ATTACHMENT 71111.07

INSPECTABLE AREA: Heat Sink Performance

CORNERSTONES: Initiating Events (20%)
Mitigating Systems (70%)
Barrier Integrity (10%)

INSPECTION BASES: Heat exchangers and heat sinks are required to remove decay heat, and provide cooling water for operating equipment. Degradation in performance can result in failure to meet system success criteria, and lead to increased risk primarily due to common cause failures. This inspectable area verifies aspects of the associated cornerstones for which there are no indicators to measure performance.

LEVEL OF EFFORT: The effort of this procedure consists of the review of a sample of one or two heat exchangers/heat sinks, on an annual basis, in accordance with the requirements specified in Section 02.01. On a biennial basis, review a sample of two or three heat exchangers/heat sinks in accordance with the requirements in Section 02.02.

71111.07-01 INSPECTION OBJECTIVES

01.01 To verify that any potential heat exchanger deficiencies which could mask degraded performance are identified. Applies to all heat exchangers connected to safety related service water systems.

01.02 To verify that any potential common cause heat sink performance problems that have the potential to increase risk are identified, i.e., icing at circulating and service water intake structures.

01.03 To verify that the licensee has adequately identified and resolved heat sink performance problems that could result in initiating events or affect multiple heat exchangers in mitigating systems and thereby increase risk, i.e., component cooling water heat exchanger performance affected by corrosion, fouling, or silting.

71111.07-02 INSPECTION REQUIREMENTS

02.01 Annual Review. Verify the readiness and availability of a sample of one or two heat exchangers/heat sinks by monitoring licensee programs, or invoking industry standards, and also, if necessary, checking critical operating parameters, and/or maintenance records. The readiness and availability of the sample of heat exchangers/heat sinks may be verified by one of the items a. through d. below. Items e. and f. may be performed as additional assurance of the heat exchanger(s) operability.

a. Observe actual performance tests for heat exchanger/heat sinks or review the data/reports for those tests for any obvious problems or errors.

b. Verify the licensee utilizes the periodic maintenance method outlined in EPRI NP-7552.

c. Observe licensee's execution of biofouling controls.

d. Observe the licensee's heat exchanger inspections and the state of cleanliness of their tubes.

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 are any evident leaks.

   4. If licensee believes the heat exchanger can perform its safety related function and whether supporting documentation or inspections support the licensee's position.

f. Determine if heat exchanger is correctly categorized under the Maintenance Rule and verify if it is receiving the required maintenance.

02.02 Biennial Review

a. Select a sample of 2-3 heat exchangers for systems that are ranked high in the plant specific risk assessment. This includes all heat exchangers directly or indirectly connected to the safety-related service water system.

b. For the selected heat exchangers that are also directly connected to the service water system, verify that testing, inspection/maintenance, or monitoring of biotic fouling controls are singularly or in combination adequate to ensure proper heat transfer.

   1. Review the method and results of heat exchanger performance testing or equivalent methods to verify performance. Verify the following items, as applicable:

      (a) The selected test methodology is consistent with accepted industry practices, or equivalent.

      (b) Test conditions (e.g., differential temperatures, differential pressures, and flows) are consistent with the selected methodology.

      (c) Test acceptance criteria (e.g., fouling factors, heat transfer coefficients) are consistent with the design basis values.

      (d) Test results have appropriately considered differences between testing conditions and design conditions (functional testing at design heat removal rate may not be practical).

      (e) Frequency of testing based on trending of test results is sufficient (based on trending data) to detect degradation prior to loss of heat removal capabilities below design basis values.

      (f) Test results have considered test instrument inaccuracies and differences.

(g) Tube and shell side heat loads are equal if adequate information is available in test results to calculate these two values.

2. For inspection/cleaning, review the methods and results of heat exchanger performance inspections or observe the actual inspection/ cleaning. Verify the following first three steps ((a)-(c)) if conducting the review and the last step (d) only if actually observing the inspection/cleaning:

(a) Methods used to inspect heat exchangers are consistent with expected degradation.

(b) Established acceptance criteria are consistent with accepted industry standards, or equivalent, including acceptability of the cleaning interval.

(c) As found results are appropriately dispositioned such that the final condition is acceptable.

(d) If observing the inspection/cleaning then perform the following:

(1.) Prior to cleaning, inspect the extent of fouling and blockage of tubes.

(2.) Inspect the condition of the cleaned surfaces.

(3.) Verify that the number of plugged tubes are within the limit of operability of the heat exchanger and are appropriately accounted for in heat exchanger performance calculations.

3. When implemented, verify that chemical treatments, tube leak monitoring, methods used to control biotic fouling corrosion (such as shells, seaweed, corbicula, and microbiological induced corrosion), and methods to control macrofouling (silt, dead mussel shells, debris, etc.) are sufficient (e.g., appropriate acceptance criteria) to ensure required heat exchanger performance.

c. For the selected heat exchangers <u>either directly or indirectly connected, except as noted,</u> to the service water system, verify the following:

1. Condition and operation are consistent with design assumptions in heat transfer calculations, e.g. for tube plugging.

2 Licensee has evaluated the potential for water hammer in those heat exchangers and undertaken appropriate measures to address it.

3. The heat exchangers do not exhibit excessive vibration during operation that could potentially damage their tubes or tubesheets based on direct observation or issues identified in corrective-action documents.

4. For heat exchangers <u>indirectly connected</u> to the service water system, that the water chemistry is being adequately controlled to discourage corrosion , e.g. stress corrosion cracking, in its metallic sub-components.

5. Redundant and infrequently used heat exchangers are flow tested periodically at maximum design flow.

d. Verify the performance of ultimate heat sinks and their subcomponents like piping, intake screens, pumps, valves, etc by tests or other equivalent methods. For heat sinks, the issue is their availability and accessibility to the in-plant cooling water systems. The inspector should check two of the following for heat sinks and their subcomponents as applicable:

1. Sufficient reservoir capacity.

2. Third party dam inspections for integrity of heat sink

3. Free from clogging due to macrofouling (silt, dead mussel shells, debris, etc.)

4. Licensee has in place adequate controls for biotic fouling.

5. Functionality during adverse weather conditions, e.g. icing or high temperatures.

6. Performance tests for pumps and valves in service water system.

e. Review, if available, eddy current summary sheets, ultrasonic testing results, and visual inspections to determine the structural integrity of the heat exchanger.

02.03 Identification and Resolution of Problems. Verify that the licensee has entered significant heat exchanger/sink performance problems in the corrective action program. As it relates to degraded heat exchanger/sink performance including issues related to silting, corrosion, fouling, and heat exchanger testing then verify that licensee corrective actions are appropriate. See Inspection Procedure 71152, “Identification and Resolution of Problems,” for additional guidance.

71111.07-03 INSPECTION GUIDANCE

General Guidance

Refer to the table below for selecting inspection activities to achieve each cornerstone objective and to 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.

Cornerstone	Inspection Objective	Risk Priority	Example
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 of a circulating water and service water intake structure.
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.

Specific Guidance

03.01 This inspection should encourage the timely identification of heat exchanger/heat sink performance problems so the licensee may take prompt corrective actions.

- The heat exchangers should be in a system that is directly or indirectly cooled by the safety-related service water system or the credited water system cooled by the ultimate heat sink, and that is ranked high in the plant specific risk assessment.

- The inspection activities in some cases may be the same as those in Section 02.02 but the inspection should not be conducted at the same level of detail or depth.

- Inspection results are appropriately categorized against pre-established engineered acceptance criteria, and are acceptable.

- Frequency of testing or inspection is sufficient (given the potential for fouling) to detect degradation prior to loss of heat removal capabilities below design basis values.

a. These tests should be those typically sanctioned by industry. The heat exchangers should be in a system that is directly cooled by the safety-related service water system or the credited water system cooled by the ultimate heat sink. 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. No specific guidance

c. The licensee should have an acceptance criteria for its bio-fouling controls that is based on an industry standard, supportive program results, or the recommendation of the appropriate vendors.

d. Primarily focus on whether the number of tubes plugged affects the heat exchanger's operability and not the biofilm on the inside of tubes which should be covered in the biennial inspection by a specialist. The licensee should have an acceptance criteria that indicates the maximum number of tubes that may be clogged for a specific heat exchanger and a basis for that acceptance criteria.

03.02 Biennial Review

a. There is no limitation on the type and size of heat exchangers that can be selected as long as they are cooled by the safety-related service water system or the credited water system cooled by the ultimate heat sink and they are ranked high in the plant specific risk assessment. The credited water source is the one relied on in accident analyses in the licensee’s safety analysis report. The selection of the heat exchanger also should consider results from previous annual inspection and heat exchangers with past history of problems/extensive corrective actions.

b. For this requirement, if possible, focus on the credited water source as defined in 03.02a. above. Of the heat exchangers selected only those directly cooled by the safety-related service water system should be reviewed or evaluated for this inspection requirement in accordance with Generic Letter 89-13

1. No specific guidance

(a - c) No specific guidance

(d). Test results need to be extrapolated to the heat exchanger design conditions.

(e) Trending of the results of heat exchanger performance tests should not have abrupt step changes without the licensee providing some valid justification as to the reason for the deviation..

(f) Test instruments should be calibrated and set on appropriate range for the parameters to be measured, otherwise small measurement errors could affect the test results. The required accuracy of the instruments depends on the margins available between the calculated parameter based on the test results and the limiting design condition.

(g) No specific guidance

2. No specific guidance

3. No specific guidance

c. This inspection requirement should target those design and operational requirements other than those evaluated by performance testing or inspection/cleaning.

1. The inspector can refer to either design assumptions in calculations or also parameters on design data sheet that can be evaluated by observation not testing.

2. No specific guidance

3. No specific guidance

1. This inspection requirement is only applicable to those heat exchangers cooled by safety-related service water or the credited water source as defined above in 03.02a. and which are also in closed loop systems.

5. No specific guidance

d. For this requirement focus on the credited water source as defined in 03.02a. above. The inspector should assess whether the ultimate heat sink and its subcomponents are capable of performing their intended safety functions. Only two of the listed parameters which are applicable for the respective plant should be reviewed on a biennial basis.

1. No specific guidance

4. Some plants may not have dams which encapsulate the ultimate heat sink so this requirement will not be applicable.

5. This requirement can be satisfied by test results, observation, or other equivalent methods that verify ultimate heat sink and subcomponents can accommodate maximum system flow.

6. Best verified by checking conformance with the acceptance criteria adopted by the licensee for checking the adequacy of the licensee's biotic fouling controls.

7. This inspection requirement should determine whether licensee has procedures to deal with adverse weather conditions. Coordinate the performance of this step with the inspection requirements of IP 71111.01, "Adverse Weather Protection."

8. No specific guidance.

e. No specific guidance

02.03 Identification and Resolution of Problems

The inspector should 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, or blockage of pipes and components. The inspector should determine whether the licensee has appropriately considered common-cause failures. If any loss of heat exchanger/sink events have occurred, these should receive the priority for review. Review the corrective actions to determine if actions were sufficient to prevent recurrence of the problem. Refer to IP 71152, "Identification and Resolution of Problems," for further guidance in this area.

71111.07-04 RESOURCE ESTIMATES

This inspection procedure is estimated to take, on average, 5 to 7 hours for an annual review and 34 to 46 hours for a biennial review at a site regardless of the number of units at that site. These estimates depend on the number of heat exchangers/sinks tested by the licensee during the inspection period.

71111.07-05 PROCEDURE COMPLETION

Inspection of the minimum sample size will constitute completion of this procedure in the Reactor Programs Systems (RPS). That minimum sample size will consist of one sample, on an annual basis, to verify the readiness/availability of one heat exchanger/heat sink per Section 02.01, and two samples, on a biennial basis, to verify the heat exchanger/heat sink performance in accordance with Section 02.02.

71111.07-06 REFERENCES

EPRI NP-7552 Heat Exchanger Performance Monitoring Guidelines

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

See the following web links for reference documents:

http://www.internal.nrc.gov/IRM/LIBRARY/standards/ihs.htm

http://www.internal.nrc.gov/IRM/LIBRARY/library.htm

http://www.nrc.gov/reading-rm/doc-collections/nuregs/

http://www.nrc.gov/reading-rm/doc-collections/reg-guides/

http://www.nrc.gov/reading-rm/doc-collections/gen-comm/

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