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REVIEW OF SAVANNAH RIVER SITE K REACTOR INSERVICE INSPECTION AND TESTING RESTART PROGRAM

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ABSTRACT

Inservice inspection (ISI) and inservice testing (IST) programs are used at commercial nuclear power plants to monitor the pressure boundary integrity and operability of components in important safety-related systems. The Department of Energy (DOE) - Office of Defense Programs (DP) operates a Category A (> 20 MW thermal) production reactor at the Savannah River Site (SRS). This report represents an evaluation of the ISI and IST practices proposed for restart of SRS K Reactor as compared, where applicable, to current ISI/IST activities of commercial nuclear power facilities.

PREFACE

Recent investigations of existing ISI and IST practices for five DOE Category A test and research reactors were conducted by staff of the Idaho National Engineering Laboratory (INEL). The findings of these investigations are documented in the following reports to NE-80, the Office of Nuclear Energy (NE) Self-Assessment:

Review of Inservice Inspection and Nondestructive Examination Practices at DOE Category A Test and Research Reactors, EGG-MS-9254, September 1990.

Inservice Testing of Pumps and Valves at DOE Category-A Reactors, EGG-NTA-9270, October 1990.

The Savannah River Site (SRS) production reactor(s) were specifically excluded from these reviews due to the significant restart efforts that were ongoing at the time. It was understood that a similar review would be performed at a later date for the SRS reactor facilities.

At the request of DP-623, the Office of Operations and Engineering Support, a limited ISI/IST evaluation was performed for SRS K Reactor during FY-1991. The review was based on WSRC-TR-90-42-123, *Restart Inspection and Testing Plan (U)*, Revision 0, which was developed by the SRS operating contractor as a Safety Evaluation Report (SER) restart commitment. This report documents that evaluation.

Evaluation criteria were developed through technical discussions between INEL and DOE. Although no offical DOE policy regarding the application of commercial ISI/IST standards at Category A reactor facilities was in effect at the time, INEL was requested to review and compare the SRS ISI/IST plan against the *ASME Boiler and Pressure Vessel Code, Section XI*. At issue, then and now, is the extent to which DOE facilities should be required to implement the rules of the ASME Code. Direction from DP-623 regarding the use of this Code guided the INEL evaluation.

It was understood this evaluation, although not intended to affect K Reactor restart, would provide DP-623 with an independent assessment of existing SRS ISI/IST program(s). The purpose of the report is to provide technical information that may assist DOE in making informed decisions regarding the future operability and general safety of SRS production reactors.

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INTRODUCTION

This report documents the Idaho National Engineering Laboratory's (INEL) review of inservice inspection (ISI) and inservice testing (IST) portions of the Restart Plan[1] for K Reactor at the Savannah River Site (SRS). The U.S. Department of Energy (DOE) - Defense Programs (DP) has oversight for SRS production reactors. This report provides a brief comparison of SRS ISI/IST practices with those of commercial nuclear power plants.

The objectives of the INEL review of the SRS ISI/IST Restart Plan were to evaluate the overall adequacy of proposed inspections and tests; to determine if Restart Criteria listed in the SRS Safety Evaluation Report (SER)[2] were being properly addressed; and to compare SRS ISI/IST program requirements to those of the *American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code*, Section XI.[3] Both the Restart Plan and SER Section 14 referenced various documents considered to be important for performing a detailed evaluation. The supporting documentation was not available to the INEL staff, consequently this review produced findings of a limited nature. It is suggested that a more comprehensive evaluation be performed that includes all basis documents when the post-restart ISI/IST program is developed.

The SRS Restart ISI/IST Plan was reviewed to ensure that applicable SER commitments were being properly addressed. Section 14 of the SER, revision dated August 15, 1990, listed several "Open Items" that were resolved and approved in the latest SER revision (April 1991). As previously stated, all documentation needed to confirm the resolution of restart ISI issues was not available to the INEL staff, however, no serious discrepancies were noted with respect to stated SER restart commitments. An evaluation of long-term (post restart) ISI/IST commitments was not performed during this review.

BACKGROUND

K Reactor is a heavy water (D_2O) cooled, low pressure and temperature (max. 225 psig and 95°C) facility that produces tritium for DOE - DP. Although many differences exist between K Reactor and commercial nuclear power facilities, which operate at much higher temperatures and pressures, both have plant systems that perform similar safety functions. At SRS these include a primary Process Water System (PWS), which consists of the reactor tank and six coolant loops, and secondary reactor support systems, e.g., Cooling Water (CWS), Emergency Cooling Water (ECWS) and Confinement Heat Removal (CHR).

Many of the SRS plant systems function to prevent, or mitigate the consequences of, an accident. Periodic monitoring of important system components is essential to ensure the safe and reliable operation of the facility. A formal ISI/IST program facilitates this effort by describing the inspections and tests, i.e., parameters to monitor, acceptance criteria, examination and test frequencies, and other plant specific requirements necessary for program implementation.

Development of a formal ISI/IST program for aging SRS production reactors requires the integration of several complicated issues. Among these are the application of appropriate inspection and testing methods given the unique design of SRS systems and components, performing a current assessment of component operability and integrity as no baseline may exist for many items, and the implementation of standardized and proven commercial nuclear industry ISI/IST practices. During this review, recognition of the complexity of these issues moderated the INEL evaluation of specific restart program items.

ISI PROGRAM REVIEW

Discussion

The SRS Restart ISI Plan referenced Section XI of the ASME Code, 1986 Edition through 1987 Addenda. The latest version of the Code is the 1989 Edition through 1991 Addenda. The most significant difference between these two versions pertains to the extent and schedule of reactor vessel shell weld examinations. Because the existing SRS ISI program specifies volumetric examinations of reactor tank welds on a more frequent schedule than required by the Code, this review compares SRS Restart ISI Plan requirements to the latest Code version.

SRS reactor cooling systems and components are similar in function to those of commercial facilities, e.g., the reactor tank and PWS correspond to a commercial reactor pressure vessel and primary coolant system (ASME Class 1), and the SRS CW system corresponds to the heat removal functions of commercial feedwater and main steam systems (ASME Class 2). Table 1 is a comparison of SRS Restart ISI Plan requirements to those of corresponding ASME Class 1 and 2 component examination categories. Of the 47 SRS component examination requirements reviewed, 6 were found to be not applicable, 5 totally compliant, 15 partially compliant, and 21 noncompliant with the examination requirements of the Code.

With some exceptions, the SRS PWS examinations are comparable to those required of commercial nuclear facilities for primary coolant systems. Several SRS ISI practices actually exceed Code requirements, e.g., volumetric examination frequencies of reactor tank welds and PWS piping welds. In addition, the qualification of nondestructive examination (NDE) personnel compares favorably with standard commercial nuclear practices.

However, the similarity of SRS ISI practices to those of commercial facilities ends at the PWS (Class 1) boundary. As indicated by Table 1, many of the examinations performed on SRS secondary reactor support systems (CW, ECWS, and CHR) deviate from Code requirements for comparable Class 2 components. It should be recognized that SRS Class 2 examination practices have evolved from plant operating experiences, e.g., component failures leading to listings in an inspection log, however, current component inspections would require significant upgrades to be commensurate with those of ASME commercial Class 2 systems. A more detailed item comparison of SRS examination requirements to those of ASME Section XI is included as Appendix A. Appendix A was developed using SRS examination requirements found in procedures DPSOL 105-1851B-PLK[4] and DPSTM-88-100-1,[5] which collectively form the basis for current ISI practices at SRS.

Conclusions

This investigation produced a brief overview of existing SRS ISI practices to establish a general point of reference for future DOE evaluations. The SRS Restart ISI Plan currently provides limited guidance for the examination of safety-related components at K Reactor. Many of the examinations for the PWS (Class 1) are commensurate with those required of commercial nuclear facilities by ASME Section XI. However, SRS secondary reactor support systems (Class 2), which may also have important safety functions, do not receive the rigor of inspections required by the Code for corresponding systems at commercial facilities.

While SRS Class 2 inspections fall short of ASME requirements, no immediate concerns of component or system integrity have been noted that might compromise overall plant safety or impact the K Reactor restart schedule. It is recommended that in future ISI program development, SRS examinations of Class 2 safety-related systems be upgraded to comply with ASME requirements and any deviations based on impracticality be documented, as is the standard commercial practice.

TABLE 1 - COMPARISON OF SRS EXAMINATIONS TO ASME SECTION XI

COMPONENT	SRS		ASME		SRS-ASME COMPLIANCE
	METHOD[a]	EXAMINATION FREQUENCY	CATEGORY	REQUIREMENT[a]	
Reactor Tank Wall Internal Surfaces (Insp #121)[4]	Periscope	5 Yr.	B-N-1	VT-3 refuel outages, approx every 3 Yr	PARTIAL
Reactor Tank Wall Exterior Surface (Insp #141)[4]	Borescope	10 Yr.	N/A	N/A	N/A
PW Reactor Tank 36 Welds, 30 Segments[5]	ET, UT, & VT	5 Yr.	B-A	Vol all welds each interval	YES
PW Plenum Inlet Nozzle (Insp #128)[4]	PT	5 Yr.	B-D	Vol all nozzles each interval	NO
Plenum Inlet Nozzle (Insp #143)[4]	VT	10 Yr.	B-D	Vol all nozzles each interval	NO
Plenum Inlet Line (Insp #142)[4]	PT	10 Yr.	B-J	≥4" Sur & Vol, <4" Sur each interval	PARTIAL
PW Plenum Tiebolts (Insp #129)[4]	"Remove one for lab exam"	5 Yr.	B-G-1 or B-G-2	Vol or Sur & VT-1, all each interval	PARTIAL
PW Expansion Joints (Insp #130)[4]	VT	5 Yr.	N/A	N/A	N/A
PW Piping Welds (Insp #101)[4]	UT	1 Yr.	B-J	≥4" Sur & Vol, <4" Sur each Interval	PARTIAL

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COMPONENT	SRS		ASME		SRS-ASME COMPLIANCE
	METHOD[a]	EXAMINATION FREQUENCY	CATEGORY	REQUIREMENT[a]	
PW Piping Welds (Insp #122)[4]	UT	5 Yr.	B-J	≥4" Sur & Vol, <4" Sur each interval	PARTIAL
PW Piping Side Welded Elbows (Insp #125)[4]	PT	5 Yr.	B-J	≥4" Sur & Vol, <4" Sur each interval	PARTIAL
PW Piping Flame Washed Metal (Insp #126)[4]	UT	5 Yr.	B-J	≥4" Sur & Vol, <4" Sur each interval	PARTIAL
PW Piping Vibration Survey (Insp #127)[4]	Vibration Meter	5 Yr.	N/A	N/A	N/A
PW System Piping[3] 54 Category A Welds 451 Category B Welds 21 Category C Welds	VT-1 & UT	18 Months to 10 Yr.; Cat. A, B, C	B-J	≥4" Sur & Vol, <4" Sur each interval	YES
PW Flame Washed Areas[3] 11 Category B Welds 1 Category C Weld	VT-1 & UT	18 Months to 10 Yr.; Cat. A, B, C	B-J	≥4" Sur & Vol, <4" Sur each interval	YES
PW Component Supports[3] 296 Supports	VT-3	Not detailed in SRS Program	B-K-1 or F-A	B-K-1 Vol or Sur, F-A VT-3, % each interval	PARTIAL

TABLE 1 - COMPARISON OF SRS EXAMINATIONS TO ASME SECTION XI

COMPONENT	SRS		ASME		SRS-ASME COMPLIANCE
	METHOD[a]	EXAMINATION FREQUENCY	CATEGORY	REQUIREMENT[a]	
Bingham Pump System (Insp #124)[4]	Flange-PT Gasket-VT	5 Yr.	B-G-1 or B-G-2	Bolts, studs Vol; Flange VT-1; Nuts, washers VT-1; 1 pump each interval	PARTIAL
Bingham Pump (Insp #306)[4]	Vibration Meter	1 Yr.	N/A	N/A	N/A
Bingham Pump Drive Train Flywheels (Insp # 312)[4]	VT	5 Yr.	Reg Guide 1.14	Vol 3 yr. intervals; Sur & Vol 10 yr. interval	NO
Bingham Pump Casing & Casing Wear Rings (Insp #102)[4]	VT	15 Yr.	B-L-1 or B-L-2	Casing welds Vol; Casing VT-3; 1 pump each interval	PARTIAL
Heat Exchanger Tubes (Insp #106)[4]	Pressure, VT	10 Yr.	B-Q	Vol, % each refuel outage	NO
HX Heads & Staybolts (Insp #109)[4]	PT	10 Yr.	B-B & B-G-1 or B-G-2	Head welds Vol; >2" dia Vol; ≤2" dia VT-1; all each interval	NO
Septifoil Piping (Insp #110)[4]	PT or UT	2 Yr.	B-J	≥4" Sur & Vol, <4" Sur, % each interval	PARTIAL

TABLE 1 - COMPARISON OF SRS EXAMINATIONS TO ASME SECTION XI

COMPONENT	SRS		ASME		SRS-ASME COMPLIANCE
	METHOD[a]	EXAMINATION FREQUENCY	CATEGORY	REQUIREMENT[a]	
Septifoil & Roto Valves 18 Valves (RIMP IM-840)	VT	Not Detailed in SRS Program	B-M-1 or B-M-2	Welds Sur or Vol; Valve Bodies VT-3	PARTIAL
Heat Exchanger Shell (Insp #105)[4]	PT	10 Yr.	C-A	Welds Vol, % each interval	NO
CW Booster Pump (Insp #215)[4]	VT	1 Yr.	C-H	Pressure test & Hydro VT-2 each interval	PARTIAL
Booster Pump (Insp #224)[4]	VT & UT thickness tester	5 Yr.	C-H	Pressure test & Hydro VT-2 each interval	PARTIAL
Cooling Water & ECW Piping (Insp #221)[4]	UT thickness tester	3 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO
CW & ECW Piping (Insp #233)[4]	VT	10 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO
CW Expansion Joints (Insp #211)[4]	PT	3 Yr.	N/A	N/A	N/A
CW Piping to AC Motors (Insp #216)[4]	VT & UT thickness tester	2 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO
CW Piping Paint (Insp #212)[4]	VT	1 Yr.	N/A	N/A	N/A

TABLE 1 - COMPARISON OF SRS EXAMINATIONS TO ASME SECTION XI

COMPONENT	SRS		ASME		SRS-ASME COMPLIANCE
	METHOD[a]	EXAMINATION FREQUENCY	CATEGORY	REQUIREMENT[a]	
CW System Integrity 24 Pipe Lines (WSIR-38)	22 lines UT; 2 thick lines VT	3 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO
ECW Pump & Expansion Joint Piping (Insp #230)[4]	UT thickness tester	3 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO
ECW Backflow Flapper Valve (Insp #362)[4]	VT	2 Yr.	C-G	Valve Body, Sur, % each interval	NO
EC System Piping[3] 64 Category B Welds	UT/VT-1	18 Months to 10 Yr.; Cat. A, B, C	C-F-1 or C-F-2	Sur/Vol welds, % each interval	PARTIAL
EC System Check Valves 7 Valves, (RIMP IM-026)	VT	Not Detailed in SRS Program	C-G	Sur, % each interval	NO
Emergency Spray System Piping & ECW-24 (Insp #352)[4]	UT thickness tester	2 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO
Emergency Pump Room Cooling Water Piping (Insp #223)[4]	UT thickness tester	5 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO
Emergency Pump Room Piping (Insp #231)[4]	VT	10 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO

TABLE 1 - COMPARISON OF SRS EXAMINATIONS TO ASME SECTION XI

COMPONENT	SRS		ASME		SRS-ASME COMPLIANCE
	METHOD[a]	EXAMINATION FREQUENCY	CATEGORY	REQUIREMENT[a]	
ECS Valves (Insp #227)[4]	VT	5 Yr.	C-G	Welds, Sur, % each interval	NO
107 Pumps (Insp #225)[4]	Casing-UT thickness tester	5 Yr.	C-G	Welds-Sur, % each interval	NO
Confinement Heat Removal Tank (Insp #355)[4]	VT & UT thickness tester	2 Yr.	C-A	Vol, % each interval	NO
Confinement Heat Removal Piping (Insp #220)[4]	VT	5 Yr.	C-F-1 or C-F-2	Sur/Vol welds, % each interval	NO
Pipe Hangers & Supports (Insp #309)[4]	VT	1 Yr.	F-A, B,C	VT-3, % each interval	YES
Pipe Hangers & Supports (Insp #325)[4]	VT, MT, PT	5 Yr.	F-A, B,C	VT-3, % each interval	YES
Supplementary Safety System Check Valves & Ink Tanks (Insp #350)[4]	VT & UT thickness tester	2 Yr.	C-A, C-G	Valves, Sur; Vessels, Vol; % each interval	NO

NOTES:

a. Surface (Sur) Examinations: Magnetic Particle (MT), Liquid Penetrant (PT), Electromagnetic Testing (ET)

Volumetric (Vol) Examinations: Ultrasonic Testing (UT), ET for Heat Exchanger Tubing

Visual (VT) Examinations: VT-1 for general surface degradation of components, VT-2 for leak detection, VT-3 for component supports

IST PROGRAM REVIEW

Discussion

The INEL staff evaluated the proposed inspections and tests described in the SRS Restart IST Plan using the restart criteria listed in Section 14 of the SER and the requirements for IST in the 1989 edition of the Code. Various plant documents also considered during the review are noted in the reference section. As stated in the introduction, some supporting documentation was not available to the INEL staff, consequently this review produced findings of a limited nature. A more comprehensive evaluation should be performed on the post-restart IST program. Appendix B presents details of the IST evaluation.

The testing requirements of the ASME Code, which addresses inspection and testing of components of commercial nuclear power plants, were considered during development of the SRS restart IST program. However, some equipment cannot be tested per the Code rules due to existing system design, configuration, or operational constraints. (This is true of commercial reactors also.) As part of the post-restart program, SRS plans to identify and prioritize systems that need modification to allow testing.

The review identified some noteworthy areas in the SRS Restart IST Plan. It is generally more comprehensive than similar programs at other DOE facilities. Also, SRS is using the industry recognized Motor-Operated Valve Testing System (MOVATS), developed by MOVATS Incorporated, to augment IST for motor-operated valves (MOVs). The post-restart program should incorporate past operational experience, e.g., problems of corrosion, erosion, or wearout that have led to pump degradation or malfunction of key valves. Aggressive implementation of the program should help to ensure that consistent and meaningful component tests are conducted.

During the review, several items were identified that should be evaluated further. These items, described in Appendix B, include concerns about the testing of pumps per WISR-6,[6] disassembly and inspection of valves as required by WISR-8,[7] selection of appropriate pumps and valves for testing, and selection of tests to effectively assess component performance. The SRS program is relatively new and the program and its implementation should be reevaluated as it becomes more fully developed.

Conclusion

SRS is taking positive steps towards developing a complete IST program. The restart program generally surpasses those found at similar DOE facilities. As previously stated, all documentation needed to confirm the resolution of the SER IST restart issues was not available to the INEL staff, however, no serious discrepancies were noted with respect to the stated SER commitments. Appendix B identifies several issues that should be evaluated further.

REFERENCES

1. Westinghouse Savannah River Company, WSRC-TR-90-42-123, "K-reactor Restart Inspection and Testing Plan," Revision 0, October 17, 1990.

2. Safety Evaluation Report, Section 14, Restart of K-Reactor, Savannah River Site, "Inspection and Testing," April 1991.

3. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components", 1989 Edition.

4. DPSOL 105-1851B-PLK, "Periodic Equipment Inspection and Testing Procedure."

5. DPSTM-88-100-1, "Augmented ISI Plan For The Savannah River Production Reactors Process Water System."

6. Westinghouse Independent Safety Review (WISR) of Savannah River Production Reactor (WISR-6), "Pump Test and Monitoring for Degradation."

7. Westinghouse Independent Safety Review (WISR) of Savannah River Production Reactor WISR-8, "Valve Inspection and Evaluation."

APPENDIX A

COMPARISON OF SRS EXAMINATIONS TO SECTION XI REQUIREMENTS

The *American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code*, Section XI, Division 1, was developed for light-water reactor designs where the core is enclosed within a pressure vessel. The Savannah River Site (SRS) production reactor differs in design from commercial reactors. The SRS reactor is low-pressure and low-temperature. The reactor is served by six primary coolant loops. Each loop consists of the main coolant pump, two heat exchangers, expansion joints, valves, and all connected piping up to the first isolation valve. This Process Water System (PWS) uses heavy water (D_2O) as the coolant and neutron moderator. The maximum operating pressure in the PWS is approximately 225 psig, the maximum temperature is approximately 95°C at the outlet of the reactor tank. Because of the low pressure and temperature, the system operating stresses may generally be lower than those of light-water reactors. In addition, the PWS has a leakage detection system that monitors fluid loss by volume or pressure drops and from measurements of radioactivity from tritium gas, which evolves from leaked coolant. This system is believed capable of isolating leakage to maintain release rates within site-allowable levels.

Many of the SRS reactor systems and components are somewhat comparable to those of ASME Code Class 1 and 2, as they perform similar functions (e.g., the reactor tank is equated to Class 1 pressure vessels, the PWS performs as the primary coolant, and the heat exchangers are the primary pressure boundary from the PWS to the comparable Code Class 2, Cooling Water System). Westinghouse Savannah River Company (WSRC) referenced Section XI of the 1986 ASME Code, 1987 Addenda in their Restart Inservice Inspection (ISI) and Testing (IST) Plan. Some modifications of Code requirements were necessary for application to the SRS systems. This appendix compares the ISI portion of the SRS Restart Inservice Inspection and Testing Program to the ISI requirements of the current 1989 Edition, including the 1990 Addenda, of the Code. There is a difference between the 1986 Section XI Edition and the present Code. In Category B-A, Pressure Retaining Welds In Reactor Vessel, the 1986 Edition calls for a volumetric examination of circumferential and longitudinal shell welds, all welds the first interval, and then only one beltline region weld in successive intervals. The present edition calls for volumetric examination of these welds, all welds the first interval, and all welds each successive interval.

PROCESS WATER SYSTEM

Reactor Tank

The reactor tank is a cylindrical vessel fabricated from Type 304 stainless steel. The bottom plate is one inch thick and the sides are one-half inch thick.

One dissimilarity between the Code and the SRS Restart ISI Plan is in reactor vessel interior examinations. The Code calls for a VT-3 visual examination at the first refueling outage and at subsequent refueling outages at approximately 3 year intervals. The requirement of the SRS ISI Plan is to examine the reactor tank wall internal surfaces every 5 years, using a periscope. In addition, SRS examines the exterior surface of the tank wall whenever a noseplug is removed or every 10 years using a borescope, a requirement the Code does not have. The SRS reactor tank apparently does not have a head weld or a shell-to-flange weld as these welds are called nonapplicable in Section II, Table 4-2 of the ISI program.

The Code requires all reactor vessel shell welds to be volumetrically examined each interval (10 yr). SRS, to date, has examined 60% of the accessible reactor tank welds ultrasonically (UT), and performed some visual (VT-1) and eddy current (ET) examinations. The SRS ISI Plan states that the remainder of the accessible welds will be examined post-startup and, in the future, every 5 years. An exception to this, which exceeds Code requirements, is in Section II, Table 4-2, of the ISI program, which states that the SRP Category C welds in both Category B-A, Pressure Retaining Welds In Reactor Vessels, and Category B-J, Pressure Retaining Welds In Piping, will be examined every 18 months. SRP Category C welds are those flame washed areas and weldments that have revealed allowable flaw indications.

The SRS ISI program requires examination of the PWS Plenum Tiebolts but it does not state the method to be used. The tiebolts would fall either under Code Category B-G-1, Pressure Retaining Bolting Greater Than 2" In Diameter, which requires volumetric examination, or Category B-G-2, Pressure Retaining Bolting 2" And Less In Diameter, which requires a VT-1 examination. Category B-D, Full Penetration Welds of Nozzles in Vessels, requires volumetric examination of all nozzles each interval. The SRS ISI Plan inspections #128 and #143 call for the PW plenum inlet nozzle to be examined visually every 10 yr and a PT examination to be performed every 5 yr. The SRS augmented examination document, DPSTM-88-100-1,[5] states that 6 reactor tank nozzles are to be UT examined.

PWS Piping

The diameter of the PWS piping varies from 12 to 24 inches with smaller lines branching off the main flow path. The piping contains both axial and circumferential welds, is relatively thin-walled (3/8 to 1/2 inch), and fabricated from 304 stainless steel. Intergranular stress corrosion cracking (IGSCC) has been observed, but, has been confined to the heat affected zones of the circumferential welds and several flame washed areas.

Code Category B-J, Pressure Retaining Welds In Piping, requires that piping with nominal pipe size (NPS) 4" and larger be examined by both surface and volumetric methods, and that piping with NPS less than 4" be examined by a surface method. The Code requires that the selected welds be examined the first inspection interval and each successive interval (every 10 yr). Section II, Table 4-2, of the SRS ISI Program deletes the surface examinations and calls for volumetric examination every 5 years of Category B-J welds. The ISI program Inspection #122 requires the PWS Piping, which is comparable to a Code Category B-J system, to be ultrasonically examined every 5 years. Inspection #101 requires the PWS piping welds with known IGSCC and new replacement piping to receive a UT examination every year. Augmented examination document

DPSTM-88-100-1 calls for VT-1 and UT examinations for a total of 526 PWS piping welds. There is a question as to whether this augmented examination supplants Inspection #101. Two other exceptions to Code requirements are the examinations of the plenum inlet line, which receives only a penetrant (PT) examination every 10 yr, and the piping side of welded elbows, which are PT examined every 5 yr. Also, SRS only examines piping with a NPS of 3" and larger, whereas the Code exempts piping 1" and less, except for steam generator piping.

Category B-P, All Pressure Retaining Components, requires a visual VT-2 examination during a pressure test each refueling outage and a VT-2 examination during a hydrostatic test each interval, whereas the SRS Restart ISI Plan requires only a visual examination every five years of the PWS expansion joints. Also, it is not clear if the PWS component supports are indeed "supports" or if they are integral attachments. If they are classified as "supports", the VT-3 examination specified in the SRS ISI Plan meets Code requirements. If they are integral attachments, Code Category B-K-1, the Code requires a volumetric examination. SRS is performing two examinations that are not required by the Code, one is VT-1 and UT examinations on the PWS flame washed areas of the piping and the other is a PWS piping vibration survey using a vibration meter.

Process Water Pumps

The Bingham Pump System examination in the SRS ISI Program requires a PT examination on the suction pipe flange face and a VT examination on the Nordel gasket. These items would fall under Code Categories B-G-1 or B-G-2, which require bolts and studs to have a volumetric exam and a VT-1 examination on the flange surfaces, nuts, bushings, and washers. SRS exceeds Code requirements by performing a PT examination on the flange face. The SRS ISI Plan specifies a VT examination for the Bingham Pump casing and casing wear rings. The Code calls for a VT-3 exam on pump casing internal surfaces, Category B-L-2, and a volumetric examination on pump casing welds, Category B-L-1.

The ISI program also requires visual examination of the Bingham Pump drive train flywheels every 5 yr. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.14 requires commercial plants to inspect flywheels as follows: (1) an in-place ultrasonic volumetric examination of the area of higher stress concentration at the bore and keyway at approximately 3-yr intervals, and (2) a surface examination of all exposed surfaces and complete ultrasonic volumetric examination at approximately 10-yr intervals.

Heat Exchangers

Each heat exchanger consists of an outer shell, approximately 9000 coolant tubes, and inlet and outlet heads. The heads are restrained by 84 Type 303 stainless steel staybolts and 72 low-alloy steel C-clamps. Overall dimensions are 33.5 feet long by 7.5 feet in diameter.

Failure of the cooling tubes would not cause a serious loss-of-coolant accident (LOCA) in the PWS, but it would release D_2O into the secondary coolant (H_2O). Cracking of the shell would result in a loss of secondary coolant only. Small leaks or seepage have been observed occasionally from the head, but a recent stress analysis reportedly proved the leak-before-break capability and pressure boundary integrity of the heat exchanger.

The normal operating pressures at the inlet head are 109 or 218 psig. A pressure of 600 psig is needed to yield the staybolts. Another analysis was performed to address stress corrosion of the staybolts. It was calculated that if several staybolts were lost, a pressure of 440 psig could be withstood but localized cracking and leaking would probably occur and be detected by visual examinations. If all the staybolts were lost, the C-clamps and seal membrane could carry the majority of the load up to 300 psig. In an SRS report on the PWS, it was documented that there have been no cases of staybolt failure in the operating history of heat exchangers.

The SRS reactor heat exchanger tubing is the primary pressure boundary from Class 1, PWS, to Class 2, Cooling Water System. The closest Code category that pertains to the heat exchanger tubing is B-Q, Steam Generator

Tubing, which requires a volumetric examination. Therefore, SRS inspection #106, which calls for a pressure test and VT examination, does not meet the Code requirements for examination of this component.

The Code calls for volumetric examination of heat exchanger head welds, volumetric examination of bolting greater than 2 inches in diameter, and surface examination on bolting less than 2 inches in diameter. SRS is deviating from the Code by specifying PT on the head welds and all of the bolting.

Other PWS examinations in the SRS ISI Plan include the Septifoil piping and Septifoil, and Roto valves. The ISI program requires a visual examination for these valves; it is assumed that these are comparable to Code Category B-M-2, Valve Bodies Exceeding NPS 4", which requires a VT-3 examination. Code Category B-M-1 pertains to valve body welds that require a surface examination for NPS less than 4" and a volumetric examination for NPS 4" and greater. The SRS Septifoil piping examination of flange necks, circumferential welds, and branch connection welds calls for PT or UT examination. These welds are also Code Category B-J, which requires both volumetric and surface examination on piping welds on NPS 4" and larger.

SRS REACTOR SUPPORT SYSTEMS

Cooling Water System

The SRS Restart ISI Plan requires that the Cooling Water (CW) piping be examined every 3 yrs. using an ultrasonic thickness tester and visually examined every 10 yr. This piping is comparable either to category C-F-1, Pressure Retaining Welds in Austenitic Stainless Steel or High Alloy Piping, or category C-F-2, Piping That is Carbon or Low Alloy Steel. The Code requirement for these categories is that piping with a nominal wall thickness equal to or greater than 3/8 inches and NPS greater than 4 inches be examined by both surface and ultrasonic methods. Piping with nominal wall thickness of 1/5 inch and NPS greater than or equal to 2 inches and less than 4 inches also is examined by both of these methods. Pipe branch connection welds greater than or equal to 2 inches NPS require only a surface examination. Augmented examinations are performed on twenty-four CW pipe lines per document WSIR-38. Twenty-two of these lines are examined with a UT thickness tester and two lines are given only a visual examination every 3 yrs. The ultrasonic thickness tester is used only for erosion/corrosion monitoring and is not intended for volumetric weld examination since it would not reliably detect cracking.

Other CW piping that falls into the Code Category C-F-1 or C-F-2 are the expansion joints and the piping to the AC motors. The expansion joints receive a penetrant examination every 3 yrs. and the piping to the motors receives a visual examination and is tested with the UT thickness tester every 2 yrs.

The CW Booster Pump is compared to Code Category C-H, pumps that receive a VT-2 examination and a pressure test each inspection period and a VT-2 examination and a hydrostatic test each inspection interval. The CW booster pump is given a visual examination every year to check for pluggage and a visual and UT thickness test every 5 yr. Another CW examination listed in the ISI program is a visual check of the condition of the piping paint. This examination is done by maintenance personnel who repaint the piping as required.

Emergency Cooling System

The Emergency Cooling System (ECS) is a safety standby system for emergency response only. The purpose of the ECS is to inject light water into the reactor inlet piping to protect the core from overheating following a LOCA or a loss of pumping accident (LOPA). LOCAs result from ruptures in the PWS. The most likely means for a LOPA is a rupture of the cooling water system that floods all of the drive motors for the six PWS circulation pumps.

The ECS pump and expansion joint piping, as well as the ECS piping in the pump room and the Emergency Spray System piping, are all similar Code Category C-F-1 or C-F-2 piping, and the Code requires volumetric and/or surface examinations of the welds. The SRS ISI Plan requires only a UT thickness examination on the ECS pump and expansion joint piping lines. The piping in the emergency pump room receives only a visual examination. However, the augmented examination document DPSTM-88-100-1 calls for UT and VT-1 examinations on 64 ECS piping welds.

The ECS backflow flapper valve, 7 check valves, and other valves receive only VT examinations. These valves are comparable to Code Category C-G valves, which receive a surface examination of the valve body welds.

Heat Exchanger Shell

The SRS heat exchanger shell equates to Code Category C-A, Pressure Retaining Welds In Pressure Vessels, which requires shell welds to be volumetrically examined each inspection interval. The SRS ISI Plan requires only a penetrant examination every ten years.

Confinement Heat Removal

The SRS ISI Program requires visual and UT thickness examinations every 2 yr on the Confinement Heat Removal tank. SRS maintenance performs the visual examination and QA performs the UT examination. This component would be classified as Code Category C-A, Pressure Retaining Welds In Pressure Vessels, and the welds would receive a volumetric examination every inspection interval. The Confinement Heat Removal piping would be classified as Class 2, Code Category C-F-1 or C-F-2, requiring either a surface and volumetric examination or just a surface examination depending on the nominal wall thickness and the nominal pipe size (NPS). This piping receives only a visual examination every 5 yr.

Other Examinations

The SRS ISI Program lists two examinations for hangers and supports. Inspection #309 requires a VT-3 examination every year. This examination is performed by maintenance personnel. Inspection #325 requires visual, magnetic particle, and penetrant examinations every 5 yr. The SRS ISI Plan exceeds the Code in this category. Code Examination Category F-A requires only a VT-3 examination each inspection interval.

The SRS examination requirements for the Supplementary Safety System check valves and tanks call out visual and UT thickness examination methods. The tanks are comparable to Code Category B-A, which requires a volumetric examination each interval, and the valves are comparable to Categories C-G and C-H. Category C-G, Pressure Retaining Welds In Pumps and Valves, requires a surface examination each interval. Category C-H, All Pressure Retaining Components, requires a VT-2 and a pressure test each period (3 1/3 yr) and a VT-2 and hydrostatic test each interval. SRS is examining the valves visually every 2 yr, and is performing visual and UT thickness examinations on the tanks every 2 yr.

SUMMARY

The SRS operating contractor has performed several engineering analyses to demonstrate or prove the integrity of the systems and components of the SRS reactor. It is unclear whether the results of these analyses justify deviations from ASME Code, Section XI requirements. Additionally, SRS appears to rely heavily on the leak detection system for early indication of safety component pressure boundary failures.

In some cases the ISI program has exceeded the Code requirements as, for example, in the examination of the reactor tank welds. For comparable Class 1, Category B-A examinations of reactor vessel welds, the Code requires a volumetric examination once every 10 yrs. The SRS ISI Plan, Section II, Table 4-2, requires the tank welds to be examined every 5 yrs. In addition, it would appear that flame washed areas and welds with known, allowable, indications are examined every 18 months. The SRS ISI Plan also exceeds Code requirements by requiring ultrasonic examinations of piping welds every 5 yr, rather than once every 10 yr as required for comparable Code Category B-J welds. Furthermore, we interpret the ISI program to require piping with known IGSCC and new replacement piping to receive an ultrasonic examination yearly.

The SRS ISI program in the above cases is more demanding than the Code. However, instances of relaxed NDE practices, with respect to Code requirements, are evident. For example, Code Category B-D requires volumetric examination of all nozzles each interval and the ISI program requires only a PT examination every 5 yr and a visual every 10 yr. The ISI program also specifies only a visual examination on the Bingham Pump casing and casing wear rings. Comparable Code categories, B-L-1 and B-L-2, require a VT-3 examination on pump casing internal surfaces and a volumetric examination on pump casing welds. The visual examination of Bingham Pump drive train flywheels is not compatible with Regulatory guidelines. Another item that should be resolved pertains to the performance of only a surface examination on the heat exchanger head welds and bolting instead of the Code-required volumetric and surface examinations. Justification for not following Code requirements for these examinations is not included in the Restart ISI Plan.

APPENDIX B

EVALUATION OF THE RESTART IST PROGRAM

The INEL evaluated the proposed inspections and tests using the restart criteria listed in Section 14 of the SRS Safety Evaluation Report (SER) and the requirements for IST in the 1989 edition of the Code. Various plant documents considered during the review are noted in the references. As noted in the body of the report, some supporting documentation was not available for review. Therefore, the findings are not complete. A more comprehensive evaluation should be performed on the IST program as implemented at SRS.

GENERAL ASPECTS OF THE IST PROGRAM

The comparison with the ASME Code identified three noteworthy areas in the proposed SRS Restart IST Plan. First, the scope of the IST program is more comprehensive than those at similar DOE facilities. SRS management has committed to develop the new IST program based on Code requirements. This is commendable and should help to achieve a level of assurance of the operational readiness of key pumps and valves that is commensurate with that of commercial plants.

Second, SRS management is using the industry-recognized Motor-Operated Valve Testing System (MOVATS), developed by MOVATS Incorporated, to augment IST. This program assesses the condition of motor-operated valves (MOVs) critical for safe plant operation. It goes beyond the Code requirements for valve testing. It is widely used at commercial nuclear power plants, but not at DOE facilities. This is a credit.

Third, the program proposes to incorporate operational experience, such as problems of corrosion, erosion, or wearout that have led to pump degradation or malfunction of key valves. It identifies and prioritizes pumps and valves that will be tested, disassembled, and inspected. The Program tables list test frequencies and parameters. The allowable ranges of the test parameters are to be based on the restart test procedures and on the ASME Code.

IST VALVE PROGRAM REVIEW

The following comments resulted from our review of the Restart IST Plan and WISR-8[7] for valves. The program was considered in the light of the Section XI valve testing requirements. The areas of concern or need for further clarification or evaluation are noted.

1. Section IV, paragraph 5.1, stated that valve categories are assigned based on the definitions in the Code. The definition given in the report for Category B valves (see below) does not agree with the definition given in Code Paragraph IWV-2100.

   SRS: "...valves which perform a safety-related function in shutting down the reactor, mitigating the consequences of an accident, or in maintaining the reactor in shutdown."

   Code: "...valves for which seat leakage in the closed position is inconsequential for fulfillment of their function."

   For the purposes of this review, the reviewers assumed that the problem is a typographical error and that the facility operator intended to use the same language as the Code definition for Category B valves. The SRS definition of Category B valves should be reevaluated.

2. For the following valves, the IST class numbers shown in the valve tables do not agree with the Restart Inspection and Testing Program Section IV system descriptions.

   <u>Blanket Gas System (BGS)</u>
   The valve table lists HV090 and HV099 as IST Class 1, but Section IV, paragraph 6.1, states that the system is IST Class 3.

Moderator Recovery System (MRS)

The valve table lists MR-1, MR-2, and MR-3 as IST Class 1, but Section IV, paragraph 6.7, states that the system is IST Class 2.

Supplementary Safety System (SSS)

The valve table lists CV271 through CV276 as IST Class 1, but Section IV, paragraph 6.11, states that the system is IST Class 2.

3. Section IV, paragraph 5.1, states that the IST Classes 1, 2, and 3 used in the pump and valve tables are consistent with the Code definition. The valves that require testing prior to restart are identified in RTM-5047.

The concern is that some valves are listed as Class 1, but are not identified by RTM-5047. ASME Class 1 components are required to perform safety-related functions in shutting down the reactor, mitigating the consequences of an accident, or in maintaining the reactor in shutdown. The following Class 1 valves should be reevaluated to determine if they can perform their safety functions as needed, even though they are not tested prior to restart.

Emergency Cooling System (ECS)

CV161, CV162, CV163, CV164, CV179, HCV18, HCV28, HCV48, HCV58

Moderator Recovery System (MRS)

MR1, MR2, MR3

Process Water System (PWS)

HV78, HV83, HV85, HV86, HV86C, PSV17, PSV27, PSV37, PSV47, PSV57, PSV67, Q84

Supplementary Safety System (SSS)

CV271 through CV276

4. Paragraph 5.1.(i), TEST REQUIREMENT, states that tests will be performed to fulfill the requirements of the Code. The test definitions and abbreviations used are identified in Table 5.1, Restart Valve Tests. The reviewers were not given a copy of this table or the test abbreviations. The reviewers interpreted the test requirements and test frequencies as follows:

Abbreviation	INEL Interpretation of SRS Abbreviations
ST-Q	Stroke Time, quarterly
FE-Q	Full Stroke Exercise, quarterly
FS-Q	Fail-Safe Actuator Test, quarterly
PI-Q	Position Indication, quarterly
AP	Alternate Position
RT-5Y	Relief Test, every 5 years
LK-T	Leak Test
EX-10	Explosive Test, every 10 years
RD	Rupture Disk

The above interpretation of the test requirement abbreviations should be reevaluated.

5. Paragraph 5.2 (c) states that the valve table identifies those check valves disassembled in accordance with WISR-8 (RTM-4987) and IM-026 (RTM-5050). However, the valve table lists RTM-4978, but not RTM-4987, for various check valves (ECS-CV160, WRS-CV205, WRS-CV213, and WRS-CV219). Also, the valve table lists RTM-4978 for components other than check valves, such as gate valves (CWS-HV200 and CWS-HV204 through CWS-HV207) and butterfly valves (ECS-HV380 and ECS-HV382). The Restart report does not reference RTM-4978 as a part of the IST program. It is unclear whether this a typographical error, or if there are two different reports.

6. WISR-8 requires disassembly and inspection of several valves. If problems are found with any disassembled valves, a thorough root cause analysis should be done. The sample size should be adjusted if

necessary. Any other components likely to be affected should be evaluated using appropriate methods to determine their condition. The results of the WISR inspection, including the root cause analysis of problems, should be evaluated. Many of the valves addressed in the WISR are check or motor-operated valves, which are difficult to assess using traditional test methods. Therefore, the adequacy of valve testing should be considered as part of the root cause analysis.

7. Valve Table, Discharge Assembly Cooling System, Note 2 states:

> "Fail safe and stroke timing are not required during restart testing. The multiple failures that must occur concurrently with discharge of heat generating assemblies make it unnecessary to include testing in the restart program. The future IST program will verify the fail-safe capability of these valves."

This statement assumes that the probability of multiple failures occurring at the same time is very low, such that the demand for the valves (identified in the valve table) to operate is likewise very low. However, regardless of whether the demand rate is high or low, there is still no assurance that the valves will operate when needed. This concern should be reevaluated to determine what are the consequences if the valves fail to perform their intended safety functions.

8. Several air-operated valves included in the restart program are equipped with position indicators. The Code would require these valves to be exercised and stroke timed. The restart program does not require an exercise or stroke time, and it is not evident that an alternative test is done, per the referenced Restart Test Identification Report (RTIR), that is equivalent to or better than the stroke time.

9. Testing of WRS check valves CV206 and CV213 (listed on page 23 of the valve tables) is indicated per procedure 1-10042. RTM-4978 is listed in the remarks section of the table. Neither the procedure nor the RTM was evaluated by the INEL reviewers. These valves should be exercised and

tested to the extent practicable after reassembly to ensure they are properly reassembled and that there are no common cause failures from improper equipment reassembly. Post-reassembly testing of these valves should be evaluated.

There have been several instances in the commercial industry where check valves have been disassembled and then reassembled improperly. Even limited post-reassembly testing with flow and differential pressure can provide valuable information about the operability of the check valve.

10. CWS check valves CV154, 167, and 174 (listed on page 3 of the valve tables) were not identified for testing before restart. The justification for deferring testing, as well as the testing done per the current IST program, should be considered for adequacy.

11. There were several discrepancies (not listed here) found in the program tables. These included IST classification, definition of valve category, and incomplete notation in the pump and valve tables. These discrepancies are not significant, but should be identified by SRS and corrected in subsequent program revisions.

IST PUMP PROGRAM REVIEW

The following comments resulted from our review of the Restart Inservice Inspection and Testing Plan and WISR-6[6] for pumps. The program was considered in the light of the Section XI pump testing requirements. The areas of concern or need for further clarification or evaluation are noted.

General

The post-restart pump program should identify many pump testing parameters, such as vibration, lubrication temperature, inlet and discharge pressure, that were left out of the restart program. The post-restart program is likely to be very different from the restart program and should be reviewed.

Cooling Water System (CWS)

1. Pump Table, Cooling Water System, Note 3 states the following:

   "Pump performance will be monitored in the future IST program by observing and recording the time required to raise the Number 3 basin a height of one foot. An allowable range will be established to assess pump performance and degradation."

   It is not clear how the proposed test will subject the pump to similar service conditions during each test (system back pressure, local temperature and pressure effects, and start-up, shut-down and steady-state flow operation) to allow an adequate assessment of performance.

2. The vibration level is not measured for pumps P107A & B. The remarks section does not propose alternative measures (acoustic monitoring, proximity devices) to assure that vibration levels are acceptable. This issue should be evaluated further.

3. Pump Table, Cooling Water System, Notes 1 and 2, respectively, state:

   "No inlet pressure is measured or recorded."

   "Discharge pressure must be between 5 and 10 psig."

   It is unclear how the differential pressure across the pump will be determined. It is unclear what controls are in place to determine the column height or pressure of the intake fluid. The testing done on the pump should be assessed.

4. Pump Table, Cooling Water System, Note 4 states:

   "The multiple failures that must occur prior to the need for EP181C and its flowpath make it unnecessary to include restart testing requirements. The future IST program will address testing requirements to monitor pump performance."

This statement assumes that the probability of multiple failures at the same time is very low, so that the demand for the pump to operate is likewise very low. However, regardless of whether the demand rate is high or low, there is still no assurance that the pump will operate when needed. The consequences of pump failure should be assessed. In addition, the method for establishing baseline pump performance values should be evaluated.

5. CWS pumps P107A, 107B, and 181C (listed on page 1 of the pump tables) are not monitored for vibration levels. Vibration is a prime indicator of the mechanical condition of rotating internal parts for most pumps. Excessive vibration can indicate impending pump failure. The justification for not measuring vibration should be assessed. Any testing done in lieu of measuring vibration should be considered.

6. CWS pump P1818C was not tested before restart and is indicated to have a low demand rate. The basis for this determination should be reviewed. The procedures and methods for assessing the condition of this pump should be evaluated.

7. The method of testing CWS pumps P107A and 107B should be evaluated for adequate hydraulic performance. Specifically, test procedures 105-2320 and RTM-5005 should be evaluated.

Discharge Assembly Cooling (DAC)

As stated in the Pump Table, Discharge Assembly Cooling, Note 1, the pump inlet pressure, vibration, and lubrication levels are not measured. There is no statement to indicate that these tests will be included in the future. It is not clear that the Post-Restart IST Program will include tests to assure that these performance parameters are kept within acceptable values.

Moderator Recovery System (MRS)

The vibration level is not measured for pumps P107A & B. Vibration is a prime indicator of the mechanical condition of rotating parts. Excessive vibration can indicate impending pump failure. The justification for not measuring vibration should be assessed, as should any alternative test.

Water Removal and Storage System (WRS)

The Pump Table, Water Removal and Storage System, Note 3, states:

> "Flowrate is calculated by measuring the rise in the BLDG 106 level over a period of two minutes."

It is not clear how the proposed test will subject the pump to similar service conditions during each test (system back pressure, local temperature and pressure effects, and start-up, shut-down and steady-state flow operation) to allow a meaningful assessment of pump performance.

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