge nozzle weld. UT examination coverage achieved for the single-sided examinations were 75 percent for the pressurizer spray nozzle weld and 26 percent for the 14-inch pressurizer surge nozzle weld. The limitation for examination of the 4-inch pressurizer spray nozzle is because of the physical design of the CS nozzle taper, which prevents performing an axial scan from the nozzle side. Increasing the volumetric examination coverage for this spray nozzle weld might be possible with single-sided qualifications for austenitic welds. The limitations on examination of the 14-inch surge nozzle weld were caused by the nozzle configuration and the configurations of a weld crown and safe-end restricting probe contact. Increasing the volumetric examination coverage for the surge nozzle may be possible if the weld crown could be removed and with single-sided qualification for austenitic welds.

4.3 Steam Generator Nozzle Dissimilar Metal Welds

A third category of DMWs in PWRs that was identified through the relief request literature search is steam generator CS nozzles welded with SS-to-CASS elbows or CS nozzles welded with Alloy 52/152 to SS safe-ends. SG DMWs were identified in relief requests addressing 16 welds at 4 plants.

Examination procedures for DMWs are PDI-qualified for single-sided examinations as the weld crowns are procedurally required to be ground flush enabling scanning over the weld. DMWs without CASS material can achieve full coverage examinations, but this is not the case with CASS material on the far side of the weld as coverage cannot be claimed due to performance demonstration requirements not yet defined in ASME Code, Section XI, Appendix VIII, Supplement 9.

Six of the SG nozzle welds are at Westinghouse Plant C and involve CS nozzles joined to CASS elbows by SS welds. The examinations were performed from the CASS elbow side and the licensee stated that it utilized ASME Code, Section XI, Appendix VIII-demonstrated personnel, equipment, and procedures for this examination. Claimed coverage for these examinations ranged from 49 to 65 percent. The scan coverage was limited due to component configuration in regards to nozzle and elbow tapers. For more details on limitations, see the table and references in Appendix A. The scan plans for these welds claim credit for coverage in the elbows, welds, and CS nozzles as shown in the Figure 4 example. Completion of efforts to develop and implement ASME Code, Section XI, Appendix VIII, Supplement 9 for CASS examinations would appear to be necessary to improve the quality of these examinations with performance-demonstrated procedures and to better quantify the coverage. In the interim, the implementation of ASME Code Case N-824, *Ultrasonic Examination of Cast Austenitic Piping Welds From the Outside Surface Section XI, Division 1*, with conditions, as proposed by NRC in the *Federal Register* on September 18, 2015 (80 FR 56820, p. 56838), may enable meaningful examinations to be conducted in these components. Eight welds at Westinghouse Plants D, E, and F involved single-sided examinations from the safe-end side. These plants have CS SG nozzles welded with Alloy 52/152 to SS safe-ends. The volumetric coverage achieved from the examinations of the welds at Westinghouse Plants D and E was 75 percent for all four welds. The volumetric coverage achieved for the examinations at Westinghouse Plant F was approximately 25 percent.

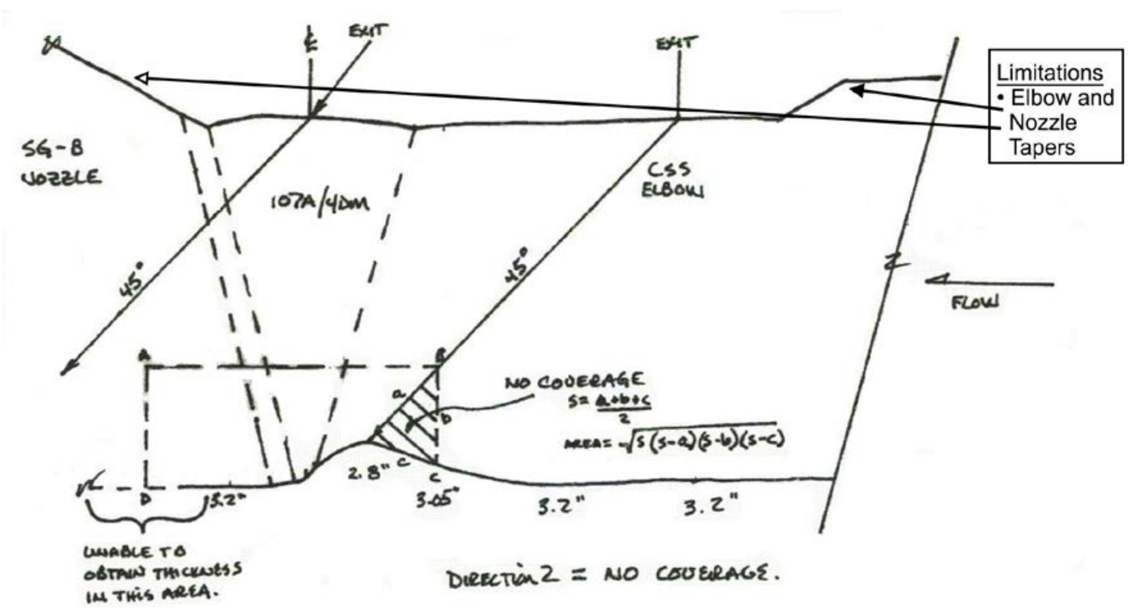


Figure 4. Example of CS Nozzle-to-CASS SS Elbow Where Only Single-Sided Access was Obtained Due to Limitation Caused by Component Configuration of the Nozzle and Elbow Tapers (Wheeler-Peavyhouse 2013, ML13178A006). Note: This inspection credited examination from CASS material using a PDI-qualified ASME Code, Section XI, Appendix VIII, Supplement 10 procedure. Although this is allowable, this is not typically done due to absence of a qualified ASME Code Section XI, Appendix VIII, Supplement 9 procedure.

The two remaining welds are at Westinghouse Plant G and were scanned in the axial direction (for circumferential flaws) from the nozzle side and were scanned in the circumferential direction (for axial flaws) from the safe-end side. Axial scanning from the safe-end side could not be performed because of the configuration of the safe-end and the CASS elbow welded to the other side of the safe-end. The volumetric coverage achieved for these two welds was approximately 40 percent.

5.0 Reactor Coolant Pump Nozzle and Steam Generator Safe-End Stainless Steel Welds

All 33 welds discussed in this section are stainless steel welds summarized in Table 2 and Appendix B. Section 5.1 involving reactor coolant pump CASS nozzle stainless steel welds to CASS safe-ends, stainless steel safe-ends, CASS elbow, CASS pipe, and stainless steel pipe. Section 5.2 covers steam generator nozzle stainless steel safe-ends to CASS elbow welds.

Table 2. PWR Limited Coverage Welds in Appendix B by Weld Configuration

Component Description	Number of Welds	Examination Description	Percent Coverage Claimed	Range of Diameters, inches
RCP CASS nozzle to SS safe-end	10	Single-sided from safe-end side	37.5 and 50	28 and 33.5
RCP CASS nozzle to CASS elbow	2	Single-sided from elbow side	48 and 50	31
RCP CASS nozzle to SS pipe	1	Single-sided from pipe side	50	29
RCP CASS nozzle to CASS pipe	3	Single-sided from pipe side	50 and 75	32
RCP CASS nozzle to CASS safe-end	1	Single-sided from safe-end side	50	30
SG SS safe-end to CASS elbow with SS weld	6	Single-sided from safe-end side	0 to 19.5	36
RCP CASS nozzle to CASS elbow	7	Dual-sided	40 to 82	31[(a)]
RCP CASS nozzle to CASS pipe	1	Dual-sided	90	31
RCP CASS nozzle to CASS safe-end	2	Dual-sided	18	30

(a) The diameters of some welds were not provided.

5.1 Reactor Coolant Pump Nozzle Stainless Steel Welds

Searches for relief requests involving RCP nozzle SS welds were identified for 20 welds at 7 plants. Two of these welds consist of CASS nozzles welded to CASS safe-ends at two CE plants (E and G) in this category. The examination of a weld at CE Plant G was dual-sided, but the volumetric coverage claimed was only 18 percent. The licensee's coverage calculations did not credit full axial scans that were completed in two directions as they were limited on both sides by component configuration and by the absence of qualified procedures to claim any coverage on the far side of the weld (see Figure 5). The examination of another weld at CE Plant E was single-sided from the safe-end side and the volumetric coverage claimed was 50 percent. The limitations for this weld were "Component Configuration" caused by the taper on the pump side and by the absence of qualified procedures to claim any coverage on the far side of the weld (see Figure 6). Single-side demonstrations to address examining components with adjoining CASS materials would certainly enable obtaining increased coverage of these CASS-to-CASS configurations. The implementation of ASME Code Case N-824, with conditions proposed by NRC, may increase meaningful volumetric coverage in these components provided that the configuration on the CASS side of the weld provides access for scanning.

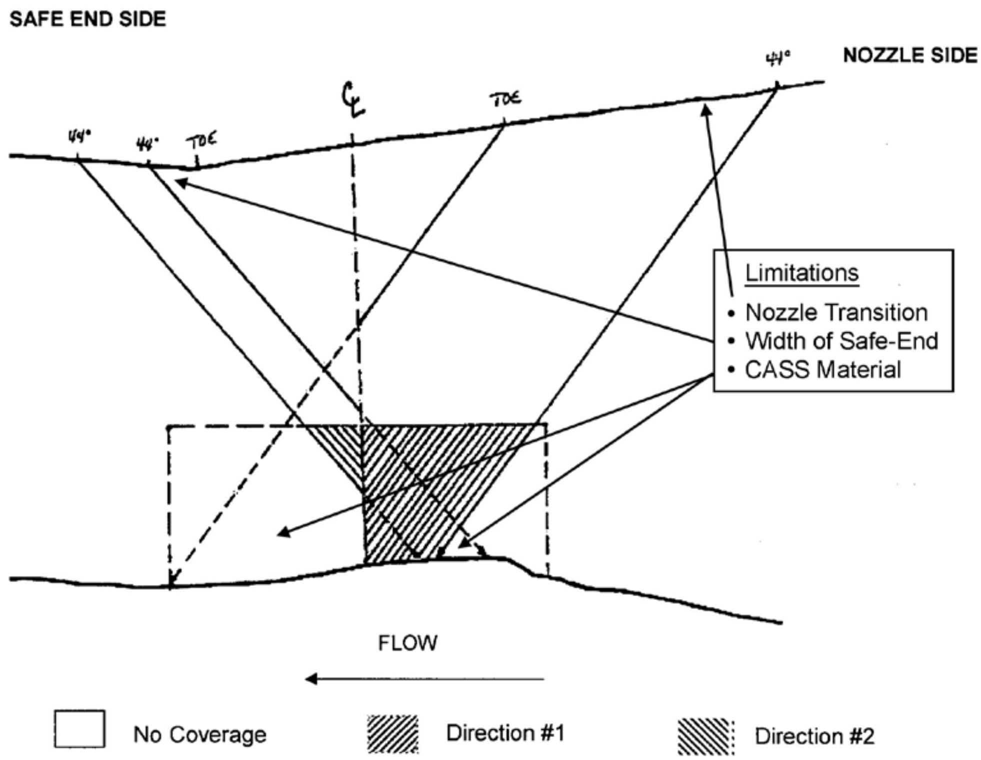


Figure 5. Example of CASS Nozzle-to-CASS Safe-End where Dual-Sided Access was Obtained But Limited on Both Sides due to Component Configuration of a Nozzle Transition and Width and Shape of Safe-End and CASS Material (Murillo 2009, ML093160319)

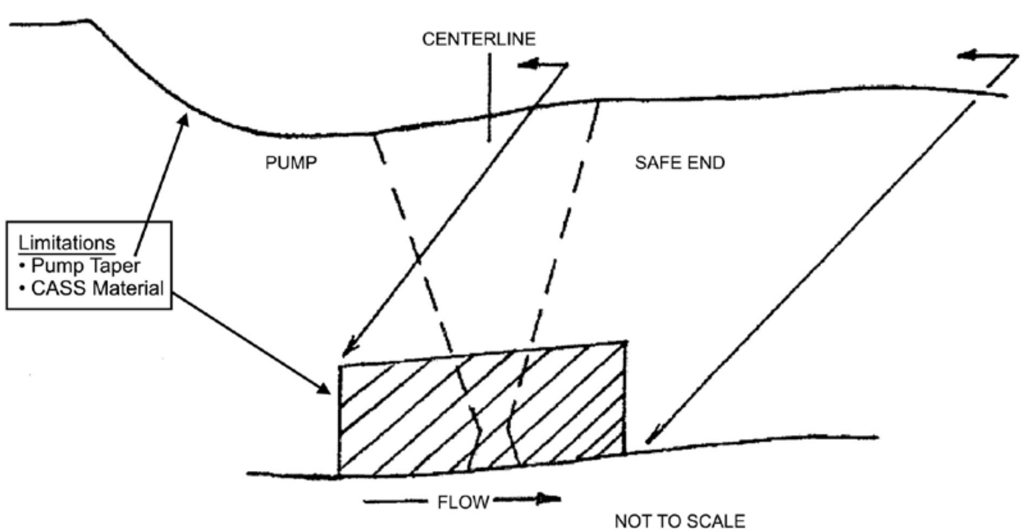


Figure 6. Example of CASS Pump-to-CASS Safe-End where Only Single-Sided Access was Obtained due to Limitation Caused by CASS Material and Component Configuration of the Pump Taper (Katzman 2009, ML090430304)

Ten of the welds consist of CASS nozzles welded to SS safe-ends at the three B&W plants in this category. The examinations for these ten welds were all single-sided from the safe-end side and limited by CASS material and component configuration caused by the weld taper of the nozzle. The volumetric coverage achieved for the nine welds at the B&W Plants A and B was 37.5 percent, and for the weld at B&W Plant C, it was 50 percent. Single-sided demonstrations to address examining austenitic components with adjoining CASS materials would certainly enable obtaining increased coverage of these SS-to-CASS configurations.

The remaining eight welds in this category are located in three Westinghouse-designed plants. Seven of these welds are configured with CASS nozzles welded to CASS elbows or a CASS pipe. The remaining weld is between a CASS nozzle welded to a wrought austenitic pipe. The welds at Westinghouse Plant H were examined prior to ASME Code, Section XI, Appendix VIII implementation; while examination was from both sides, it was partially limited when scanning from the nozzle side (see Figure 7). The examinations for five of these welds, all single-sided, were performed from the elbow or pipe side and limited due to CASS material and component configuration caused by the nozzle taper. For more details on limitations, see the table and references in Appendix B. As noted above, single-sided demonstrations to address examining austenitic components with adjoining CASS materials would certainly enable obtaining increased coverage of these SS-to-CASS configurations. The implementation of ASME Code Case N-824, with conditions proposed by NRC, may increase meaningful volumetric coverage in these components provided that the configuration on the CASS side of the weld provides access for scanning.

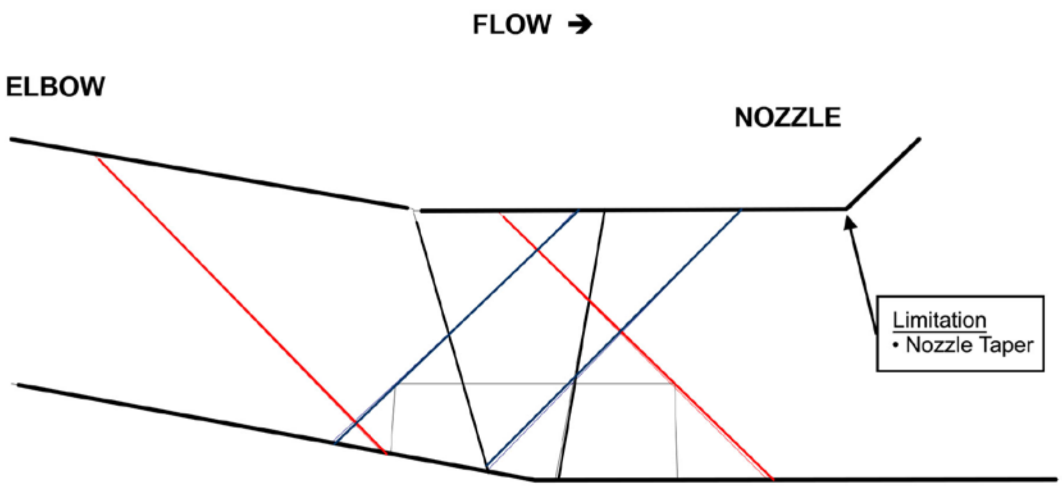


Figure 7. Example of CASS Nozzle-to-CASS Elbow Where Dual-Sided Access was Obtained and Only Partially Limited by the Nozzle Taper When Scanning from the Nozzle Side (Ajluni 2009, ML091110411)

5.2 Steam Generator Safe-End Stainless Steel Welds

Searches for relief requests involving SG nozzle SS welds were identified for six welds at two Westinghouse designed plants. All six welds are between SS safe-ends and CASS elbows. Single-sided examinations were performed from the safe-end side. No Code (zero) coverage was claimed for the two welds at Westinghouse Plant G. The coverage claimed for the four welds at Westinghouse Plant I was 19.5 percent. These welds were limited partially due to component configuration and weld geometry but primarily due to no examinations being performed from the CASS elbow side (see Figure 8 for configuration). For more details on limitations, see the table and references in Appendix B. Development and implementation of Supplement 9, in conjunction with single-sided demonstrations for austenitic components with adjoining CASS materials, might enable obtaining increased coverage of these SS-to-CASS configurations. In the interim, the implementation of ASME Code Case N-824, with conditions proposed by NRC, may increase meaningful volumetric coverage in these components provided that the configuration on the CASS side of the weld provides access for scanning.

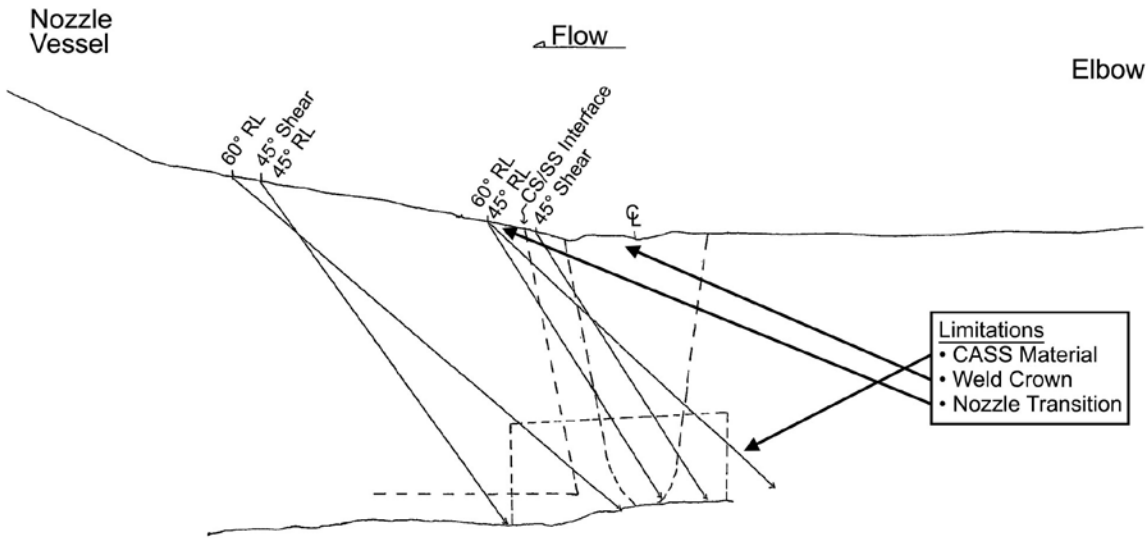


Figure 8. Example of SS Safe-Ends and CASS Elbows with No Inspections Attempted from the CASS Elbow Side (Gebbie 2011, ML11110A042)

6.0 PWR Limited Coverage Stainless Steel Welds

A search was performed for an additional category of PWR limited coverage welds. The welds from this search are not connected directly to reactor pressure vessel, pressurizer, SG, or RCP nozzles, except for an ASME Code Class 2 auxiliary feedwater SG nozzle weld. None of the welds identified in this search overlap with the welds considered in Sections 4.0 and 5.0 above. The search was performed on 17 PWR units for relief requests dating back to about 2008. Fifty-two welds were identified in this search. The welds included in this search include SS and Alloy 600/182/82 welds, but not CS welds. Forty-eight welds in this category are SS welds between SS components. Two welds in this category involve CS nozzles welded to SS safe-ends with SS welds. The remaining two welds involve Alloy 600/182/82 welds to CS components on either side of an Alloy 600/182/82 transition ring. The welds identified in this search include ASME Code, Section XI, Examination Categories B-J, R-A, and C-F-1. The search identified relief requests on 12 welds in 12 Westinghouse units, 31 welds in 1 CE unit, and 9 welds in 4 B&W units. The results of this search are summarized in Appendix C. The welds identified cover 18 different types of configurations. This wide range of weld configurations was considered sufficiently representative of PWRs to limit the search to 17 units, however, it is not all encompassing.

The general coverage limitations found in this study are component configuration, weld geometry, CASS material, single-sided, and adjacent components. These general descriptions for coverage limitations are defined in Section 3.0. The biggest contributor to coverage limitations for these particular PWR welds is component configuration in conjunction with austenitic SS or CASS material, which tends to limit examinations to one side of the weld, and by the absence of qualified procedures to claim any coverage on the far side of the weld. Weld geometry and close proximity to adjacent components also contribute to coverage limitations but do not have as great of an impact. For more details on coverage limitations for each of the PWR welds in this study, please see the tables in Appendices A, B, and C.

In order to obtain additional perspectives on the relief request searches performed on these PWR welds, the 52 welds were grouped according to configuration types as shown in Table 3.

Table 3. PWR Limited Coverage Welds in Appendix C by Weld Configuration

Component Description	Number of Welds	Examination Description	Percent Coverage Claimed	Range of Diameters, inches
SS pipe to SS valve	13	Single-sided from pipe side	38 to 68	2½ to 12
SS pipe to CASS valve	6	Single-sided from pipe side	50 and 79	2½ to 27½
SS pipe to CASS valve	2	Single-sided axial scans from pipe side. Dual-sided circumferential scans	37	2 and 14
SS safe-end to CASS valve	4	Single-sided from safe-end side	50	2½
CASS pipe to CASS valve	1	Single-sided from pipe side	50	27½
SS pipe to SS tee	3	Single-sided from pipe side	50 to 60	2 to 14
SS elbow to SS valve	2	Single-sided from elbow side	41 and 50	2½ and 12
SS pipe butt weld to SS branch connection	1	Single-sided from pipe side	46	8
SS flued head penetration to SS pipe	1	Single-sided from pipe side	50	6
SS pipe to SS weld-o-let	2	Single-sided from pipe side	50 and 69	3 and 6
CS nozzle to Alloy 600/182/82 transition ring with Alloy 600/182/82 weld (ASME Class 2)	1	Single-sided from the transition ring side	69	7.5
Alloy 600/182/82 safe-end to CS nozzle	1	Single-sided from the safe-end side	79	6
SS elbow to SS tee	1	Dual-sided	77	4
SS pipe to SS tee	4	Dual-sided	71 to 81	3 to 6
SS pipe to SS elbow	6	Dual-sided	74 to 88	2 to 24
SS elbow to SS safe-end	2	Dual-sided	83 and 85	2 and 3
SS safe-end to CS nozzle	1	Dual-sided	83	3
Alloy 600/182/82 transition ring to CS elbow with Alloy 600/182/82 weld (ASME Class 2)	1	Dual-sided	77	6

Thirty-five of the 52 welds were only scanned from one side. In two additional cases, it was stated that axial scans could only be performed from only one side, while circumferential scans were performed from both sides of the welds. The remaining 15 welds were scanned from both sides.

In this literature search PNNL did not attempt to verify coverage stated by licensees. It is not clear how coverage higher than 50 percent for single-sided examinations was credited, because it was not stated that the procedures used were demonstrated for single-sided examination. For example, Table 3 shows that there were 13 SS pipe to SS valves identified in the search. These 13 welds received a single-sided examination from the pipe side. Nine of the welds had a stated coverage of 50 percent. The coverage for one of the welds was about 38 percent. The coverage stated for the remaining three welds was over 50 percent. PNNL is not aware of ASME Code, Section XI, Appendix VIII, Supplement 2 procedures that have been demonstrated for single-sided examination. A small number of other similar examples of single-sided examinations in austenitic materials with volumetric coverage greater than 50 percent can also be seen in Table 3. Although not stated, it is possible in these cases that the axial scans are single-sided and the circumferential scans can be performed partially on the far side of the weld. The scan plans in the submittals frequently depict only the axial scans. Other explanations for having volumetric coverage greater than 50 percent could be that some of the configurations have tees, or other appurtenances, that may have limitations at certain scanning locations but not for the entire 360-degree circumference of the weld.

Thirty-seven of the 52 welds identified in this search could be examined from only one side of the weld. Typical coverage limitations from single-sided examinations of the welds in Table 3 are caused by component configuration in conjunction with austenitic SS or CASS material, which tends to limit examinations to one side of the weld, and by the absence of qualified procedures to claim any coverage on the far side of the weld.

The component configuration that is the most limiting from Table 3 is valve tapers, which affect 28 of the 37 welds identified as having single-sided access. The other component configurations vary from tapers or transitions from tees, weld-o-let, nozzles, branch connections, and flue head penetrations. The regions often missed on the far side include the weld, heat-affected zone (HAZ), and counterbore transition, as applicable. Figure 9 is an example of a single-sided examination for a SS pipe-to-SS valve weld.

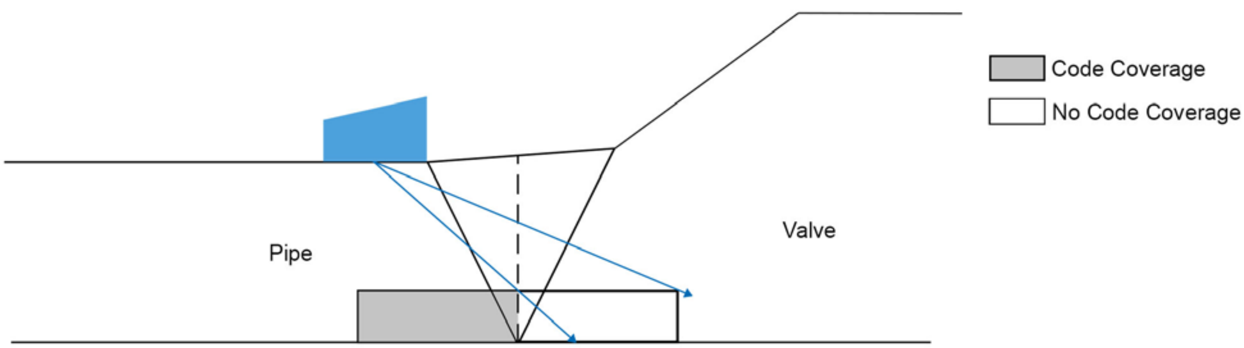


Figure 9. Example of SS Pipe to SS (or CASS) Valve where Only Single-Sided Access was Obtained due to Limitation Caused by Valve Taper and SS/CASS Material

Twenty-three of the 37 single-sided welds are SS welds between SS components. Thirteen of the welds have CASS material on one side of the weld. The reported coverage for the majority of these welds was 50 percent or more. For configurations similar to the ones in Table 3, it appears that the number of relief requests submitted on these welds could be reduced if single-sided qualifications were developed.

Typical coverage limitations from dual-sided examinations of the welds in Table 3 are caused by component configuration in conjunction with weld geometry or being in close proximity to adjacent components. Materials are not a significant limitation when dual sided access is available. The regions often missed are near the weld centerline for weld geometry limitations and the HAZ for component configuration limitations, as applicable. The component configurations that are the most limiting from Table 3 for dual-sided examination are pipe-to-elbow or pipe-to-tee. Figure 10 depicts a dual-sided examination of a SS elbow-to-SS pipe configuration that is primarily limited due to weld crown. This figure only shows the axial scans (towards the weld) and does not show the missed coverage for the circumferential scans (parallel to the weld).

All 15 of the welds for which dual-sided examination was performed have a stated coverage of greater than 70 percent. Eight of the 15 welds examined from both sides have a stated coverage of greater than 80 percent. The configurations of these eight welds were reviewed to determine whether the condition of the weld surfaces was a factor in limiting the coverage. It appears from the submittals that in three of the eight welds with stated coverage greater than 80 percent, if surface conditioning could be performed without violating minimum wall thickness requirements, the relief requests for those welds may not have been necessary. Seven of the 15 welds examined from both sides have a stated coverage of between 71 and 79 percent. Similarly, it appears from the submittals that in four of the seven welds with stated coverage between 71 and 79 percent, if surface conditioning could be performed without violating minimum wall thickness requirements, the relief requests for those welds may not have been necessary.

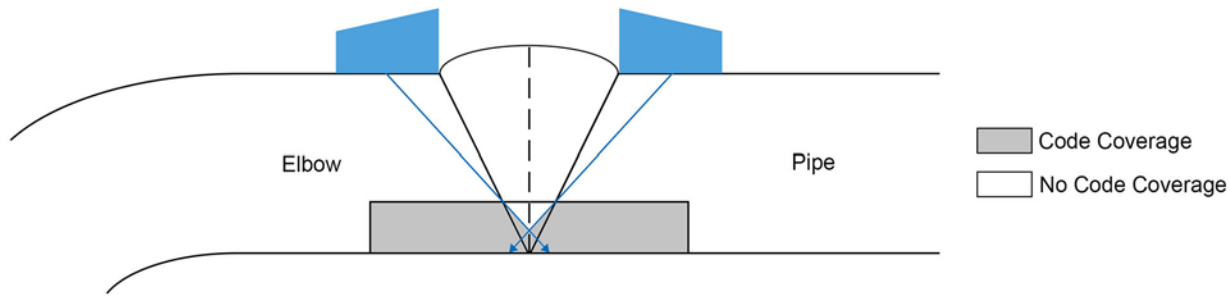


Figure 10. Example of SS Elbow to SS Pipe where Dual-Sided Access was Obtained and Partially Limited due to Weld Geometry. Note: This figure only shows the axial scans (towards the weld) and does not show the missed coverage for the circumferential scans (parallel to the weld).

7.0 BWR Limited Coverage Stainless Steel Welds

A search was performed for welds in BWRs with limited coverage. The search was conducted using safety evaluations and relief requests pertaining to 12 BWRs. The limited coverage welds summarized in this category of welds include CS-to-SS, SS-to-SS, SS-to-CASS, and Alloy 600/182/82-to-Alloy 600/182/82 components, but do not include CS-only welds. Five of the welds were fabricated with Alloy 600/182/82 material while the rest were SS welds. Fifty-nine welds with limited coverage were identified in this search. The comments made in Section 6.0 regarding PNNL not attempting to verify volumetric coverage applies to the BWR weld searches as well.

The welds identified in this search of 12 BWR units include ASME Code, Section XI, Examination Categories B-F, B-J, R-A, and C-F-1. The results of this search are summarized in Appendix D. The welds identified cover 27 different types of configurations. This wide range of weld configurations was considered sufficiently representative; however, it is not all encompassing.

The general coverage limitations found in this study are component configuration, weld geometry, CASS material, single-sided, and adjacent components. These general descriptions for coverage limitations are defined in Section 3.0. The biggest contributor to coverage limitations for the BWR welds found in this limited study is component configuration in conjunction with austenitic SS, which tends to limit examinations to one side of the weld and by the absence of qualified procedures to claim any coverage on the far side of the weld. Weld geometry also contributed to some of the limited examinations. CASS material also contributes to coverage limitations, but there were not as many components with CASS materials in this BWR subset as seen in the PWRs. For more details on coverage limitations for each of the BWR welds, please see the table in Appendix D.

In order to obtain additional perspectives on the relief request searches performed on these BWR welds, the 59 welds were grouped according to configuration types as shown in Table 4.

Table 4. BWR Limited Coverage Welds in Appendix D by Weld Configuration

Component Description	Number of Welds	Examination Description	Percent Coverage Claimed	Range of Diameters,[a] inches
SS pipe to SS valve	5	Single-sided from the pipe side	50	10 to 18
SS pipe to SS tee	5	Single-sided from the pipe side	50 for 4 welds and 75 for 1 weld	12 and 24
SS pipe to SS sweep-o-let	3	Single-sided from the pipe side	50	12
SS penetration to SS valve	1	Single-sided from the penetration side	50	
SS pipe to SS cross	1	Single-sided from the pipe side	50	16
SS pipe to SS flued head	3	Single-sided from the pipe side	50	18
SS pipe to SS penetration	4	Single-sided from the pipe side	50	6 and 10
SS pipe to SS weld-o-let	1	Single-sided from the pipe side	35	4
SS pipe to SS reducer	2	Single-sided from the pipe side	50	12
SS pipe to SS saddle	2	Single-sided from the pipe side	50	12
SS elbow to SS valve	2	Single-sided from the elbow side	50	
SS pipe to SS branch	3	Dual-sided	83	12
SS pipe to SS weld-o-let	1	Dual-sided	86	6
SS elbow to SS tee	1	Dual-sided	85.6	
SS pipe to CASS valve	4	Single-sided from the pipe side	50–75	6 and 28
SS flued head to CASS valve	1	Single-sided from the flued head side	50	24
SS elbow to CASS valve	1	Single-sided from the elbow side	54	20
SS sweep-o-let to CASS valve	1	Single-sided from the sweep-o-let side	31	6
CS pipe to CASS valve with SS weld	1	Single-sided from the pipe side	30	6
CS elbow to SS valve with SS weld	1	Single-sided from the elbow side	53	4
CS pipe to SS elbow with SS weld	1	Dual-sided	87	
CS nozzle to SS safe-end with SS weld	2	Single-sided from the safe-end side	76 and 77	24 and 14
CS pipe to SS valve with Alloy 600/182/82 weld	2	Single-sided from the pipe side	22 and 37	10
CS nozzle to SS safe-end with Alloy 600/182/82 weld	4	Dual-sided axial scans with circumferential scan from the pipe side only	75	
CS nozzle to SS safe-end with Alloy 600/182/82 weld	4	Dual-sided	75 and 81	12 and 28

Component Description	Number of Welds	Examination Description	Percent Coverage Claimed	Range of Diameters,[(a)] inches
CS safe-end to Alloy 600/182/82 buttered nozzle	2	Dual-sided	87	
Alloy 600/182/82 safe-end to Alloy 600/182/82 safe-end extension with Alloy 600/182/82 weld	1	Dual-sided	87	

(a) The diameters of some welds were not provided.

Typical coverage limitations from single-sided examinations of the welds in Table 4 are caused by component configuration which tends to limit examinations to one side of the weld and by the absence of a qualified procedure to claim any coverage on the far side of the SS weld. As noted previously, CASS material also contributes to coverage limitations, but there were not as many components with CASS materials in this search as was seen in the PWRs.

The component configuration that is the most limiting from Table 4 is valve tapers which affect 17 of the 42 welds identified as having single-sided access. The other component configurations vary from tapers or transitions from tees, weld-o-lets, nozzles, branch connections, sweep-o-lets, reducers, and flue head penetrations. The regions often missed on the far side include the weld, HAZ, and counterbore transition, as applicable. Figure 9 is an example of a single-sided examination for a SS pipe-to-SS (or CASS) valve weld.

Forty-two of the 59 welds identified in this search could be examined from only one side of the weld. The coverage for the majority of these welds was 50 percent or more. For configurations similar to those in Table 2, it appears that the relief requests submitted could be reduced with single-sided qualifications for Supplement 2 and development of Supplement 9, albeit a more limited implementation in BWRs.

Typical coverage limitations from dual-sided examinations of the welds in Table 4 are caused by component configuration in conjunction with weld geometry or being in close proximity to adjacent components. Materials did not present a significant limitation when dual-sided access is available. The regions often missed are near the weld centerline for weld geometry limitations and the HAZ for component configuration limitations, as applicable. The component configuration that is the most limiting from Table 4 for dual-sided examination are SS safe-end-to-CS nozzle. Figure 11 depicts a dual-sided examination of a SS safe-end-to-CS nozzle configuration that is limited due to weld geometry and the nozzle taper. This figure only shows the axial scans (towards the weld) and does not show the missed coverage for the circumferential scans (parallel to the weld).

All 17 of the welds for which dual-sided examination was performed have a stated coverage of greater than 75 percent. The configurations of these 17 welds were reviewed to determine whether the condition of the weld surfaces was a factor in limiting the coverage. Where the contour of the configurations was represented in the submittals, it appears that surface conditioning was not a factor in the limited coverage. This result appears reasonable because austenitic welds in BWRs have been susceptible to stress corrosion cracking and BWR owners have taken steps to remove or condition weld crowns to increase weld coverage.

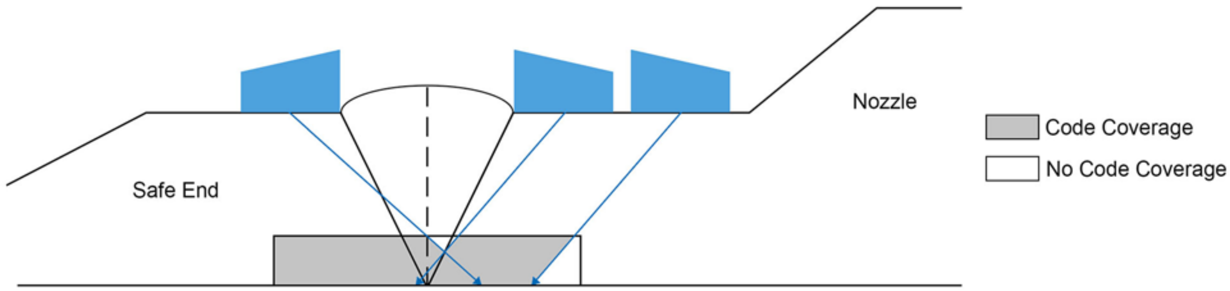


Figure 11. Example of SS Safe-End to CS Nozzle where Dual-Sided Access was Obtained and Partially Limited due to Weld Geometry and Nozzle Taper. Note: This figure only shows the axial scans (towards the weld) and does not show the missed coverage for the circumferential scans (parallel to the weld).

8.0 Examination Limitations

The limitations to examinations that are apparent from a review of the relief requests identified in this search fall into two main categories of materials and geometry. Figures 12 and 13 summarize the component configurations and materials that are most limiting to coverage examinations for PWRs and BWRs, respectively. The figures are divided into single-sided (blue) and dual-sided (green) examinations. Of the welds reported in this report, there are approximately 75 percent that were single-sided and 25 percent that were dual-sided, which is represented by the off-axis shift in the Venn diagram. Single-sided examinations were mostly limited by geometry and materials, and mostly geometry for dual-sided access. There were no cases in this report where materials were the sole factor for limiting coverage, which is why the material oval is completely inside the geometry oval. The most common geometry limitations are the component configurations highlighted in the text bubbles within the figures. Each geometry limitation is highlighted in a color using the color scale on the right which represents the relative rate of occurrence in this report.

For single-sided examinations, most welds have examination limitations that are related to both materials and geometry. The geometry limitation for single-sided examination in PWRs is predominately due to component configuration which means the tapers or transitions from nozzles, valves, elbows, and other components, and narrow width of safe-ends restrict physical access of the transducers. The component configurations that are most limiting are (1) CASS/SS safe-end-to-CS (elbow/pipe/nozzle), (2) CASS nozzle-to-SS/CASS (safe-end/elbow/pipe), (3) CASS/SS valve-to-SS/CASS (pipe/safe-end/elbow), and (4) SS pipe-to-SS component (other than valve/safe-end/elbow). For BWRs, the limiting component configurations are (1) SS/CASS valve-to-SS (pipe/elbow/other components), and (2) SS pipe-to-SS component (tee/sweep-o-let/penetration/…). For materials, the use of CASS materials and the absence of ASME Code rules for examination of CASS is one of the main sources of examination limitations in PWRs. In addition, the absence of demonstrated single-sided procedures for examination of austenitic materials under current ASME Code, Section XI, Appendix VIII Supplement 2 can be viewed as another source of examination limitations in both PWRs and BWRs.

For dual-sided examinations, most welds are limited primarily to geometry and less affected by materials. The geometry limitation for dual-sided access is due to both component configuration and weld geometry (presence of weld crowns). The component configurations that are the most limiting for PWRs are (1) CS nozzle-to-CASS/SS safe-end, (2) CASS nozzle-to-CASS (elbow/safe-end), (3) SS pipe-to-SS (tee/elbow), and (4) SS elbow-to-SS (tee/safe-end). The component configurations that are the most limiting for BWRs are (1) CS nozzle-to-SS safe-end, and (2) SS (pipe/elbow)-to-SS (branch/weld-o-let/tee).

Limitations caused by geometry result from the lack of priority in the original designs for access to perform UT examinations of the welds and adjoining components. Utilities have performed surface conditioning in many cases involving susceptible materials as a result of industry initiatives. Weld crowns still exist on many welds where the weld material has not been identified as susceptible to a degradation mechanism. In a small number of cases, the volumetric coverage is calculated to be close to, but less than, 90 percent. In these cases, use of more advanced UT techniques and procedures may provide an avenue for increasing coverage and reducing the number of relief requests.

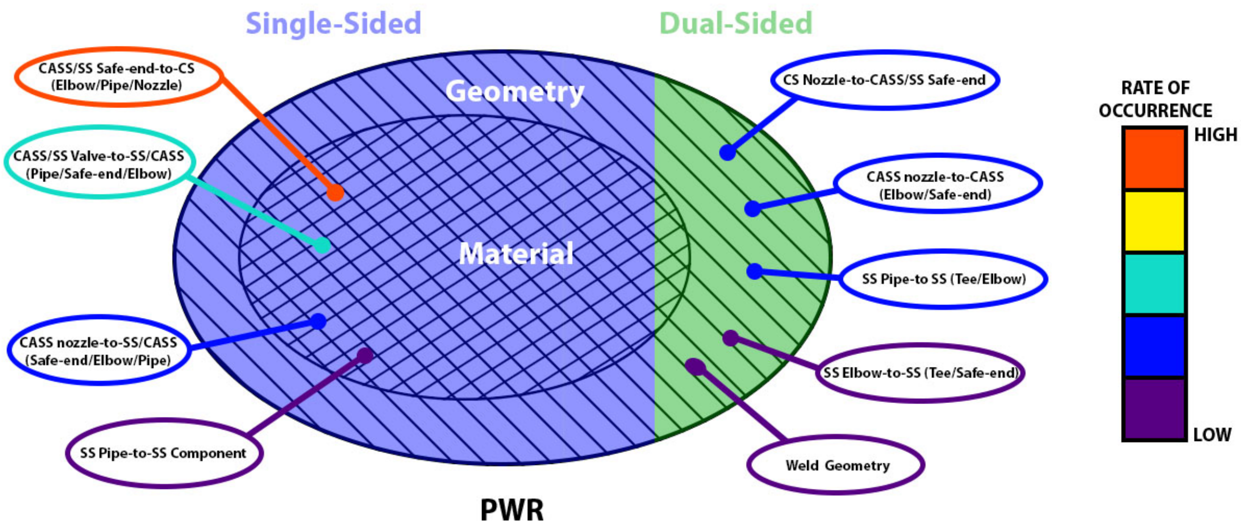


Figure 12. Summary of Main Coverage Limitations in PWRs. The figure is divided into single-sided (blue) and dual-sided (green) examinations. Approximately 75 percent of the welds were single-sided and 25 percent were dual-sided, which is represented by the off-axis shift in the Venn diagram. Single-sided examinations were mostly limited by geometry and materials, and mostly geometry for dual-sided access. There were no cases in this report where materials was the sole factor for limiting coverage which is why the material oval is completely inside the geometry oval. The geometry limitations are the component configurations highlighted in a colored text bubble for single- and dual-sided examinations representing their relative rate of occurrence in this report.

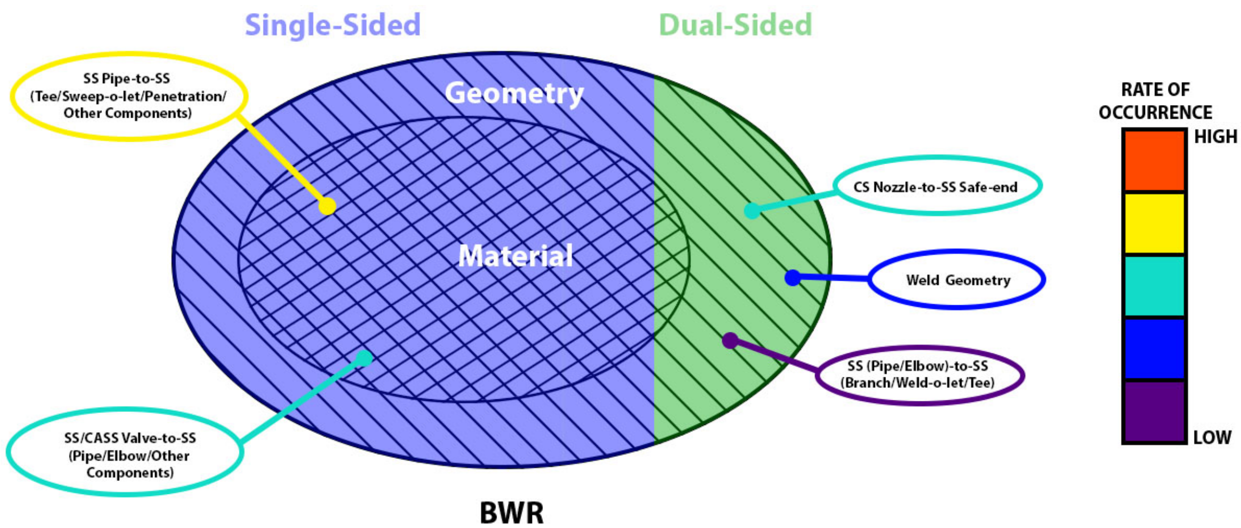


Figure 13. Summary of Main Coverage Limitation in BWRs. The figure is divided into single-sided (blue) and dual-sided (green) examinations. Approximately 75 percent of the welds were single-sided and 25 percent were dual-sided, which is represented by the off-axis shift in the Venn diagram. Single-sided examinations were mostly limited by geometry and materials, and mostly geometry for dual-sided access. There were no cases in this report where materials were the sole factor for limiting coverage, which is why the material oval is completely inside the geometry oval. The greatest geometry limitations are the component configurations highlighted in colored text bubbles for single- and dual-sided examinations representing their relative rate of occurrence in this report.

9.0 Conclusions

One of the purposes of this literature search was to identify candidate weld configurations for future empirical studies on improving examination coverage using advanced UT techniques and procedures. Based on the assessment of relief requests that PNNL conducted, incomplete examination coverage occurred more frequently for the CE RCP DMWs than other weld types covered by ASME CC N-770-1. PNNL concludes that should mockups be built for empirical study, the initial mockup should be based upon CE design RCP safe-end-to-pipe welds. Such a mockup should be constructed to have coverage limitations for both the axial and circumferential scans. It is also recommended to consider including geometric limitations that prevent examination of at least some portion of the ID of the susceptible material when performing circumferential scans.

The other objective of the literature search was to generally characterize, and classify, the limitations encountered in examining piping and nozzle butt welds that contribute to incomplete UT examination coverage.[a]

The biggest contributor to coverage limitations for the PWR welds with single-sided access is component configuration with no qualified single-sided procedures for austenitic SS and CASS. The most limiting

(a) It should also be noted that ASME Code Case N-711-1, "Alternative Examination Coverage Requirements for Examination Category B-F, B-J, C-F-1, C-F-2, and R-A Piping Welds," was approved after the research conducted in this report. This Code Case will have an impact on coverage but a thorough assessment and details associated with N-711 are not covered in this report.

configurations are: (1) CASS/SS safe-end-to-CS (elbow/pipe/nozzle), (2) CASS nozzle-to-SS/CASS (safe-end/elbow/pipe), (3) CASS/SS valve-to-SS/CASS (pipe/safe-end/elbow), and (4) SS pipe-to-SS component (other than valve/safe-end/elbow). Tapers or transitions from nozzles, valves, elbows, and other components, and narrow width of safe-ends limit examinations to one side of the weld. For dual-sided access, the limitations are mainly caused by weld geometry, the tapers from nozzles, elbows, and tees, and narrow width of safe-ends.

The biggest contributor to coverage limitations for the BWR welds with single-sided access is austenitic SS component configuration with no qualified single-sided procedures. The component configurations that are most limiting are (1) SS/CASS valve-to-SS (pipe/elbow/other components), and (2) SS pipe-to-SS component (tee/sweep-o-let/penetration/…). Tapers or transitions from valves, tees, elbows, sweep-o-lets, penetrations, and other components limit examinations to one side of the weld. For dual-sided access, the limitations are mainly caused by weld geometry and the tapers from nozzles, elbows, and tees and narrow width of safe-ends component.

For both BWRs and PWRs, the use of CASS materials, especially for components other than pipes, presents significant challenges for UT examinations. While the development and implementation of ASME Code, Section XI, Appendix VIII, Supplement 9 will improve the quality of examinations performed on CASS materials, it will not enhance coverage when configuration is the primary issue unless there are qualified procedures for coverage on the far side of the welds. Until Supplement 9 qualified procedures are developed, the implementation of CC N-824 may provide a means to increase meaningful coverage on CASS components provided that the surface on the CASS side of the weld is prepared to allow adequate coupling and the configuration provides access for scanning.

The literature search identified a large number of relief requests involving single-sided examination of SS components joined to SS components, such as a SS pipe to SS elbow, valve, or tee configuration. As stated above, it appears that the majority of these relief requests could be eliminated with the achievement of single-sided qualifications for austenitic welds.

The number of relief requests related to weld geometry could be reduced in some cases where surface conditioning is feasible and where there is sufficient incentive to improve the quality of examinations, such as currently being implemented for detecting PWSCC in DMWs.

Use of phased array techniques or other advanced UT methods and/or other procedure changes may provide an avenue for increasing coverage and reducing the number of relief requests, especially in cases where volumetric coverage is calculated to be close to, but less than, 90 percent.

10.0 References[(a)]

80 FR 56820. September 18, 2015. "Incorporation by Reference of American Society of Mechanical Engineers Codes and Code Cases. Proposed Rule." *Federal Register* 80(181):56820-56864. Nuclear Regulatory Commission, Washington, D.C.

(a) References to other licensee submittals and NRC safety evaluations by ADAMS accession numbers are contained in Appendices A, B, C, and D.

Ajluni MJ. 2009. Letter to NRC Document Control Desk. "Vogtle Electric Generating Plant Second 10-year Interval Inservice Inspection Report Request for Additional Information." April 20, 2009, Southern Nuclear Operating Company, Inc., Birmingham, Alabama. ADAMS Accession No. ML091110411.

Cumblidge SE. 2015. "Coverage Relief Requests." Presented at *Industry/NRC NDE Technical Information Exchange Public Meeting*, January 13-15, 2015, Washington, D.C. ADAMS Accession No. ML15013A266. Available at https://www.nrc.gov/docs/ML1501/ML15013A266.pdf.

EPRI. 2008. *Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guideline (MRP-139, Revision 1)*. EPRI Report 1015009, Electric Power Research Institute (EPRI), Palo Alto, California.

Gebbie JP. 2011. Letter to NRC Document Control Desk. "Donald C. Cook Nuclear Plant Units 1 and 2, Relief Requests for Limited Coverage Examinations Performed In The Third 10-Year Inspection Interval." April 8, 2011, Indiana Michigan Power, Bridgman, Michigan. ADAMS Accession No. ML11110A042.

Heasler PG and SR Doctor. 1996. *Piping Inspection Round Robin*. NUREG/CR-5068, PNL-10475, U.S. Nuclear Regulatory Commission, Washington, D.C.

Kalyanam NK. 2013. *Arkansas Nuclear One, Unit No. 2 - Summary of Telephone Conference re: Verbal Authorization for Revised Relief Request ANO2-ISI-007 (TAC No. MF0331)*. Memorandum to File, February 26, 2013, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML13052A470.

Katzman ES. 2009. Letter to NRC Document Control Desk. "St. Lucie Unit 1, Docket No. 50-335, Unit 1 Third Interval Relief Requests 31 and 32." February 6, 2009, Florida Power & Light Company, Jensen Beach, Florida. ADAMS Accession No. ML090430304.

Markey MT. 2012. Letter to JT Conway. "Diablo Canyon Power Plant, Unit No.1 – Approval of Request for Relief NDE-RCS-SE-lP1 CL to Allow Use of Alternate ASME Code Case N-770-1 Baseline Examination." February 24, 2012, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML120530680.

Mason ME. 2012. Letter to NRC Document Control Desk. "Waterford 3 Request for Alternative W3-ISI-020, ASME Code Case N-770-1 Baseline Examination Request for Alternative Waterford Steam Electric Station, Unit 3; Docket No. 50-382, License No. NPF-38." October 16, 2012, Entergy Operations, Inc., Killona, Louisianna. ADAMS Accession No. ML12296A241.

Murillo RJ. 2009. Letter to NRC Document Control Desk. "Response to NRC Request for Additional Information Re: Waterford 3 Steam Electric Station, Unit 3 - Requests for Relief from ASME Section XI Volumetric Examination Requirements - Second 10-Year Inservice Inspection Interval; Waterford Steam Electric Station, Unit 3; Docket No. 50-382; License No. NPF-38." November 6, 2009, Entergy Operations, Inc., Killona, Louisianna. ADAMS Accession No. ML093160319.

Pascarelli RL. 2013. Letter to DA Heacock. "North Anna Power Station, Unit 2 (NAPS2), Fourth 10-Year Interval Inservice Inspection (lSI) Program, Steam Generator Nozzle-to-Vessel Weld Examination Requirements Alternative Request N2-14-LMT-001-R1." May 2, 2013, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML13120A507.

PNNL. 2013a. *Technical Letter Report, Evaluation of Licensee's Alternative to 10 CFR 50.55a(g)(6)(ii) for Limitations to Volumetric Examinations of Dissimilar Metal Welds, Entergy Operations, Inc., Arkansas Nuclear One, Unit 2 – Docket Number 50-368*. Pacific Northwest National Laboratory, Richland, Washington. ADAMS Accession No. ML13113A218.

PNNL. 2013b. *Technical Letter Report, Evaluation of Licensee's Alternative to 10 CFR 50.55A(G)(6)(II)(F) for Limitations to Volumetric Examinations of Dissimilar Metal Welds, Constellation Energy, Calvert Cliffs Nuclear Power Plant – Docket Number 50-318*. Pacific Northwest National Laboratory, Richland, Washington. ADAMS Accession No. ML13113A233.

PNNL. 2013c. *Technical Letter Report, Evaluation of Alternative to 10 CFR 50.55a(g)(6)(ii)(F)(4) for Limitations to Volumetric Examinations of Dissimilar Metal Welds, Florida Power & Light, St. Lucie Power Plant Unit 1 – Docket Number 50-335*. Pacific Northwest National Laboratory, Richland, Washington. ADAMS Accession No. ML14149A195.

Sartain MD. 2014. Letter to NRC Document Control Desk. "Dominion Nuclear Connecticut, Inc., Millstone Power Station Unit 2, Response to Request for Additional Information Regarding ASME Section XI Inservice Inspection Program Alternative Request RR-04-15, Limited One-Sided Ultrasonic Examination Technique (TAC No. MF1405)." February 7, 2014, Dominion Nuclear Connecticut, Inc., Glen Allen, Virginia. ADAMS Accession No. ML14051A109.

Stanley JJ. 2011. Letter to NRC Document Control Desk. "Calvert Cliffs Nuclear Power Plant Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318, Relief Request for Dissimilar Metal Butt Welds Baseline Inspections (RR-ISI-04-06 & ISI-04-07)." December 29, 2011, Constellation Energy Generation Group, Calvert Cliffs Nuclear Power Plant, LLC, Lusby, Maryland. ADAMS Accession No. ML12009A073.

Stanley JJ. 2012. Letter to NRC Document Control Desk. "Calvert Cliffs Nuclear Power Plant Unit No. 2; Docket No. 50-318, Relief Request for Unit 2 Dissimilar Metal Butt Welds Baseline Examinations (RR-ISI-04-07A)." June 7, 2012, Constellation Energy Generation Group, Calvert Cliffs Nuclear Power Plant, LLC, Lusby, Maryland. ADAMS Accession No. ML12164A372.

Wheeler-Peavyhouse SA. 2013. Letter to NRC Document Control Desk. "H. B. Robinson Steam Electric Plant, Unit No. 2, Docket No. 50-261/Renewed License No. DPR-23, Relief Request (RR)-20 for Limited Examinations Performed in the Fourth Ten-Year Inservice Inspection Program Plan." June 3, 2013, Duke Energy Progress, Hartsville, South Carolina. ADAMS Accession No. ML13178A006.

Appendix A

PWR Dissimilar Metal Welds with Limited Coverage

Appendix A

PWR Dissimilar Metal Welds with Limited Coverage

Plant/NSSS	Weld Descriptions/ Examination Technique/Coverage (if provided)	Configurations,[1] [2] Scan Plans	Coverage Limitations (licensee stated)	References
		Code Case N-770-1 Welds		
ANO-2/CE	36" RCP inlet nozzle CASS safe-ends to CS elbows (4 welds) Manual non-encoded single-sided phased array (PA) UT from the CS side Successive exams with manual encoded PAUT (see Ref. 3)	CC N-770-1 baseline coverage and scan plans in Table 1 on page 6 and 7 of Ref. 1 Configuration/scan plans on pages 8–15 of Ref. 1 Scan plans and coverage for successive exams in App A&B of Ref. 3	CASS material, component configuration, weld geometry	1) ML113340158 2) ML12319A367 3) ML13052A470 Safety Evaluation – Ref. 2
	36" RCP outlet nozzle CASS safe-ends to CS pipes (4 welds) Manual non-encoded single-sided PAUT from the CS side Successive exams with manual encoded PAUT (see Ref. 3)	CC N-770-1 baseline coverage and scan plans in Table 1 on page 6 and 7 of Ref. 1 Configuration/scan plans on pages 8–15 of Ref. 1 Scan plans and coverage for successive exams in App A&B of Ref. 3	CASS material, component configuration	1) ML113340158 2) ML12319A367 3) ML13052A470 Safety Evaluation – Ref. 2

[1] Representations of configurations referenced in this table vary in quality from scale drawings to hand sketches.
[2] All page numbers in this table refer to the pdf page number, not the page number of the letter or an attachment.

Plant/NSSS	Weld Descriptions/ Examination Technique/Coverage (if provided)	Configurations,[1 2] Scan Plans	Coverage Limitations (licensee stated)	References
	12" Safety Injection CASS safe-ends to CS nozzles (4 welds) Successive exams with manual encoded dual-sided PAUT with the same Appendix VIII procedures from both sides	CC N-770-1 coverage for successive examinations, configurations and scan plans in App A&B of Ref. 1 Configurations/scan plans also in Attachment A of Ref. 2 Coverage estimates in Attachment B of Ref. 2	Component configuration, CASS material	1) ML13052A470 2) ML14122A250 Safety Evaluation not located in ADAMS
Calvert Cliffs 1/CE	30" RCP inlet nozzle CASS safe-ends to CS elbows (4 welds) 30" RCP outlet nozzle CASS safe-ends to CS pipes (4 welds) Manual non-encoded PAUT single-sided examinations from the CS side	CC N-770-1 baseline coverage on page 6 Ref. 1 Configurations/scans plans on pages 12–27 of Ref. 1	CASS material, component configuration, weld geometry	1) ML12009A073 2) ML12345A055 3) ML14329A085 Safety Evaluation – Ref. 2
	12" PZR surge line CASS safe-end to RCS CS hot leg nozzle and 12" PZR surge line CASS safe-end to CS PZR nozzle. Welds 111100 and 110450. Manual non-encoded single-sided PAUT from the CS side	CC N-770-1 baseline coverage on page 6 Ref. 1 Configurations/scans plans on pages 28–31 of Ref. 1	CASS material, component configuration	
	12" shutdown cooling line CASS safe-end to RCS hot leg CS nozzle. Weld 113150. Manual non-encoded single-sided PAUT from the CS side	CC N-770-1 baseline coverage on page 6 Ref. 1 Configurations/scan plans on pages 32 & 33 of Ref. 1	CASS material	
	12" safety injection CASS safe-ends to RCS cold leg CS nozzles (4 welds) Manual non-encoded single-sided PAUT from the CS side	CC N-770-1 baseline coverage on page 6 Ref. 1 Configurations/scan plans on pages 34–41 of Ref. 1	CASS material, component configuration	

Plant/NSSS	Weld Descriptions/ Examination Technique/Coverage (if provided)	Configurations,[1] [2] Scan Plans	Coverage Limitations (licensee stated)	References
	3" PZR spray line safe-end weld to PZR nozzle 4" PZR Safety/Relief safe-end weld to PZR nozzle Both of these welds were mitigated by MSIP (Ref. 2)	CC N-770-1 baseline coverage on page 6 Ref. 1 Further information on these DMWs not included in this table since all Alloy 82/182 PZR nozzle DMWs have been mitigated except at Palisades per Draft TLR on Unmitigated Welds	No limitation	
	3" PZR spray from 11A and 11B cold leg nozzles, 2" cold leg letdown, 2" charging inlet, 2" cold leg drains, and 2" hot leg drain	CC N-770-1 baseline coverage on page 6 Ref. 1 Further information on these DMWs not provided in submittal because CC N-770-1 the baseline coverage was 100%	No limitation	
Calvert Cliffs 2[3]/CE	12" PZR surge, shutdown cooling, and safety injection CASS safe-ends to CS nozzles. Welds 113010, 113130, 114900, 115140, 116190, 117120, and 118120. Mitigated by MSIP – Ref. 3 Manual non-encoded single-sided PAUT from the CS side	CC N-770-1 baseline coverage on page 6 Ref. 1 Configurations/scan plans on pages 71–84 of Ref. 1	CASS material	1) ML12009A073 2) ML12164A372 3) ML13141A647 Safety Evaluation – Ref. 3
Millstone 2/ CE	36" RCP inlet nozzle CASS safe-ends to CS elbows (4 welds) 36" RCP outlet nozzle CASS safe-ends to pipes (4 welds) Automated encoded single-sided PAUT from the CS side	CC N-770-1 anticipated coverage in Table 2, page 10 in Ref. 1 and page 7 in Ref. 2 Configurations/scans plans on pages 13–36 in Ref. 1. Configurations/scans plans on pages 8 & 9 in Ref. 2	Component configuration, proximity to adjacent component/structures, CASS material	1) ML13108A008, 2) ML14051A109, 3) ML14063A578 Safety Evaluation – Ref. 3

[3] The relief requests for Calvert Cliffs 2 included an extensive list of welds, not all of which are represented in this table.

Plant/NSSS	Weld Descriptions/ Examination Technique/Coverage (if provided)	Configurations,[1 2] Scan Plans	Coverage Limitations (licensee stated)	References
North Anna Unit 2/W	29" SG CS cold leg nozzle welded to a SS safe-end with an Alloy 82/182 butter and weld and inlaid with Alloy 52. Weld N-SE29 IN. Manual non-encoded conventional examination. Dual-sided examination limited by the nozzle outside radius.	Coverage on page 283 Scan plan page 375 of Ref. 1	Component configuration	1) ML11270A122 2) ML12227A773 Safety Evaluation – Ref. 2
	31" SG CS hot leg nozzle welded to a SS safe-end with an Alloy 82/182 butter and weld and inlaid with Alloy 52. Weld N-SE31 IN. Manual, non-encoded, conventional, dual-sided examination limited by the nozzle outside radius	Coverage on page 283 Scan plan page 379 of Ref. 1	Component configuration	
St. Lucie 1/ CE	30" (ID) RCP inlet nozzle CASS safe-ends to CS elbows (4 welds) 30" RCP outlet nozzle CASS safe-end-to-pipe welds (4 welds) Manual non-encoded single-sided PAUT from the CS side	CC N-770-1 baseline coverage in Table 1 on page 11 in Ref. 1 Configurations/scans plans on pages 13–63 in Ref. 1	CASS material, component configuration, proximity to adjacent component/ structures	1) ML13046A101 2) ML13316A555 Safety Evaluation – Ref. 2
St. Lucie 2/ CE	30" (ID) RCP inlet nozzle CASS safe-ends to CS elbows (4 welds) 30" RCP outlet nozzle CASS safe-ends to pipes (4 welds) Manual non-encoded single-sided PAUT from the CS side	CC N-770-1 baseline coverage in Table 1 on page 9 in Ref. 1 Configurations/scans plans on pages 10–19 in Ref. 1	CASS material, component configuration, proximity to adjacent component/ structures	1) ML12172A142 2) ML12313A415 Safety Evaluation – Ref. 2

Plant/NSSS	Weld Descriptions/ Examination Technique/Coverage (if provided)	Configurations,[1] [2] Scan Plans	Coverage Limitations (licensee stated)	References
Waterford/ CE	30" RCP inlet nozzle CASS safe-ends to CS elbows (4 welds) 30" RCP outlet nozzle CASS safe-ends to CS pipes (4 welds) Manual non-encoded single-sided PAUT from the CS side	CC N-770-1 baseline coverage in Table 1 on pages 13–15 in Ref. 1 Configurations/scans plans on pages 17–24 in Ref. 1	CASS material, component configuration	1) ML12296A241 2) ML13128A129 Safety Evaluation – Ref. 2
	12" safety injection CS nozzle to CASS safe-ends (4 welds) Manual non-encoded single-sided PAUT from the CS side	CC N-770-1 baseline coverage in Table 1 on pages 15 and 16 in Ref. 1 Configurations/scan plans on pages 25–28 in Ref. 1	CASS material, component configuration	1) ML12296A241 2) ML13128A129 Safety Evaluation – Ref. 2
	2" RCP SS charging line to a CS nozzle. Weld 08-007. Manual non-encoded dual-sided PAUT using an Appendix VIII procedure demonstrated for a similar nozzle. However, procedures concluded to be outside of the PDI mockup range of applicability.	CC N-770-1 coverage – 100%; however, the examination was not qualified. Relief needed to develop a qualified procedure. Configuration on pages 30 and 31 in Ref. 1 Scan Plan on page 12 in Ref. 1	No limitation	1) ML12339A070 2) ML13192A222 Safety Evaluation – Ref. 2
Pressurizer Nozzle Dissimilar Metal Welds (Not covered by Code Case N-770-1)				
H.B. Robinson/ W	B-F: 4" PZR spray CS nozzle to SS safe-end with a SS weld Manual non-encoded conventional single-sided examinations performed from the safe-end side Coverage – 75% for weld 116/19DM	Configuration/scan plans on page 83	Component configuration, proximity to adjacent component/structures	1) ML13178A006 2) ML14162A094 Safety Evaluation – Ref. 2

Plant/NSSS	Weld Descriptions/ Examination Technique/Coverage (if provided)	Configurations,[1] [2] Scan Plans	Coverage Limitations (licensee stated)	References
Kewaunee/ W	B-F: 6" PZR CS relief nozzles to SS safe-ends with SS welds Manual, non-encoded, conventional, dual-sided examinations Coverage – 68% for weld PR-W1DM and 37% for weld PR-W26DM	Configuration/scan plan on page 50 for weld PR-W1DM and page 58 for PR-W26DM in Ref. 1	Component configuration	1) ML11284A193 2) ML12249A441 Safety Evaluation – Ref. 2
	B-F: 14" PZR CS surge nozzle to SS safe-end with a SS weld Manual, non-encoded conventional single-sided examination from the safe-end side Coverage – 26% for weld RC-W67DM	Configuration/scan plan on page 301 in Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
Salem 1/W	R-A: 15" PZR CS surge nozzle to SS safe-end with a SS weld Manual non-encoded conventional dual-sided examination Coverage – 83.3% for weld 14-PS-1131-2	Configuration/scan plan on pages 81–87 in Ref. 1	Adjacent component/structure	1) ML12125A152 2) ML13071A215 Safety Evaluation – Ref. 2
Salem 2/W	B-F: 6" PZR CS relief nozzle to SS safe-end with a SS weld Manual non-encoded conventional dual-sided examination Coverage – 86% for weld 6-PR-1203-1	Configuration/scan plans on page 495 in Ref. 1	Weld geometry	1) ML071900437 2) ML081260365 Safety Evaluation – Ref. 2

Plant/NSSS	Weld Descriptions/ Examination Technique/Coverage (if provided)	Configurations,[1 2] Scan Plans	Coverage Limitations (licensee stated)	References
	Steam Generator (SG) Nozzle Dissimilar Metal Welds (Not Covered by Code Case N-770-1)			
D.C. Cook 1 & 2/W	B-F: SG CS nozzles welded to SS safe-ends with Alloy 52 welds Manual, non-encoded, conventional, single-sided examination from the safe-end side Coverage – 25.7% for STM-12-02R, 23.9% for STM-02-03R, 25.7% for STM-14-02R, and 23.9% for STM-14-03R	Coverage/configurations/scan plans on pages 82-90 of Ref. 1	Component configuration, no qualified single-sided procedure	1) ML11110A042 2) ML12109A100 Safety Evaluation – Ref. 2
Ginna/W	B-F: 38" Replacement SG (RSG) CS nozzles to SS safe-ends with Alloy 52/152 welds Manual, non-encoded, conventional, examinations. Axial scan from the nozzle side. Circumferential scans from the safe-end side. Coverage – 42% for welds NSE-4R inlet and 40.5% for NSE-3R outlet	Configuration/scan plans on pages 4–6 in Ref. 2	Component configuration, no qualified single-sided procedure	1) ML10362A105 2) ML12081A119 3) ML11215A012 4) ML12158A115 Safety Evaluation – Ref. 4
H.B. Robinson/ W	B-F: 34" and 38" SG inlet and outlet CS nozzles to CASS elbows with SS welds Manual, non-encoded, conventional, single-sided, Appendix VIII examinations performed from the CASS elbow side Coverage – 52.8% for weld 107/04DM, 64.8% for 107/05DM, 49.1% for 107A/04DM, 47.5% for 107A/05DM, 50% for 107B1/04DM, and 50% for 107B/05DM.	Configuration/scan plans on page 34 for weld 107/04DM, page 40 for 107/05DM, page 49 for 107A/04DM, page 59 for 107A/05DM, page 66 for 107B1/04DM, and page 75 for 107B/05DM in Ref. 1	Component configuration, CASS material	1) ML13178A006 2) ML14162A094 Safety Evaluation – Ref. 2

Plant/NSSS	Weld Descriptions/ Examination Technique/Coverage (if provided)	Configurations,[1 2] Scan Plans	Coverage Limitations (licensee stated)	References
South Texas 1 and 2/W	42" RSG Loops 1 and 4 Inlet CS nozzle to SS safe-ends with Inconel weld – 2 RI-ISI RSG loop welds per unit (these welds are assumed be Alloy 52/152 welds, since relief was not sought by South Texas under Code Case N-770-1) Manual, non-encoded, conventional, single-sided examinations performed from the safe-end side Coverage – 75% for welds RSG-1A-IN-SE, RSG-1D-IN-SE, RSG-2A-IN-SE, and RSG-2D-IN-SE	Configuration/scan plans on pages 99–103, 105–109, 222–225, and 227–230 in Ref. 2	Component configuration, CASS material	1) ML102240169 2) ML11133A186 3) ML111860535 Safety Evaluation – Ref. 3

Appendix B

PWR Reactor Coolant System Stainless Steel Welds with Limited Coverage

Appendix B

PWR Reactor Coolant System Stainless Steel Welds with Limited Coverage

Plant/NSSS	Weld Descriptions Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	Reactor Coolant Pump CASS Nozzle Stainless Steel Welds			
ANO-1/ B&W	B-J: 28" RCP CASS nozzle to SS safe-end/pipe Manual, non-encoded, conventional single-sided examination from the safe-end/pipe side Coverage – 50% for weld 09-001	Configuration/scan plan on page 24 of Ref. 2	Component configuration, CASS material	1) ML091520610 2) ML093070060 3) ML100470758 4) ML101170119 Safety evaluation – Ref. 4
Ginna/W	B-J: 31" RCP CASS nozzles to CASS elbows Manual non-encoded conventional best effort (Appendix III) single-sided examination from the elbow side Coverage – 48% for PL-weld FW-XIII and 50% for weld PL-FW-XV	Configuration/scan plan on pages 17 and 18 in Ref. 1	Component configuration, CASS material	1) ML10362A105 2) ML12081A119 3) ML12158A115 Safety evaluation – Ref. 3
	B-J: 29" RCP CASS nozzle to wrought SS pipe Manual, non-encoded, conventional, best effort (Appendix III) examination from the pipe side Coverage – 50% for weld PL-FW-VI	Configuration/scan plan on page 17 in Ref. 1	Component configuration, CASS material	

[1] Representations of configurations referenced in this table vary in quality from scale drawings to hand sketches.
[2] All page numbers in this table refer to the pdf page number, not the page number of the letter or an attachment.

Plant/NSSS	Weld Descriptions Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
North Anna Unit 2/W	R-A: 32" RCP CASS discharge nozzles to CASS piping Manual, non-encoded, single-sided examination from the pipe side Coverage – 50% for welds 9 and 21 and 75% for weld 33	Configurations/scan plans for welds 9, 21, and 33 shown on pages 334, 345, and 349, respectively	Component configuration, CASS material	1) ML11270A122 2) ML12227A773 Safety evaluation – Ref. 2
Oconee 2/3/ B&W	B-J: 33.5" RCP CASS nozzle to SS safe-end Manual non-encoded conventional single-sided UT examination-from the safe-end side Coverage – 37.5% for 2-PIB2-8 and 2-PIB1-8 Coverage – 37.5% for 3-PDA1-1, 3-PDB2-1, 3-PIA2-8, 3-PIB1-8, 3-PIB2-8, 3-PDA2-1, and 3-PDB1-1	Location of configuration/scan plans indicated in Table 1 of Ref. 1	Component configuration, CASS material	1) ML12066A175 2) ML13025A291 Safety Evaluation – Ref. 2 SEs for similar Oconee 1 RCP welds are at ML12334A549 and ML12111A006.
South Texas 1 & 2/W	R-A-1: RCP CASS nozzle to CASS elbow (3 welds per unit) Manual, non-encoded, conventional, dual-sided examinations Per Reference 2, examinations were performed to Section V, Article IV for Unit 1 and Appendix VIII for Unit 2 Coverage – 40% for 31-RC-1102, 52% for 31-RC-1202, 82% for 31-RC-1302, 42% for 31-RC-2102, 45% for 31-RC-2202, and 50% for 31-RC-2302	Scan plans shown on pages 128, 144–146, 245, 247–248, and 250–251 in Ref. 2 Safety evaluation – Ref. 3	Component configuration, weld geometry, CASS material	1) ML102240169 2) ML11133A186 3) ML111860535

Plant/NSSS	Weld Descriptions Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
St. Lucie 1/ CE	B-J: 30" RCP CASS nozzle to CASS safe-end Manual non-encoded conventional single-sided examination from the safe-end side Coverage – 100% from safe-end and 0% from the pump side Weld RC-1 15-FW-3-500E	Configuration on page 37 in Ref. 1 Safety evaluation – Ref. 2	Component configuration, CASS material	1) ML090430304 2) ML100321281
Vogtle 1/W	B-J: 31" RCP CASS nozzle to CASS elbow (11201-005-8) and 27.5" RCP CASS nozzle to CASS pipe (11201-009-1) Manual, non-encoded, dual-sided, Appendix III examination from the elbow and pipe sides Coverage – 75% for weld 11201-005-8 and 90% for weld 11201-009-1	Configuration/scan plans on pages 5 in Ref. 2	Component configuration	1) ML081510904 2) ML091110411 3) ML091240434
Waterford 3/CE	B-J: 30" RCP CASS nozzles to CASS safe-ends Manual non-encoded conventional dual-sided examinations Coverage – 17.5% for Weld 09-017 Coverage – 18% for weld 10-001	Configuration/scan plans on pages 46–48 in Ref. 2	Component configuration, CASS material	1) ML091540088 2) ML093160319 3) ML101590574 Safety evaluation – Ref. 3

Plant/NSSS	Weld Descriptions Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	Steam Generator Stainless Steel Safe-End to CASS Elbow Stainless Steel Welds			
D.C, Cook, Unit 2	B-F[3]: SG SS safe-end to CASS elbows with SS welds Manual, non-encoded, conventional, single-sided examination from the safe-end side Coverage – 19.5% for welds STM-22-02, STM-22-03, STM-23-02, and STM-23-03	Configurations/scan plans on page 93 of Ref. 1	Component configuration, weld geometry, CASS material	1) ML11110A042 2) ML12109A100 Safety Evaluation – Ref. 2
Ginna	B-J: 36" RSG SS safe-end to CASS elbow with SS welds Manual, non-encoded, conventional, single-sided examination from the safe-end side Welds are narrow groove welds not addressed by PDI. No Code coverage achieved. Best effort coverage of 10% for welds PL-FW-III-R and PL-FW-X-R.	Configurations/scan plans on page 16 of Ref. 1	Component configuration, CASS material	1) ML10362A105 2) ML12081A119 3) ML12158A115 Safety Evaluation – Ref. 3

[3] Labeled as B-F welds in submittal. No diameter specified.

Appendix C

Summary of PWR Limited Coverage Stainless Steel and Alloy 600/182/82 Welds

Appendix C

Summary of PWR Limited Coverage Stainless Steel and Alloy 600/182/82 Welds

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
ANO-1/ B&W	B-J: 2.5" HPSI SS pipe to SS elbow. Dual-sided, manual, conventional UT. Coverage – 88%. Weld 22-064	Page 14 of Ref. 1	Component configuration, proximity to adjacent component/ structures	1) ML12207A594 2) ML13179A116 Safety evaluation – Ref. 2
	B-J: 2.5" HPSI SS pipe to SS Valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 22-060	Page 16 of Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 2.5" Pressurizer Spray SS valve to SS pipe. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 18-010.	Page 25 of Ref. 2	Component configuration, no qualified single-sided procedure	1) ML091520610 2) ML093070060 3) ML100470758 4) ML101170119 Safety evaluation – Ref. 4
	B-J: 2.5" High Pressure Injection SS elbow to SS valve. Single-side, manual, conventional UT from the elbow side. Coverage – 41%. Weld 23-055		Component configuration, proximity to adjacent component/ structures, no qualified single-sided procedure	
ANO-2/ CE	C-F-1: 6" Safety Injection SS pipe to CASS valve. Single-side, manual, conventional UT from the pipe side. Coverage reported as 79% per Appendix VIII. Weld 61-021.	Page 71 of Ref. 1	Component configuration, CASS material	1) ML12086A293 2) ML13037A049 3) ML13071A634

[1] Representations of configurations referenced in this table vary in quality from scale drawings to hand sketches.
[2] All page numbers in this table refer to the pdf page number, not the page number of the letter or an attachment.

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	C-F-1: 6" Safety Injection SS flued head penetration to SS pipe. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 66-014.	Page 68 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	Safety evaluation – Ref. 3
	C-F-1: 6" Safety Injection SS weld-o-let-to SS pipe. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 55-034A.	Page 69 of Ref. 1	Component configuration, no qualified single-sided procedure	
	C-F-1: 14" Safety Injection SS tee to SS pipe. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 55-043.		Component configuration, weld geometry, no qualified single-sided procedure	
	C-F-1: 8" Safety Injection SS pipe butt weld to SS branch connection. Single-side, manual, conventional UT from the pipe side. Coverage – 46%. Weld 55-057.	Page 70 of Ref. 1	Component configuration, proximity to adjacent component/ structures, no qualified single-sided procedure	
	C-F-1: 6" Safety Injection SS pipe to CASS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 61-002		Component configuration, CASS material	
	C-F-1: 6" Safety Injection SS pipe to CASS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 61-011	Page 71 of Ref. 1	Component configuration, no qualified single-sided procedure	
	C-F-1: 24" Containment Spray SS elbow to SS pipe. Dual-sided, manual, conventional UT. Coverage – 84%. Weld 78-056.		Weld geometry	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-J: 12" Safety Injection SS elbow to SS valve. Single-side, manual, conventional UT from the elbow side. Coverage 50%. Weld 21-007.	Figure 5 (mislabeled as weld 21-001), page 33 in Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 12" Safety Injection SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 22-004.	Page 34 in Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 12" Safety Injection SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 22-005.		Component configuration, no qualified single-sided procedure	
	B-J: 12" Safety Injection SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 23-006.	Page 35 in Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 12" Safety Injection SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 23-007.		Component configuration, no qualified single-sided procedure	
	B-J: 12" Safety Injection SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 24-006.	Page 36 in Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 3" Pressurizer Spray SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 27-065.	Page 38 in Ref. 1	Component configuration, no qualified single-sided procedure	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-J: 4" Pressurizer LTOP SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 67.6%. Weld 43-027.	Page 44 in Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 2" Charging SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 59.6%. Weld 40-005.	Page 39 in Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	B-J: 2" Charging SS pipe to SS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 60%. Weld 41-003.	Page 41 in Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 3" Shutdown cooling SS pipe butt weld to SS weld-o-let. Single-side, manual, conventional UT from the pipe side. Coverage – 68.75%. Weld 25-024.	Page 37 in Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 3" Pressurizer spray SS pipe to SS tee. Dual-sided, manual, conventional UT. Coverage – 73%. Weld 27-066.	Page 39 in Ref. 1	Weld geometry, no qualified single-sided procedure, component configuration	
	B-J: 2" Charging SS pipe to SS tee. Single-side, manual, conventional UT from the pipe side. Coverage – 60%. Weld 41-003C.	Page 41 in Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	B-J: 6" Pressurizer LTOP SS pipe to SS tee. Dual-sided, manual, conventional UT. Coverage – 71.2%. Weld 43-022.	Page 42 in Ref. 1	Component configuration, weld geometry	
	B-J: 6" Pressurizer LTOP SS pipe to SS tee. Dual-sided, manual, conventional UT. Coverage – 81%. Weld 43-023.	Page 43 in Ref. 1	Component configuration, weld geometry	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-J: 3" Pressurizer LTOP SS pipe to SS tee. Dual-sided, manual, conventional UT. Coverage – 72.5%. Weld 43-033.	Page 44 in Ref. 1	Component configuration, weld geometry	
	B-J: 2" Pressurizer Auxiliary Spray SS pipe to SS tee. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 29-056.	Page 46 in Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	B-J: 3" Pressurizer Spray SS pipe to SS elbow. Dual-sided, manual, conventional UT. Coverage – 83%. Weld 27-003.	Page 38 in Ref. 1	Component configuration	
	B-J: 2" Charging SS pipe to SS elbow. Dual-sided, manual, conventional UT. Coverage – 74%. Weld 40-008.	Page 40 in Ref. 1	Component configuration, weld geometry	
	B-J: 3" Pressurizer Spray SS elbow to SS safe-end. Dual-sided, manual, conventional UT. Coverage – 83%. Weld 27-002	Page 38 in Ref. 1	Component configuration	
	B-J: 2" Charging SS elbow to SS safe-end. Dual-sided, manual, conventional UT. Coverage – 85%. Weld 40-025.	Page 46 in Ref. 1	Component configuration	
	B-J: 3" Pressurizer Spray SS safe-end to CS loop piping nozzle with a SS weld. Dual-sided, manual, conventional UT. Coverage – 83%. Weld 27-001.	Page 37 in Ref. 1	Component configuration, weld geometry	
Beaver Valley 1&2/ W	No incomplete coverage relief request safety evaluations found between 2008 and 2015 for incomplete coverage of B-J, B-F, C-F-1, or R-A welds.			

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
Braidwood Unit 1 & 2/ W	R-A (B-J): 4" Pressurizer Spray SS pipe to SS valve. Single-side manual, conventional UT from the pipe side. Coverage – 50%. Weld 1RC-17-13.	Page 66 in Ref. 1	Component configuration, no qualified single-sided procedure	1) ML090960468 2) ML100480699 Safety evaluation – Ref. 2
	R-A (C-F-1): 6" Auxiliary Feedwater Inconel safe-end to CS steam generator nozzle with Inconel 690 weld. Single-side manual, conventional UT from the safe-end side. Coverage – 79%. Weld 1SG-05-SGSE-02.	Page 74 & 75 in Ref. 1	Component configuration	
Callaway/W	No incomplete coverage relief request safety evaluations found between 2008 and 2015 for incomplete coverage of B-J, B-F, C-F-1, or R-A welds.			
Catawba 1 & 2/W	B-J: 6" Cold Leg Safety Injection SS pipe to SS valve. Single-side, manual, conventional UT. Coverage – 37.5%. Weld #2NI70-4.	Page 125 in Ref. 1	Component configuration, no qualified single-sided procedure	1) ML11278A184 2) ML12228A723 Safety evaluation – Ref. 2
	C-F-1: 4" Safety Injection SS elbow to SS tee. Dual-sided, manual, conventional UT. Coverage – 77%. Weld #1NI11-9.	Pages 65 to 68 in Ref. 1	Component configuration, proximity to adjacent component/structures	
	C-F-1: 7.5" Auxiliary Feedwater CS nozzle to Inconel transition ring with an Inconel weld. Appendix VIII, Supplement 10, demonstrated procedure for Single-side axial scanning. Single-sided, manual, conventional UT from the transition ring in the axial direction. Dual-sided circumferential scans. Coverage – 68.6%. Weld #1SGD-W261.	Page 92 and 93 in Ref. 1	Component configuration	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	C-F-1: 6" Auxiliary Feedwater System Inconel transition ring Inconel weld to CS elbow. Dual-sided, manual, conventional UT. Coverage – 77%. Weld #1CA66-35.	Page 99 and 100 in Ref. 1	Component configuration	
Comanche Peak 1/W	R-A (B-J): 10" SI Accumulator Discharge System SS elbow to SS pipe. Dual-sided, manual, conventional UT. Coverage – 82% and 79%. Welds TBX-1-4201-9 and TBX-1-4201-10	TBX-1-4201-9 page 7 in Ref. 1 TBX-1-4201-10 page 9 in Ref. 1	Proximity to adjacent component/structures	1) ML103560597 2) ML112650083 Safety evaluation – Ref. 2
Davis Besse/ B&W	No incomplete coverage relief request safety evaluations found between 2008 and 2015 for incomplete coverage of B-J, B-F, C-F-1, or R-A welds.			
McGuire 1/ W	R-A (C-F-1): 2" Chemical and Volume Control System SS pipe to CASS valve. Single-side axial scans from the pipe side and Dual-sided circumferential scans using manual, conventional UT. Coverage – 37.5%. Weld #1NV1 FW53-27.	Page 81 of Ref. 1	Component configuration, CASS material	1) ML12355A149 2) ML13294A609 Safety evaluation – Ref. 2
North Anna 2/W	R-A (B-J): 27.5" CASS pipe to CASS stop valve SS weld on valve inlet side of RCP discharge leg. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld 22	Page 383 of Ref. 1	Component configuration, CASS material	1) ML11270A122 2) ML12227A773 Safety evaluation – Ref. 2
Oconee 3/ B&W	B-J: 14" Low Pressure Injection System CASS valve to SS pipe. Single-side scan in axial direction from the pipe side. Dual-sided scans in the circumferential direction. Manual, conventional UT. Coverage – 36.8%. Weld 3-53A-15-26	Page 98 of Ref. 1	Component configuration, CASS material	1) ML13273A037 2) ML14216A476 Safety evaluation – Ref. 2

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
Point Beach 1 & 2/W	R-A: 10" Auxiliary Cooling System SS wrought pipe to CASS valve. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Welds AC-10-SI-1001-19 and AC-10-SI-2001-17	Configurations on page 5 in Ref. 1	Component configuration, CASS material	1) ML13079A144 2) ML13241A201 3) ML13329A042 Safety evaluation – Ref. 3
TMI-1/ B&W	R-A: 2 ½" High Pressure Injection CASS valve to SS safe-end. Single-side, manual, conventional UT from the safe-end side. Coverage – 50%. Welds MU0901BM, MU0903BM, MU0907BM, and MU0952BM.	Pages 18 and 19 of Ref. 1	Component configuration, CASS material	1) ML110410126 2) ML113410469 Safety evaluation – Ref. 2

Appendix D

Summary of BWR Limited Coverage Welds

Appendix D

Summary of BWR Limited Coverage Welds

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
		Welds		
Browns Ferry, Unit 1	No Safety Evaluations related to code required volume coverage found back through 2008 for incomplete coverage of B-J, B-F, C-F-1, or R-A welds.			
Browns Ferry, Unit 2	B-J: 6" Reactor Water Cleanup System stainless steel pipe to stainless steel weld-o-let; dual-sided, manual, conventional UT. Coverage – 85.5%. Weld RWCU-2-003-070.	Page 18 of Ref. 1	Component configuration	1) ML12150A368 2) ML13085A027 3) ML13148A308 Safety evaluation – Ref. 3
	B-J: 4" Reactor Control Rod Drive System SS valve to CS elbow with a SS DMW. Single-sided, manual, conventional UT from the elbow side and on top of weld. Coverage – 53.4%. Weld RCRD-2-50.	Pages 27 of Ref. 1	Component configuration, weld geometry	
	B-J: 24" Decay Heat Removal System. SS flued head to CASS valve. Single-sided manual, conventional UT from the flue head. Coverage – 50%. Weld DRHR-2-03.	Page 30 of Ref. 1	Component configuration, CASS material	

[1] Representations of configurations referenced in this table vary in quality from scale drawings to hand sketches.
[2] All page numbers in this table refer to the pdf page number, not the page number of the letter or an attachment.

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-J: 12"– Reactor Water Recirculating System SS branch connection (tee) a SS pipe. Single-sided, manual, conventional UT examined from pipe side. Coverage – 75%. Weld GR-2-09.	Page 33 of Ref. 1	Component configuration, no qualified single-sided procedure	
Browns Ferry, Unit 2	R-A (B-J): 6", Reactor Water Cleanup System pipe to CASS valve. Single-sided, manual, conventional UT examined from pipe side. Coverage – 50%. Weld RWCU-2-003-025.	Page 19 of Ref. 1	Component configuration, CASS material	1) ML100570413 2) ML103370466 Safety evaluation – Ref. 2
	R-A (B-J): 12" Reactor Recirculation System SS pipe saddle to SS pipe. Single-sided, manual, conventional UT examined from pipe side. Coverage – 50%. Weld GR-2-22.	Pages 25 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	R-A (B-J): 12" Reactor Recirculation System SS pipe saddle to SS pipe. Single-sided, manual, conventional UT examined from pipe side. Coverage – 50%. Weld GR-2-35.	Pages 31 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
Browns Ferry, Unit 3	R-A (B-J): 28" Reactor Recirculation System CASS valve to SS pipe. Single-sided, manual, conventional UT examined from pipe side. Coverage – 75%. Weld GR-3-63.	Page 18 of Ref. 1	Component configuration, CASS material	1) ML072560047 2) ML080080524 Safety evaluation – Ref. 2
	R-A (B-J): 6" Reactor Water Cleanup System SS sweep-o-let to CASS valve. Single-sided, manual, conventional UT examined from sweep-o-let side. Coverage – 30.5%. Weld RWCU-3-001-070.	Page 18 of Ref. 1	Component configuration, CASS material	1) ML110260395 2) ML12003A081 Safety evaluation – Ref. 2

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	R-A (B-J): 6" Reactor Water Cleanup System SS pipe to CASS valve. Single-sided, manual, conventional UT examined from pipe side. Coverage – 69%. Weld RWCU-3-001-071.	Page 31 of Ref. 1	Component configuration, CASS material	
	R-A (B-J): 20" Residual Heat Removal SS elbow to CASS valve. Single-sided, manual, conventional UT examined from elbow side. Coverage – 54%. Weld DRHR-3-21.	Page 71 of Ref. 1	Component configuration, CASS material	
Clinton	No Safety Evaluations related to code required volume coverage found back through 2008 for incomplete coverage of B-J, B-F, C-F-1, or R-A welds.			
Cooper	B-F: Core Spray CS nozzle to SS safe-end with Alloy 82 weld to an Alloy 182 butter. Dual-sided axial scans with circumferential scans from the pipe side only. Coverage – 75%. Weld CSA-BF-lx.	Configuration on page 8 of Ref. 1 No scan plan or information on techniques provided	Weld geometry	1) ML090540420 2) ML092650190 3) ML093521350 Safety evaluation – Ref. 3
	B-F: Reactor Recirculation System CS nozzle to SS safe-end with an Inconel weld. Dual-sided axial scans with circumferential scans from the pipe side only. Coverage – 75%. Weld RRH-BF-1.		Weld geometry	
	B-F: Reactor Recirculation System CS nozzle to SS safe-end with an Inconel weld. Dual-sided axial scans with circumferential scans from the pipe side only. Coverage – 75%. Weld RRK-BF-1.		Weld geometry	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-F: Reactor Recirculation System CS nozzle to SS safe-end with an Inconel weld. Dual-sided, axial scans with circumferential scans from the pipe side only. Coverage – 75%. Weld RRE-BF-1		Weld geometry	
Dresden 2/3	No Safety Evaluations related to code required volume coverage found back through 2008 for incomplete coverage of B-J, B-F, C-F-1, or R-A welds.			
Duane Arnold	B-J: 4" Recirculation Discharge Line SS weld-o-let to SS pipe. Single-sided, manual, conventional UT from the pipe side only. Coverage – 35%. Weld RBB-J001.	Page 119 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	1) ML073130049 2) ML080990636 Safety evaluation – Ref. 2

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
Edwin Hatch[3]	B-J: Reactor Water Cleanup System SS elbow to SS valve. Single-sided, manual conventional UT from the elbow side. Coverage – 50%. Weld 1G31-1RWCUM-6-D-20	Page 13 of Ref. 1	Component configuration, weld geometry	1) ML101890572 2) ML103280372 3) ML110820261 4) ML11164A133 Safety evaluation – Ref. 4
	B-J: Reactor Circulation System SS valve to SS elbow. Single-sided, manual conventional UT from the elbow side. Coverage – 50%. Weld 2B31-1 RCM-28AD-3		Component configuration, weld geometry	
	B-J: Residual Heat Removal System SS elbow to SS tee. Dual-sided, manual, conventional UT. Coverage – 85.6%. Weld 2E11-1 RHRM-24A-13		Component configuration	
	B-J: Residual Heat Removal System SS elbow to CS pipe with a SS weld. Dual-sided, manual, conventional UT. Coverage – 87%. Weld 2E11-1 RHRM20RS-3	Figs 1, 2, and 3, pages 37–39 in Ref. 1	Component configuration	
	B-J: Feedwater System Inconel weld joining an Inconel safe-end to Inconel safe-end extension. Dual-sided, manual, conventional UT. Coverage – 86.5%. Weld 2B21-1 FW12BC-12.	Pages 43 and 44 in Ref. 1.	Component configuration	
	B-F: Core Spray System low alloy steel safe-end to Inconel welds to Inconel buttered nozzles. Dual-sided, manual, conventional UT. Coverage – 86.5%. Welds 2E21-1CS-10A-21 and 2E21-1CS-10B-20	Page 48 of Ref. 1	Weld geometry	

[3] Component diameters were not provided in the Hatch submittals.

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-J: Reactor Water Cleanup System SS pipe to wrought austenitic penetration. Single-sided, manual conventional UT from the penetration side. Coverage – 50%. Weld 2G31-1RWCUM-6-D-15	Page 53 of Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: Reactor Water Cleanup System wrought austenitic pipe to CASS valve. Single-sided, manual conventional UT from the pipe side. Coverage – 50%. Weld 2G31-1RWCUM-6-D-16	Page 54 of Ref. 1	Component configuration, CASS material	
	B-J: Reactor Water Cleanup System SS valve to wrought penetration. Single-sided, manual conventional UT from the penetration side. Coverage – 50%. Weld 2G31-1RWCUM-6-D-17		Component configuration, no qualified single-sided procedure	
Fermi	No Safety Evaluations related to code required volume coverage found back through 2008 for incomplete coverage of B-J, B-F, C-F-1, or R-A welds.			
Grand Gulf[4]	B-F: 24" Reactor Recirculation System CS nozzle to SS safe-end with SS weld. Single-sided, manual, conventional UT from the safe-end side. Coverage – 75.6%. Weld N01A-KB	Page 37 of Ref. 2	Weld geometry	1) ML091490755 2) ML092750079 3) ML101410002 Safety evaluation – Ref. 3
	B-F: 14" Reactor Recirculation System CS nozzle to SS safe-end with SS weld. Single-sided, manual, conventional UT from the safe-end side. Coverage – 77.3%. Weld N02K-KB		Weld geometry	

[4] Information was not provided of the systems of some of the welds in the Grand Gulf submittals.

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-J: 16" RCS SS pipe to SS cross. Single-sided, manual, conventional pre-Appendix VIII UT from the pipe side. Coverage – 50%. Weld B33G10-B1-B	Page 42 of Ref. 2	Component configuration, no qualified single-sided procedure	
	B-J: 12" RCS SS pipe to SS tee. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld B33G001-W20	Page 48 of Ref. 2	Component configuration, no qualified single-sided procedure	
	B-J: 12" RCS SS pipe to SS tee. Single-side, manual, conventional UT from the pipe side. Coverage – 50%. Weld B33G001-W22		Component configuration, no qualified single-sided procedure	
	B-J: 12" RCS SS valve to SS pipe. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld B33G001-W33	Page 55 of Ref. 2	Component configuration, no qualified single-sided procedure	
	B-J: 24" SS pipe to SS tee. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 1B33G001W11	Page 57 of Ref. 2	Component configuration, no qualified single-sided procedure	
	B-J, 24" SS pipe to SS tee. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 1B33G10-A1-A		Component configuration, no qualified single-sided procedure	
	B-J, 12" RCS SS pipe to SS sweep-o-let. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld B33G10-B1-H	Page 48 of Ref. 2	Component configuration, no qualified single-sided procedure	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1] [2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-J, 12" RCS SS pipe to SS sweep-o-let. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld B33G10-B1-G		Component configuration, no qualified single-sided procedure	
	B-J: 12" RCS SS pipe to SS sweep-o-let. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld B33G10-B1-F		Component configuration, no qualified single-sided procedure	
	B-J: 12" RCS SS branch to SS pipe. Dual-sided, manual, conventional UT. Coverage – 83%. Welds 1B33G10-A1-F, 1B33G10-A1-G, and 1B33G10-A1-H	Page 53 of Ref. 2	Component configuration	
Pilgrim	B-F: 10" Core Spray System SS valve to CS pipe with Inconel weld. Single-sided, manual, conventional UT from the pipe side. Coverage – 37%. Weld 14-A-10A	Page 128 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	1) ML072620080 2) ML081300415 Safety evaluation – Ref. 2
	B-F: 10" Core Spray System SS valve to CS pipe with Inconel weld. Single-sided, manual, conventional UT from the pipe side. Coverage – 22%. Weld 14-B-10A	Page 134 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	B-F: 28" Reactor Recirculation System CS RPV nozzle to SS safe-end with an Inconel weld. Dual-sided, manual, conventional UT. Coverage – 75%. Weld 2R-N1B-1	Pages 139–150 of Ref. 1	Weld geometry, minimum, wall	
	B-F: 12" Reactor Recirculation System CS RPV nozzle to SS safe-end with an Inconel weld. Dual-sided, manual, conventional UT. Coverage – 81%. 2R-N2E-1	Pages 150–162 of Ref. 1	Weld geometry, minimum, wall	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-F: 12" Reactor Recirculation System CS RPV nozzle to SS safe-end with an Inconel weld. Dual-sided, manual, conventional UT. Coverage – 75%. Weld 2R-N2-G-1	Pages 163–176 of Ref. 1	Weld geometry, minimum, wall	
	B-F: 12" Reactor Recirculation System CS RPV nozzle to SS safe-end with an Inconel weld. Dual-sided, manual, conventional UT. Coverage – 75%. Weld 2R-N2J-1	Pages 177–188 of Ref. 1	Weld geometry, minimum, wall	
	B-J: 18" Residual Heat Removal SS pipe to SS flued head. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 10-1A-14	Page 199 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	B-J: 18" Residual Heat Removal SS pipe to SS valve. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 10-1A-15	Page 201 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	B-J: 18" Residual Heat Removal System SS pipe to SS valve. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 10R-1A-6	Page 204 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	B-J: 18" Residual Heat Removal System SS pipe to SS valve. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 10R-1A-7	Page 207 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	
	B-J: 6" Reactor Water Cleanup System SS penetration to SS pipe. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 12-0-24	Page 210 of Ref. 1	Component configuration, weld geometry, no qualified single-sided procedure	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	B-J: 10" Core Spray SS pipe to SS valve. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 14-A-19	Page 213 of Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 10" Core Spray SS penetration to SS pipe. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 14-B-17	Page 217 Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 10" Core Spray SS penetration to SS pipe. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 14-B-20	Page 218 Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 12" Reactor Recirculation System SS pipe to SS reducer. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 2R-HB-1	Pages 225/226 of Ref. 1	Component configuration, no qualified single-sided procedure	
	B-J: 12" Reactor Recirculation System SS pipe to SS reducer. Single-sided, manual, conventional UT from the pipe side. Coverage – 50%. Weld 2R-HB-4	Page 230 of Ref. 1	Component configuration, no qualified single-sided procedure	

Plant	Weld Descriptions/ Examination Technique/Coverage	Configurations[1 2] and Scan Plans (if provided)	Coverage Limitations (licensee stated)	References
	C-F-1: 6" Core Spray System CS pipe to CASS valve with SS weld. Single-sided, manual, conventional UT from the pipe side. Coverage – 30%. Weld GB-14-F34 GB-14-F34; Limitation from the pipe side caused primarily because licensee did not comply with procedural requirements to sufficiently prepare the surface condition of the weld for adequate ultrasonic accessibility. Licensee proposed using RT. Staff denied request.	Page 240, Ref. 1		

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99352
1-888-375-PNNL (7665)

www.pnnl.gov

Prepared for the U.S. Nuclear Regulatory Commission
under a Related Services Agreement with the U.S. Department of Energy
CONTRACT DE-AC05-76RL01830

U.S. DEPARTMENT OF
ENERGY