STEAM GENERATOR ACTION PLAN

Date Updated: 12/31/2009 FINAL
Lead Division: DPR
Supporting Divisions: DCI, DRA, & DSS
Supporting Office: RES

Item No. (TAC No.)	Milestone	Date (T=Target) (C=Complete)	Lead	Support
1.21 (MC2470)	Staff issues a Generic Letter requesting PWR licensees to address adequacy of their technical specifications to ensure tube integrity between inspections.	01/20/06 (C) ML060200385	DCI K. Karwoski	
3.1 (MD7256)	In order to address ACRS comments on current risk assessments, develop a better understanding of the potential for damage progression of multiple steam generator (SG) tubes due to depressurization of the SGs (e.g., during a main steam line break (MSLB) or other type of secondary side design basis accident). (NUREG-1740, Pgs. 46, 8-12) Specific tasks include:	ACRS Agrees Item 3.1 is Closed 05/21/04 ML041420237 10/22/09 ML092890375		
	a. Perform thermal-hydraulic (T-H) calculations and sensitivity studies using the 3-D hydraulic component of TRAC-M to assess the loads on the tube support plate and SG tubes during main steam line break (MSLB). Perform sensitivity studies on code and model parameters including numerics. Develop conservative estimate of loads and evaluate against similar analyses.	12/30/02 (C) ML023650132	RES W. Krotiuk	DSS W. Jensen
	b. Perform T-H assessment of flow-induced vibrations during MSLB. Using the T-H conditions calculated during the transient, generate a conservative estimate of flow-induced vibration displacement and frequency assuming steady state behavior.	12/30/02 (C) ML023650132	RES W. Krotiuk	DSS W. Jensen
	c. Perform additional sensitivity studies as needed.	06/30/03 (C)	RES W. Krotiuk	DSS W. Jensen
	d. Obtain information from existing analyses related to loads and displacements (axial, bending, cyclic) experienced by SG structures under MSLB conditions.	12/26/02 (C) ML030230822	RES J. Muscara	

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3.1 (cont'd)	e. Using information from tasks 3.1a, 3.1b, and 3.1d, estimate upper bound loads and displacements.	12/26/02 (C) ML030230822	RES J. Muscara	DE E. Murphy
	f. Estimate crack growth, if any, for a range of crack types and sizes using bounding loads from task 3.1e in addition to the pressure stresses. Include the effects of TSP movement in these evaluations and any effects from cyclic loads.	12/26/02 (C) ML030230822	RES J. Muscara	DE E. Murphy
	g. Estimate the margins to crack propagation for a range of crack sizes for MSLB types loads and displacements in addition to the pressure stress.	12/26/02 (C) ML030230822	RES J. Muscara	DE E. Murphy
	h. Based on the margins calculated in task 3.1.g over and above the bounding loads, decide if more refined T-H analyses need to be conducted to obtain forces and displacements of structures under MSLB conditions.	12/26/02 (C) ML030230822	RES J. Muscara	DE E. Murphy
	i. Conduct tests of degraded tubes under pressure and with axial and bending loads to validate the analytical results from above tasks.	07/14/03 (C) ML032080002	RES J. Muscara	DE E. Murphy
	j. Conduct analyses similar to above with refined load estimates if necessary.	08/09/04 (C) ML042720174	RES J. Muscara	DE E. Murphy
	k. Use information developed in tasks 3.1a through 3.1.j to evaluate the conditional probabilities of multiple tube failures for appropriate scenarios in risk assessments for SG tube alternate repair criteria (ARC).	06/18/09 (C) ML091120480	DRA R. Palla	DCI E. Murphy
3.2	Confirm that damage progression via jet cutting of adjacent tubes is of low enough probability that it can be neglected in accident analyses. (NUREG-1740, Pgs. 10-11) Specific tasks include:	ACRS Agrees Item 3.2 is Closed 05/21/04 ML041420237		
	a. Complete tests of jet impingement under MSB conditions.	12/31/01 (C) ML021910311	RES J. Muscara	DE E. Murphy
	b. Conduct long duration tests of jet impingement under severe accident conditions.	12/31/01 (C) ML021910311	RES J. Muscara	DE E. Murphy

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3.2 (cont'd)	c. Document results from tasks 3.2.a and 3.2.b.	12/31/01 (C) ML021910311	RES J. Muscara	DE E. Murphy
3.3 (MB7216)	When available, use data from the ARTIST program (planned in Switzerland) to develop a better model of the natural mitigation of the radionuclide release that could occur in the secondary side of the SGs. (NUREG-1740, Pgs. 12-13)	ACRS Agrees Item 3.3 is Closed 06/13/08 ML081620324		
	a. RES will continue to follow results of ARTIST program, especially the results of integrated testing of particulate removal during passage through the full secondary flow path. From the integral results, determine whether the decontamination factor should be revised for radionuclides transport in the secondary side of the SGs during a SGTR. Based on this, provide a report to closeout SGAP item 3.3.a.	09/30/05 (C) ML052440175 11/08/07 (C) ML073040481	RES R. Lee	
3.4 (MD7256)	In order to address ACRS criticism of current risk assessments, develop a better understanding of RCS conditions and the corresponding component behavior (including tubes) under severe accident conditions in which the RCS remains pressurized. (NUREG-1740, Pgs. 46-47, 12-15) Specific tasks include:	ACRS Agrees Item 3.4 is Closed 10/22/09 ML092890375		
	a. Perform system level analyses to assess the impact of plant sequence variations (e.g., pump seal leakage and SG tube leakage).	09/28/01 (C) ML012720004 08/12/09 (C) ML091660110	RES C. Tinkler	DSS W. Jensen DRA S. Long
	b.1 Re-evaluate existing system level code assumptions and simplifications.	08/12/09 (C) ML091660110	RES D. Bessett	DSS W. Jensen DRA S. Long
	b.2 Following the results from 3.4.a and 3.4.b.1, perform additional analysis to include modeling of heat transfer enhancement from radiation heat transfer in the hot leg and steam generator; suppress unphysical numerically driven flows in the calculations; and investigate the sensitivity of calculated results to bypass flows and other key parameters.	04/01/04 (C) ML040910022 08/12/09 (C) ML091660110	RES C. Boyd	DSS W. Jensen

Item No. (TAC No.)	Milestone	Date (T=Target) (C=Complete)	Lead	Support
3.4 (cont'd)	c. Examine 1/7 scale data to assess tube to tube temperature variations and estimate variations for plant scale.	10/31/03 (C) ML033140399	RES D. Bessett	DSS W. Jensen DRA S. Long
	d. Perform more rigorous uncertainty analyses with system level code to address the uncertainty caused by key governing parameters. Distribution functions will be developed for key parameters. Peer review.	06/21/06 (C) ML061450055 05/30/06 (C) ML061510011 08/12/09 (C) ML091660110	RES C. Boyd	DSS W. Jensen DRA S. Long
	e. Examine SG tube severe accident T-H conditions using computational fluid dynamics (CFD) methods. This includes the following:			
	e.1 Benchmark CFD methods against 1/7 scale test data.	10/31/03 (C) ML033140399	RES C. Boyd	DSS W. Jensen DRA S. Long
	e.2 Perform full scale plant calculations (hot leg and SG) for a 4 loop Westinghouse design. Evaluate scale effects.	05/31/04 (C) ML041820239 06/24/04 (C) ML041820075 08/11/09 (C) ML093070048	RES C. Boyd	DSS W. Jensen DRA S. Long
	e.3 Perform plant analysis to address the effects on inlet plenum mixing resulting from tube leakage and hot leg orientation (CE design impact).	05/31/04 (C) ML041820239 06/24/04 (C) ML041820075 08/11/09 (C) ML093070048	RES C. Boyd	DSS W. Jensen DRA S. Long
	f. Examine the uncertainty in the T-H conditions associated with core melt progression.	01/24/05 (C) ML050120025 03/31/04 (C) ML050250006 08/12/09 (C) ML091660110	RES C. Boyd	DSS W. Jensen DRA S. Long
	g. Perform experiments to develop data on inlet plenum mixing impacts due to SG tube leakage and hot leg/ inlet plenum configuration.	03/31/03 (C) Note 6	RES D. Bessett	DSS W. Jensen DRA S. Long

Item No. (TAC No.)	Milestone	Date (T=Target) (C=Complete)	Lead	Support
3.4 (cont'd)	h. Perform a systematic examination of the alternate vulnerable locations in the RCS that are subject to failure due to severe accident conditions. This includes the following			
	h.1 Evaluate the creep failure of primary system passive components such as pressurizer surge line and the hot leg taking into account the material properties of the base metal, welds, and heat affected zones in the presence of residual and applied stresses, in addition to the pressure stress, and the presence of flaws.	12/02/08 (C) ML082900611 ML082900620	RES J. Page	
	h.2 Evaluate the failure of active components such as PORVs, safety valves, and bolted seals based on operability and "weakest link" considerations for these components.	12/02/08 (C) ML082900611 ML082900620	RES J. Page	
	h.3 Determine the feasibility of extending the Rhodes RCP seals leakage/failure model to severe accident conditions.	12/02/08 (C) ML082900611 ML082900620	RES J. Page	
	h.4 Conduct large scale tests if needed.	12/02/08 (C) ML082900611 ML082900620	RES J. Page	
	i. Use existing international data and develop analyses for predicting leak rates of degraded tubes in restricted areas under design basis and severe accident conditions.	08/09/04 (C) ML042720174 07/31/09 (C) ML092260349	RES J. Muscara	DRA S. Long DE E. Murphy
	j. Put the information developed in task 3.4.i into a probability distribution for the rate of tube leakage during severe accident sequences, based on the measured and regulated parameters for ARCs applied to flaws in restricted places (e.g., drilled-hole TSPs and the unexpanded sections of tubes in tube sheets).	07/13/09 (C) ML091620041	DRA R. Palla	DCI E. Murphy

Item No. (TAC No.)	Milestone	Date (T=Target) (C=Complete)	Lead	Support
3.4 (cont'd)	k. Integrate information provided by tasks 3.4.a through 3.4.j and 3.5 to address ACRS criticisms of risk assessments for ARCs that go beyond the scope and criteria of GL 95-05 (e.g., ARCs that credit "indications restricted against burst") as well as dealing with other SG tube integrity and licensing issues (e.g., relaxation of SG tube inspection requirements).	07/13/09 (C) ML091620138	DRA R. Palla	DCI E. Murphy
3.5 (MD7256)	Develop improved methods for assessing the risk associated with SG tubes under accident conditions. (NUREG-1740, Pgs. 47, 16-20) Specific tasks include:	ACRS Agrees Item 3.5 is Closed 10/22/09 ML092890375		
	a. Development of an integrated framework for assessing the risk for the high-temperature/high-pressure accident scenarios of interest.	04/01/02 (C) ML020910624	RES H. Woods	DRA S. Long
	b. Issue report describing improved methods and appropriate treatment of uncertainty for identifying severe accident scenarios that lead to challenges of the reactor coolant pressure boundary.	06/30/03 (C) ML031810753 ML031810787	RES H. Woods	DRA S. Long
	c. Develop logic framework for improved PRA models of the scenarios identified above, including the impact of operator actions.	06/30/03 (C) ML031810753 ML031810787 04/12/04 (C) ML041400416 05/19/04 (C) ML041400394	RES H. Woods	DRA S. Long
	d. Using the 3.5.b methods and (c) logic framework, identify scenarios, calculate the frequency of containment bypass events at an example plant, make indicated method improvements, and document the improved methods and results.	05/27/05 (C) ML051470187 ML051470179 03/20/09 (C) ML083540412 08/21/09 (C) ML092150157 ML092150382	RES Sancaktar	
	e. Extend the 3.5.b methods and (c) model logic to include CE plants, and document them.	03/20/09 (C) ML083540412 08/21/09 (C) ML092150157 ML092150382	RES Sancaktar	

Item No. (TAC No.)	Milestone	Date (T=Target) (C=Complete)	Lead	Support
3.5 (cont'd)	f. Extend the 3.5.b methods and (c) model logic to include consideration of external events as initiators, and low power and shutdown as initial conditions, and document them.	03/20/09 (C) ML083540412 08/21/09 (C) ML092150157 ML092150382	RES Sancaktar	
	g. Extend the 3.5.d, e, and f improved methods and logic to include consideration of core damage sequences initiated by secondary depressurization events (such as MSLB design basis accident scenarios) that induce tube rupture.	03/20/09 (C) ML083540412	RES Sancaktar	
3.6	To address an ACRS report conclusion that improvements can be made over the current use of a constant probability of detection (POD) for flaws in SG tubes, RES has recently completed an eddy current round robin inspection exercise on a SG mock-up as part of NRC's research to independently evaluate and quantify the inservice inspection reliability for SG tubes. This research has produced results that relate the POD to crack size, voltage, and other flaw severity parameters for stress corrosion cracks at different tube locations using industry qualified teams and procedures. Complete analysis of research results and prepare topical report to document the results. (NUREG-1740, Pgs. 47, 33)	ACRS Agrees Item 3.6 is Closed 05/21/04 ML041420237		
		12/31/01 (C) ML021910311	RES J. Muscara	DE E. Murphy
3.7 (MB7216)	Assess the need for better leakage correlations as a function of voltage for 7/8" SG tubes. (NUREG-1740, Pgs. 48, 28-29)	ACRS Agrees Item 3.7 is Closed 05/21/04 ML041420237		
		04/26/03 (C) ML031150674	DE J. Tsao	RES J. Muscara
3.8 (MB0258)	Develop a program to monitor the prediction of flaw growth for systematic deviations from expectations. (NUREG-1740, Pg. 48)	ACRS Reviewed and EDO Decides Item 3.8 is Closed 08/25/24 ML042190267		
		01/03/02 (C) ML020070081	DE J. Tsao	

Item No. (TAC No.)	Milestone	Date (T=Target) (C=Complete)	Lead	Support
3.9 (MB7216)	Develop a more technically defensible position on the treatment of radionuclide release to be used in the safety analyses of design basis events. (NUREG-1740, Pgs. 48, 38-44) Specific tasks include:	ACRS Agrees Item 3.9 is Closed 06/21/06 ML061740413		
	a. Assess the Adams and Atwood, and the Adams and Sattison spiking data with respect to the ACRS comments.	06/21/06 (C) ML061100331	DRA M. Hart	
	b. Based upon the assessment performed in task 3.9.a, and the outcome of the screening of candidate generic safety issue GSI-197, develop a response to the ACRS comments.	06/21/06 (C) ML061100331 See Note 5	DRA M. Hart	
3.10 (MD7256)	To address concerns in the ACRS report regarding our current level of understanding of stress corrosion cracking, the limitations of current laboratory data, the difficulties with using the current laboratory data for predicting field experience (crack initiation, crack growth rates), and the notion that crack growth should not be linear with time while voltage growth is, the following tasks will be performed: (NUREG-1740, Pgs. 20-29)	ACRS Agrees Item 3.10 is Closed 10/22/09 ML092890375		
	a. Conduct tests to evaluate crack initiation, evolution, and growth. Tests to be conducted under prototypic field conditions with respect to stresses, temperatures and environments. Some tests will be conducted using tubular specimens.	05/20/08 (C) ML081200180	RES Carpenter	
	b. Using the extensive experience on stress corrosion cracking in operating SGs, and results from laboratory testing under prototypic conditions, develop models for predicting the cracking behavior of SG tubing in the operating environment.	05/20/08 (C) ML081200180	RES Carpenter	
	c. Based on the knowledge accumulated on stress corrosion cracking behavior and the properties of eddy current testing, attempt to explain the observed relationship between changes in eddy current signal voltage response and crack growth.	05/20/08 (C) ML081200180	RES Carpenter	

Item No. (TAC No.)	Milestone	Date (T=Target) (C=Complete)	Lead	Support
3.11 (MD7256)	In order to resolve GSI 163, it is necessary to complete the work associated with tasks 3.1, 3.7, 3.8, and 3.9. Upon completion of this task, develop detailed milestones associated with preparing a GSI resolution document and obtaining the necessary approvals for closing the GSI, including ACRS acceptance of the resolution.	ACRS Agrees Item 3.11 is Closed 10/22/09 ML092890375		
		07/16/09 (C) ML091540192	DCI E. Murphy	DRA R. Palla
3.12 (MD7256)	Review the risk insights developed under Task 3.5 and assess the need for completing DG 1073, "Plant Specific Risk-Informed Decision Making: Induced SG Tube Rupture."	ACRS Agrees Item 3.12 is Closed 10/22/09 ML092890375		
		08/21/09 (C) ML092300556	DRA R. Palla	DCI E. Murphy

Notes:

1. Steam Generator Action Plan milestones 3.1 through 3.11 were developed from Attachment 1 of a memorandum from S. Collins and A. Thadani to W. Travers dated May 11, 2001 (Accession No. ML011300073). That memorandum provided a revision to the Steam Generator Action Plan as requested by a memorandum from W. Travers to S. Collins and A. Thadani dated March 5, 2001 (Accession No. ML010670217). SG Action Plan milestones 3.1 through 3.11 are associated with the SG DPO. The page numbers referenced in the milestone description indicate the source of the milestone as described in ACRS Report NUREG-1740, "Voltage-Based Alternative Repair Criteria." The ACRS report was included as an enclosure to a memorandum from D. Powers to W. Travers dated February 1, 2001 (Accession No. ML010780125).

   The S. Collins and A. Thadani memorandum dated May 11, 2001 states that the final product for each major milestone for which NRR has lead responsibility will be a memorandum provided by the lead NRR division to the Associate Directors in NRR. For those major milestones for which RES has the lead responsibility, documentation will be by a memorandum provided by the lead RES division to the Deputy Director of RES.

2. Steam Generator Action Plan items 1.1 through 2.8 have been completed and except for item 1.21, they no longer appear in the above table. Items 1.1 through 2.8 were developed from Attachment 1 of a memorandum from J. Zwolinski, J. Strosnider, B. Boger, and G. Holahan to B. Sheron and R. Borchardt dated March 23, 2001 (Accession No. ML010820457). That memorandum provided a revision to the Steam Generator Action Plan that was originally issued via a memorandum from B. Sheron and J. Johnson to S. Collins dated November 16, 2000 (Accession No. ML003770259).

3. The work described in milestones 3.1 through 3.5 and 3.7 through 3.9 is related, in part, to previously planned work associated with GSI 163, "Multiple Steam Generator Tube Leakage." The work described in milestone 3.1 is related, in part, to previously planned work associated with GSI 188, "Steam Generator Tube Leaks/Ruptures Concurrent with Containment Bypass."

4. The work described in milestones 3.2, 3.3 and 3.4 is related, in part, to previously planned work associated with an NRR User Need request dated February 8, 2000 (Accession No. ML003682135), and the associated RES response to the request dated September 7, 2000 (Accession No. ML003714399). Although the research in milestone 3.10 was approved by the EDO to resolve the SG DPO, this work was undertaken by RES on an anticipatory basis and there is no associated NRR User Need request.

5. In SECY-04-0156, dated August 27, 2004, Iodine Spiking Phenomena was identified as candidate generic safety issue (GSI) 197 with the Office of Nuclear Regulatory Research (RES) listed as the lead organization. Initial screening of candidate GSI-197 is complete, and the issue was recommended to be dropped from further consideration per memo dated May 8, 2006, from the GSI-197 review panel to the director of RES, as approved by the director (Accession No. ML061100331). During the 533rd meeting of the ACRS, the committee considered the results of the GSI-197 initial screening and had no objection to the staff's proposal to drop the issue from further consideration. The ACRS decision was sent by memo to the EDO by memo dated June 21, 2006 (Accession No. ML061740413). Therefore, the ACRS review of the closure of SG Action Plan item 3.9 is considered complete.

6. Milestone 3.4.g was not performed as evaluation of the cost to perform experiments that would improve upon the Westinghouse experiments showed the cost to be prohibitive. CFD analysis provided better information than possible experiments at a very small fraction of the cost. Hence, the objective was satisfied by the completion of milestone 3.4.e.2.

Description:

The Steam Generator Action Plan consolidates numerous activities related to steam generators including:

(1) The NRC's review of the industry initiative related to steam generator tube integrity (i.e., NEI 97-06);
(2) GSI-163 (Multiple Steam Generator Tube Leakage);
(3) The NRC's Indian Point 2 (IP2) Lessons Learned Task Group recommendations;
(4) The Office of the Inspector General (OIG) report on the IP2 steam generator tube failure event; and
(5) The differing professional opinion (DPO) on steam generator issues.

The plan does not address plant-specific reviews or industry proposed modifications to the Generic Letter 95-05 (voltage-based tube repair criteria) methodology. The plan also includes non-steam generator related issues that arose out of recent steam generator related activities (e.g., Emergency Preparedness issues from the OIG report). The milestone table shown above is organized as follows:

- Item Nos. 1.1 through 1.21: SG-related issues (not including the DPO-related issues);
- Item Nos. 2.1 through 2.8: Non-SG related issues; and
- Item Nos. 3.1 through 3.11: DPO-related issues.

Historical Background: The NRC originally planned to develop a rule pertaining to steam generator tube integrity. The proposed rule was to implement a more flexible regulatory framework for steam generator surveillance and maintenance activities that allows a degradation specific management approach. The results of the regulatory analysis suggested that the more optimal regulatory approach was to utilize a generic letter. The NRC staff suggested, and the Commission subsequently approved, a revision to the regulatory approach to utilize a generic letter. In SECY-98-248, the staff recommended to the Commission that the proposed GL be put on hold for 3 months while the staff works with NEI on their NEI 97-06 initiative. In the staff requirements memorandum dated December 21, 1998, the Commission did not object to the staff's recommendation. In late 1998 and 1999, the NRC and industry addressed NRC technical and regulatory concerns with the NEI 97-06 initiative, and on February 4, 2000, NEI submitted the generic licensing change package for NRC review. The generic licensing change package included NEI 97-06, Revision 1, proposed generic technical specifications, and a model technical requirements manual section. SECY-00-0078 outlines the staff's proposed review process associated with the revised steam generator tube integrity regulatory framework described in NEI 97-06. This review process was subsequently revised as described in SECY-03-0080.

Originating Document: Memorandum from B. Sheron/J. Johnson to S. Collins dated November 16, 2000, "Steam Generator Action Plan" (Accession No. ML003770259).

Current Status:

Closed. All SG Action Plan items are complete and the SG Action Plan is **closed.** [Memorandum from W. Borchardt to M. Bonaca dated December 3, 2009, "Response to the Advisory Committee on Reactor Safeguards Letter on "Closure Of Steam Generator Action Plan Items 3.1k, 3.4, 3.5, 3.10, 3.11, and 3.12" and Staff Closeout of Steam Generator Action Plan" (Accession No. ML093200502)]

Contact: David Beaulieu, NRR/DPR/PGCB, 301-415-3243