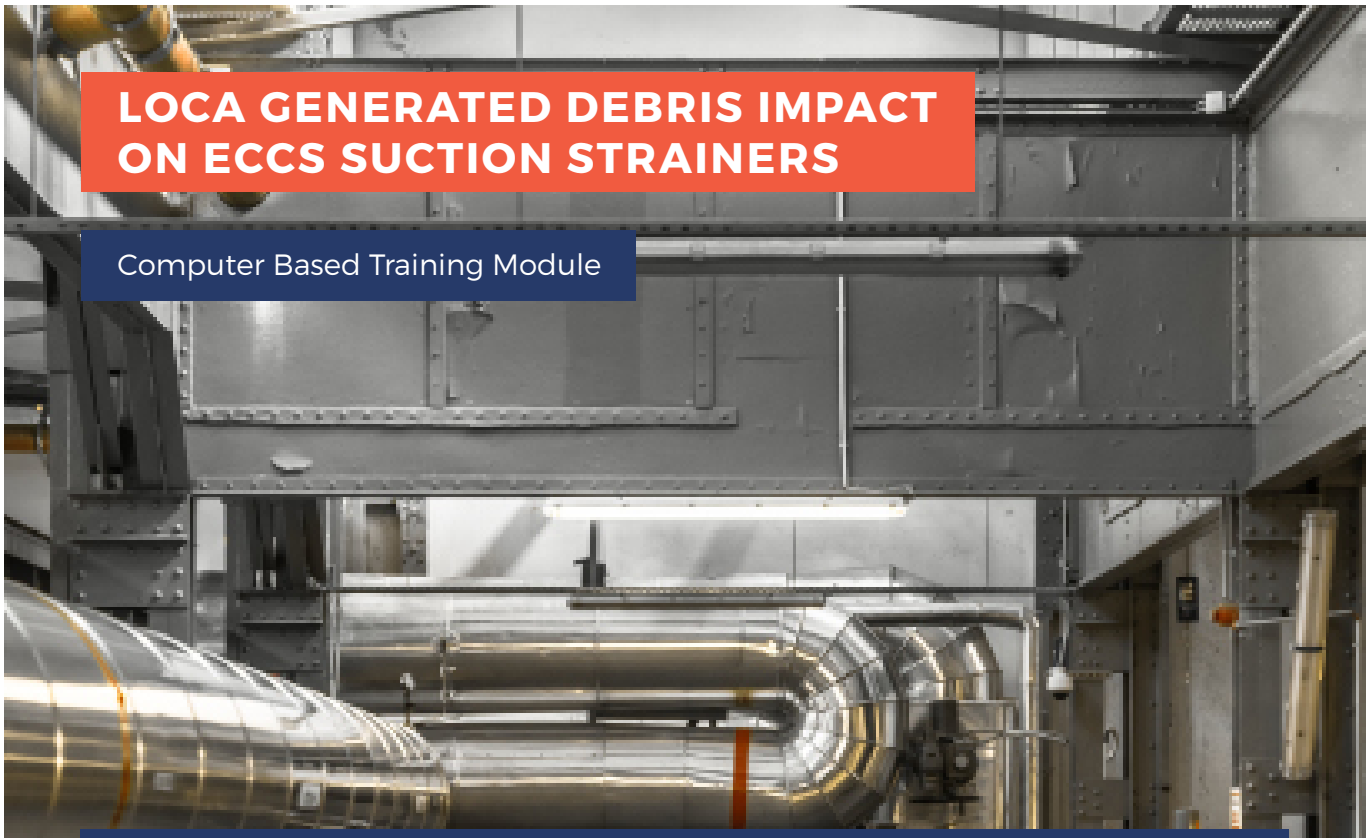

LOCA GENERATED DEBRIS IMPACT ON ECCS SUCTION STRAINERS

Computer Based Training Module

ABSTRACT

This AET training describes the resolution to generic safety concerns with the emergency core cooling system (ECCS) suction strainers due to debris generated by a loss of coolant accident (LOCA) for both pressurized-water reactors (PWRs) and boiling water reactors (BWRs). It provides a comprehensive overview of the safety issues and the major analysis and testing steps that are taken to resolve the issues. In addition, it gives a summary of historical and on-going regulatory requirements from the Nuclear Regulatory Commission (NRC) on the performance of ECCS suction strainers and the actions taken by the industry to address the issues.

INTENDED AUDIENCE

1. Experienced nuclear plant mechanical engineers who are developing expertise in LOCA Generated Debris Impact on ECCS Suction Strainers
2. Site engineering Managers or Supervisors

DURATION

- 5 hours
- An additional 8-12 hours for reading materials provided within the CBT

TERMINAL LEARNING OBJECTIVES

1. Describe the strainer performance issues addressed in USI-A43.
2. Describe the new strainer performance issues identified by the Barsebäck incident, which were subsequently addressed by the U.S. Boiling Water Reactor (BWR) fleet.
3. Describe the new strainer performance issues identified by research and testing for the Pressurized Water Reactor (PWR) fleet and subsequently addressed in GSI-191.
4. Identify the NRC and industry guidance documents that outline acceptable methodologies to resolve the Emergency Core Cooling System (ECCS) strainer performance issue.
5. Describe in general the post-LOCA accident progression and plant response.
6. Identify the systems that are used to mitigate the consequences of an accident at a PWR and BWR.
7. Describe the post-LOCA conditions (other than debris) that can affect the performance of the ECCS strainers (water levels, pressure and temperature profiles, pH).
8. Recognize and describe the major sources of conventional debris (insulation, coatings, miscellaneous, and latent).
9. Define Zone of Influence (ZOI).
10. Describe the concept of the size distribution for insulation debris sources.
11. Describe the important characteristics of the different debris types.
12. Describe the different modes of transport (blowdown, washdown, pool fill, recirculation, and erosion).
13. Apply the logic tree methodology to calculate the overall transport fraction.
14. Identify potential upstream blockage points.
15. Identify past chemical effects research that has been performed by the industry.
16. Describe the evaluation process for chemical effects.
17. Summarize the WCAP-16530-NP-A Base Model approach for quantifying chemical precipitates.
18. Describe how debris accumulates on strainers.
19. Identify the problematic types of debris and combinations of debris with respect to strainer head loss.
20. Explain the difference between clean strainer head loss and debris laden head loss.
21. Describe how generic and prototype strainer testing is used to determine strainer head loss.
22. Explain the concepts of bore holes, bed shifts, flow correction, temperature correction, and 30-day head loss extrapolation.
23. Describe penetration mechanisms and how they are impacted by bed development.
24. List the factors that impact penetration quantity.
25. Describe how penetration testing conditions and results are conservatively representative of conditions at the plant.

26. Describe the methods in which gas can be drawn into the ECCS suction piping via the strainer(s).
27. Describe the methodology to determine whether degasification would occur under various containment conditions.
28. Identify the methods through which accumulated gas in the strainer can exit.
29. Identify gas void limits based upon pump types and other standard industry documentation.
30. Describe the methodology for determining the maximum allowable strainer head loss from the strainer structural and pump Net Positive Suction Head (NPSH) margins under various containment conditions.
31. Describe failure mechanisms due to high debris bed head losses for partially submerged and vented strainers.
32. Describe failures that could be caused by gas bubbles accumulating within the strainer or transporting to the pumps, as well as the impact of gas bubbles on the Net Positive Suction Head (NPSH) required.
33. Describe 'downstream effects' and the potential impacts on ECCS and Containment Spray System (CSS) components.
34. Identify the typical ECCS and CSS components potentially susceptible to downstream effects.
35. Recognize which failure mechanism affects the ECCS and CSS components.
36. Describe how wear and/or plugging affect the ECCS and CSS components.
37. Recognize how the accumulation of conventional and chemical debris on fuel rods challenges longterm core cooling capabilities by inhibition of heat transfer from fuel rods to coolant.
38. Describe the methodology for evaluating peak cladding temperature and scale thickness on the fuel rods due to accumulated conventional and chemical debris on the fuel rods.
39. Describe the methodology for evaluating time-dependent accumulation of fibrous debris at the reactor core inlet and within the core for a hot leg and cold leg break in both upper plenum injection and non-upper plenum injection plants.
40. Describe how boric acid precipitation within the reactor vessel challenges long-term core cooling and how this issue can be addressed for the resolution of ECCS strainer performance issues.
41. Explain the difference between conservatism and realism, and which is more appropriate for a risk-informed application.
42. Describe the five key principles for risk-informed decision making that are defined in Regulatory Guide 1.174.
43. Explain the difference between defense-in-depth and safety margin.
44. Describe the types of uncertainty that must be considered for a risk-informed application.

45. Identify three relevant Operating Experience (OE) examples of issues related to ECCS strainer performance following initial resolution of the generic issue.
46. Discuss the types of operability issues related to ECCS strainer performance that are likely to arise in the future.
47. Demonstrate an understanding of the key factors that should be considered when making a prompt operability determination and a past operability evaluation for typical emergent issues related to ECCS strainer performance.

KEY INDUSTRY DOCUMENTS

1. BWR_ECCS_Strainer_Blockage_Issue_Summary_Research_Resolution_Actions
2. ENERCON_Additional_OEs_Operability_Issues_Related_to_ECCS_Strainer_Performance
3. ENERCON_Details_Related_to_Debris_Penetration_of_Sump_Strainers
4. FedReg_Vol51_P30028_Safety_Goals_for_the_operation_of_Nuclear_Power_Plants
5. NEDO-32686-GE_Resolution_Guide_ECCS_Suction_Stratiner_Blockage
6. NEI_04-07_Vol_1_PWR_Sump_Performance_Eval_Methodology
7. NEI_04-07_Vol_2_NRC_SER_for_PWR_Sump_Perf_Eval_Methodology
8. NEI_ZOI_Fibrous_Debris_Preparation_Processing_Storage_and_Handling
9. NRC_Bulletin_95-02_BWR_Unexpected_Clogging_RHR_pump_strainer
10. NRC_Bulletin_96-03_Staff_Reviews_Potential_Plugging_BWR_ECCS
11. NRC_Bulletin_2003-01_PWR_Potential_Impact_Debris_Blockage
12. NRC_GL85-22_Potential_Loss_of_Post-LOCA_Recirc_due_to_Insulation_Debris
13. NRC_GL2004-02_Closure_Plant_Specific_Chemical_Effect_Evaluation_Staff_Review_Guidance
14. NRC_GL2004-02_Potential_Impact_Debris_Blockage_ECCS_PWR
15. NRC_GL2008-01_Managing_Gas_Accumulation_Emergency_Core_Cooling
16. NRC_RegGuide_1.82_Rev4_2012_Water_Sources_for_Long_Term_Recirculation_Cooling_following_LOCA
17. NRC_RegGuide_1.174_Approch_for_using_PRA_for_Risk_Informed_Decisions
18. NRC_RegGuide_1.229_Risk-Informed_Approach_for_Addressing_Effects_of_Debris_DRAFT
19. NRC_SECY-10-0113_Closure_Options_for_GSI191
20. NRC_SECY-2009-0156_Status_Lessons_Learned_PWR_ECCS_suction_strainer_performance
21. NRC_Staff_Review_Guidance_Regarding_GL_2004-02_Closure_Strainer_Head_Loss
22. NRC-03-03-038_Dev-Imp_Algorithm_for_Void_Fraction_Calc
23. NUREG_1855_Rev1_Draft_Guidance_Treatment_of_Uncertainties_with_PRAs
24. NUREG_CR-6369_Vol_1_Drywell_Debris_Transport_Study
25. NUREG_CR-6762_Vol4_Dev_Debris_Transport_Fractions
26. NUREG_CR-6772_GSI-191_Separate-Effects_Characterization_Debris_Transport_in_Water
27. NUREG_CR-6808_Knowledge_Base_Effect_of_Debris_PWR_ECCS_Performance
28. NUREG_CR-6916_Hydraulic_Transport_Coating_Debris
29. NUREG_CR-7011_Evaluation_Treatment_Effects_of_Debris_in_Coolant
30. NUREG_CR-7172_Knowledge_Base_Report_ECCS_Performance
31. NUREG_CR-7172_Sect_4_8_and_5_9_KnowlBase_ECC_Sump_Perf
32. PWR_OG-13-205_Technical_Concerns_Regarding_Boric_Acid_Precipitation
33. WCAP-16406-P_NRC_Final_Safety_Eval_of_Downstream_Sump_Debris
34. WCAP-16530-NP-A_Eval_Post-Accident_Chem_Effects_Containment_Sump
35. WCAP-16530-NP-An_Error_Corrections
36. WCAP-16530-NP-NRC_Final_Safety_Evaluation_Report
37. WCAP-16785-NP_Evaluation_Additional_Inputs_to_WCAP-16530-NP_Chemical_Model
38. WCAP-16793-NP_Rev2_NRC_Final_Safety_Evaluation
39. WCAP-17788-NP_Vol1_Comprehensive_Analysis_Test_Program_GSI-191
40. WCAP-17788-NP_Vol3_Comprehensive_Analysis_Test_Program_CLB_Evaluation_Method