

# NRC INSPECTION MANUAL

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## INSPECTION PROCEDURE 71111 ATTACHMENT 07

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### HEAT EXCHANGER/SINK PERFORMANCE

Effective Date: 01/01/2024

PROGRAM APPLICABILITY: IMC 2515 A

CORNERSTONES:           Initiating Events  
                                  Mitigating Systems  
                                  Barrier Integrity

INSPECTION BASES:       See IMC 0308, Attachment 2

#### SAMPLE REQUIREMENTS

Sample Requirements		Minimum Baseline Completion Sample Requirements		Budgeted Range	
Sample Type	Section(s)	Frequency	Sample Size	Samples	Hours
Heat Exchanger/Sink	03.01	Annual	1 per site	1-2	7 +/- 1
				1 at Vogtle Units 3 & 4	

#### 71111.07-01 INSPECTION OBJECTIVES

- 01.01 To verify that any potential heat exchanger or heat sink deficiencies which could mask degraded performance are identified. Applies to all risk significant or safety-related heat exchangers directly or indirectly connected to service water systems or the ultimate heat sink (UHS), including heat exchangers in closed cooling water systems.
- 01.02 To verify that any potential common-cause heat exchanger or heat sink performance problems that have the potential to increase risk are identified (e.g., icing and grassing at circulating and service water intake structures or discharge silting).
- 01.03 To verify that the licensee has adequately identified and resolved heat exchanger or heat sink performance problems that could result in initiating events or affect multiple heat exchangers in mitigating systems and thereby increase risk (e.g., component cooling water heat exchanger performance affected by corrosion, fouling, or silting).

71111.07-02 GENERAL GUIDANCE

Apply risk informed insights together with other factors, such as engineering analysis and judgment, operating experience, previous inspection results, performance history, and renewed licensee aging management or other program actions (e.g., inspections, tests, etc.) that the licensee agreed to implement to determine which heat exchangers or heat sinks will be selected for review. Consider previously inspected heat exchangers or heat sinks during the **previous** years to avoid duplication.

When **performing** this inspection, consider refueling outage and at-power maintenance schedules to identify opportunities to observe infrequent activities associated with risk significant heat exchangers, **heat sinks**, or service water inspections/testing (e.g., heat exchanger inspections and testing, internal service water pipe inspections, external underground service water pipe inspections).

For plants with a renewed license, aging management programs and implementing activities may have resulted in additional or different requirements and/or commitments. The inspector should review these aging management program descriptions and commitments as part of informing sample selections. The applicable aging management programs may include, but are not limited to: open-cycle cooling water, closed treated water systems, water chemistry, selective leaching, and buried and underground piping and tanks. Additionally, licensees may have conducted one-time, internal surface inspections of components in the cooling water systems associated with the heat exchangers or the UHS. These inspections would have been in accordance with the one-time inspection and inspection of internal surfaces in miscellaneous piping and ducting components aging management programs.

Refer to the table below for **guidance on sample selection, which should focus on** those activities that have a risk priority (i.e., those common-cause failures with a reasonable probability of occurring should be targeted by inspection to determine impact on cornerstones). **Additional information with regards to heat exchanger or heat sink inspections can be found in IP 71111.21M, appendix E.**

<u>Cornerstone</u>	<u>Inspection Objective</u>	<u>Risk Priority</u>	<u>Example</u>
Initiating Events	Evaluate events, issues, or conditions involving the degradation or loss of both the normal and ultimate heat sinks.	Common-cause issues affecting heat removal capabilities.	Icing and grassing of a circulating water and service water intake structure or discharge silting.
Mitigating Systems/ Barrier Integrity	Evaluate any potential degraded performance of heat exchangers/containment fan coolers.	Heat exchanger selection should focus on the potential for common-cause failures or on potentially high-risk heat exchangers with a low margin to their design point or the high potential for fouling.	Degraded containment cooling or component cooling water heat exchanger performance due to corrosion, fouling, silting, etc.

For each sample, routine review of problem identification and resolution activities should be conducted using IP 71152, "Problem Identification and Resolution." Problems involving silting, water hammer, voiding, corrosion, and fouling should be reviewed. Focus on events or conditions that could cause the loss of a heat exchanger/sink due to events such as heat transfer problems, improper cleaning, ice buildup, grass intrusion, leaks/breaks, or blockage of pipes and components. Determine whether the licensee has appropriately considered common-cause failures. If any loss of heat exchanger/sink events have occurred, these should receive review priority. Review the corrective actions to determine if actions were enough to prevent/address recurrence of the problem.

## 71111.07-03 INSPECTION REQUIREMENTS

### 03.01 Heat Exchanger/Sink.

#### **Verify heat exchanger and/or heat sink readiness and availability.**

##### Specific Guidance

- a. Heat exchanger/sink performance can be reviewed by observation, by evaluating test data/reports, or both. These tests should be those typically sanctioned by industry. Test acceptance criteria and results have appropriately considered differences between testing conditions and design conditions (functional testing at design heat removal rate may not be practical); and the test results have appropriately considered test instrument inaccuracies and differences.
- b. Verify periodic maintenance activities are with consistent licensee commitments made in response to Generic Letter (GL) 89-13. The principal **Electric Power Research Institute (EPRI)** guidance documents related to GL 89-13 program implementation are TR-107397, "Service Water Heat Exchanger Testing Guidelines," for service water heat exchanger thermal performance testing, and 1003320, "Supplemental Guidance for Testing and Monitoring Service Water Heat Exchangers." Early guidance consisted of EPRI NP-7552, "Heat Exchanger Performance Monitoring Guidelines," although it has largely been replaced by the additional detail in TR-107397. Guidance is provided in EPRI 1009839, "Heat Exchanger Single Tube Test Device," for an alternative heat exchanger test method which does not require testing of the entire tube bundle.
- c. Bio-fouling controls can be reviewed by observation, by evaluating data/reports, or both. The licensee should have acceptance criteria for bio-fouling controls which are based on an industry standard, supportive program results, or the recommendation of the appropriate vendors.
- d. Heat exchanger inspections can be observed to identify the state of tube cleanliness and the number and condition of plugged tubes. Primarily focus on whether the number of tubes plugged affects the heat exchanger's operability and not the biofilm on the inside of tubes (**see IP 71111.21M, appendix E for more guidance**). The licensee should have acceptance criteria that indicates the maximum number of tubes that may be plugged for a specific heat exchanger and a basis for that acceptance criteria.

- e. Check, by either a walkdown or the review of operations data, any or all of the following:
  1. The heat exchanger's inlet and/or outlet temperatures.
  2. Primary or secondary side fluid flow.
  3. If there is any evidence of leaks.
  4. Whether the heat exchanger can perform its safety-related or risk significant function by reviewing documentation or results of licensee inspections.
  5. Comparison of end bell orientation of one heat exchanger to the orientation of a similar redundant train heat exchanger, to confirm proper orientation. Improper end bell orientation can significantly reduce or isolate flow to an otherwise functional heat exchanger.
  
- f. Determine if heat exchanger is correctly categorized under the Maintenance Rule and verify if it is receiving the required maintenance.

#### 71111.07-04 REFERENCES

IMC 0308, Attachment 2, "Technical Basis for Inspection Program"

IMC 2515, Appendix A, "Risk-Informed Baseline Inspection Program"

IP 71111.01, "Adverse Weather Protection"

IP 71111.21M, "Comprehensive Engineering Team Inspection"

IP 71152, "Problem Identification and Resolution"

EPRI NP-7552, "Heat Exchanger Performance Monitoring Guidelines" (Call the NRC Technical Library to get a copy of this if needed.)

EPRI TR-106438, "Water Hammer Handbook for Nuclear Plant Engineers" (Call the NRC Technical Library to get a copy of this if needed.)

TR-107397, "Service Water Heat Exchanger Testing Guidelines"

TR-1003320, "Supplemental Guidance for Testing and Monitoring Service Water Heat Exchangers"

EPRI 1009839, "Heat Exchanger Single Tube Test Device"

TEMA Standards, "Standards of the Tubular Exchanger Manufacturers Association"

ASME OM-S/G Part 21, "Inservice Performance Testing of Heat Exchangers in Light-Water Reactor Power Plants"

NUREG 1275 Vol. 3, "Operating Experience Feedback Report- Service Water System Failures and Degradations"

NUREG/CR-5865, "Generic Service Water System Risk-Based Inspection Guide"

NUREG/CR-0548, "Ice Blockage of Water Intakes"

Generic Letter 89-13, "Service Water System Problems Affecting Safety-Related Equipment"

Generic Letter 91-13, "Request for Info Related to the Resolution of GI 130, "Essential Service Water System Failures at Multi-Unit Sites"

Generic Letter 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-basis Accident Conditions"

Generic Letter 96-06, "Assurance of Equipment Operability and Containment Integrity Supplement 1 During Design-basis Accident Conditions"

Bulletin 79-15, "Deep Draft Pump Deficiencies"

Bulletin 88-04, "Potential Safety-Related Pump Loss [strong-pump to weak-pump interaction, and minimum flow requirements]"

IN 80-07, "Pump Shaft Fatigue Cracking"

IN 93-68, "Failure of Pump Shaft Coupling Caused by Temper Embrittlement"

IN 94-45, "Potential Common-Mode Failure for Large Vertical Pumps"

IN 2004-07, "Plugging of Safety Injection Pump Lubrication Oil Coolers with Lakeweed"

IN 2006-17, "Recent Operating Experience of Service Water Systems due to External Conditions"

IN 2007-05, "Vertical Deep Draft Pump Shaft and Coupling Failures"

IN 2007-06, "Potential Common Cause Vulnerabilities in Essential Service Water Systems"

RG 1.27, "Ultimate Heat Sink for Nuclear Power Plants"

RG 1.127, "Inspection of Water-Control Structures Associated with Nuclear Power Plants"

See the following Web links for reference documents:

IHS Codes and Standards:

<https://drupal.nrc.gov/tech-lib/35748> (non-public)

NRC Technical Library:

<https://drupal.nrc.gov/tech-lib> (non-public)

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Attachment 1: Revision History for IP 71111.07

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment and Feedback Resolution Number (Pre-Decisional, Non-Public Information)
N/A	04/03/00 CN 00-003	Initial Issue - Revised Reactor Oversight Process	N/A	
N/A	01/17/02 CN 02-001	Revised to differentiate between heat sinks and heat exchangers, including their independent performance requirements. In addition, inspection resource estimates and level of effort are revised to provide a band for more inspection flexibility.	None, N/A	
N/A	ML051650399 06/06/05 CN 05-015	Revised to clarify inspection requirements and guidance for annual review and to add inspection guidance for determining the structural integrity of heat exchangers. In addition, minor changes have been made to the Cornerstones, Level of Effort, Inspection Completion, and References Sections of the inspection procedure.	None, N/A	
N/A	05/25/06	Researched commitments back four years - none found.	None, N/A	N/A
N/A	<a href="#">ML060460027</a> 05/25/06 CN 06-013	Revised to incorporate lessons learned from ANO inspection regarding UHS dam integrity (report number 2005008); FB-937. Inspections of the UHS water reservoir is required every other biennial inspection.  Also, addressed FB-996 regarding inspections to prevent clogging of UHS equipment with sediment.  Other minor editorial comments also included.	None, N/A	<a href="#">ML061290102</a>

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment and Feedback Resolution Number (Pre-Decisional, Non-Public Information)
N/A	<a href="#">ML073050455</a> 01/31/08 CN 08-005	Revised to change biennial portion of this inspection procedure to triennial inspection periodicity based on 2007 ROP realignment results. Revise to provide more specific inspection guidance, and to make it more effective and efficient. Other minor editorial comments also included.	None, N/A	<a href="#">ML080290277</a>
N/A	<a href="#">ML082970641</a> 03/23/09 CN 09-010	Revised to provide more specific inspection guidance. Other minor editorial comments also included.	None, N/A	<a href="#">ML090130171</a>
N/A	<a href="#">ML092300324</a> 02/02/10 CN 10-004	Changed samples from 2-3 to 2-4 on Triennial Inspection. See 2009 ROP Realignment Results (ML092090312). Revised procedure to clarify sample requirements and add additional guidance.	None, N/A	N/A 71111.07-1438 <a href="#">ML093380140</a>
N/A	<a href="#">ML100820347</a> 07/06/10 CN 10-015	Added additional sample selection guidance.	None, N/A	<a href="#">ML101740062</a> 71111.07-1476
N/A	<a href="#">ML16161A056</a> 12/08/16 CN 16-032	Revised to incorporate aging management programs. Revised text to clarify inspection requirements versus guidance (should and shall), to address recommendations from OIG 16-A-12 audit.	None, N/A	<a href="#">ML16162A010</a> 71111.07-2059 <a href="#">ML16160A006</a> 71111.07-2185 <a href="#">ML16160A008</a>

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment and Feedback Resolution Number (Pre-Decisional, Non-Public Information)
N/A	ML19291A214 10/21/20 CN 20-053	Major revision and reissue (no redline). Relocated optional requirements to the guidance section to better align with IMC 2515, section 8.04, sample completion requirements. Eliminated need to perform redundant UHS Containment Device or Dam inspections at sites already receiving dedicated and focused inspections. Added AP1000 sample requirements. Reformatted to conform to IMC 0040.	None	ML19316B054 (2019)  ML20233A519 (2020)
N/A	ML22024A114 02/18/22 CN 22-004	Restored and clarified sample selection guidance for heat exchanger/sink/UHS in the General Guidance section that was inadvertently removed from the preceding revision.	None	N/A
N/A	ML23191A517 08/18/23 CN 23-025	Per SECY 18-0113 and SECY 22-0053 (and approved in SRM-SECY 22-0053), revised to remove sections that discussed inspections contained in IP 71111.21M.	None	ML23192A120