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GAS AND
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GEORGE C. CREEL
VICE PRESIDENT
NUCLEAR ENERGY
(301) 260-4455

January 29, 1990

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318
Response to Generic Letter 89-13, "Service Water System Problems Affecting Safety-Related Equipment"

REFERENCE: (a) Generic Letter 89-13, "Service Water System Problems Affecting Safety Related Equipment," dated July 18, 1989

(b) Letter from Mr. G. V. McGowan (BG&E) to Mr. J. M. Taylor (NRC), dated July 31, 1989, Performance Improvement Plan Implementation Program

Gentlemen:

In Reference (a), you outlined concerns regarding the safe operation and maintenance of the service water system. Recommended actions to address these concerns were provided.

The Baltimore Gas and Electric Company (BG&E) shares the concerns presented in Generic Letter 89-13. Our response to the Generic Letter's recommended actions is provided as Enclosure (1).

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Should you have any further questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

STATE OF MARYLAND :
: **TO WIT** :
County of Calvert :

I hereby certify that on the 29th day of January, 1990, before me, the subscriber, a Notary Public of the State of Maryland in and for St. Mary's County, personally appeared George C. Creel, being duly sworn, and states that he is Vice President of the Baltimore Gas and Electric Company, a corporation of the State of Maryland; that he provides the foregoing response for the purposes therein set forth; that the statements made are true and correct to the best of his knowledge, information, and belief; and that he was authorized to provide the response on behalf of said Corporation.

WITNESS my Hand and Notarial Seal:

Gerry L Adams
Notary Public

My Commission Expires:

1 July 1990
Date

GCC/MDM/bjd

Enclosure

cc: D. A. Brune, Esquire
J. E. Silberg, Esquire
R. A. Capra, NRC
S. A. McNeil, NRC
W. T. Russell, NRC
J. E. Beall, NRC
T. Magette, DNR

ENCLOSURE (1)

BG&E RESPONSE TO NRC GENERIC LETTER 89-13

BACKGROUND

In Generic Letter 89-13 you identified several concerns associated with ensuring proper heat transfer capability in the service water systems. You also provided recommended actions to address these concerns.

Baltimore Gas and Electric Company shares the concerns outlined in General Letter (GL) 89-13 and has initiated efforts to ensure the service water systems will be capable of meeting their design function under all conditions.

Our response to GL 89-13 is broken down into five tasks. Each task addresses the scope of the Nuclear Regulatory Commission (NRC) recommendations, our current programs, and a list of planned actions. The proposed schedule for completing the Task Actions is included as well.

As defined in the GL, a service water system is "the system or systems that transfer heat from safety-related structures, systems, or components to the UHS." An intermediate system is a service water system "used between the safety-related items and the system rejecting heat to the UHS..." A closed-cycle system is "a part of the service water system that is not subject to significant sources of contamination, one in which water chemistry is controlled, and one in which heat is not directly rejected to a heat sink." An open-cycle system is a part of the service water system that does not meet all of the requirements of a closed-cycle system.

Using the above definitions, the Calvert Cliffs service water system is comprised of one open-cycle system (Salt Water) and two intermediate/closed-cycle systems (Component Cooling and Service Water). The Salt Water System is composed of two independent and redundant safety-related trains that remove heat from the Component Cooling heat exchangers, Service Water heat exchangers, ECCS pump room air coolers, and transfer the heat to the Chesapeake Bay (ultimate heat sink).

The Service Water System is an intermediate/closed-cycle system, with two trains that remove heat from turbine plant components, containment cooling units, spent fuel pool cooling heat exchangers, blow-down recovery heat exchangers, emergency diesel generator heat exchangers, and transfer heat to the Salt Water System. A chemical addition tank injects Hydrazine into the system to minimize corrosion.

The other intermediate/closed-cycle system is Component Cooling. This service water system transfers heat from the following equipment to the Salt Water System:

- Shutdown Cooling heat exchangers
- Letdown heat exchanger
- Reactor Coolant Pump seal and Lube Oil coolers
- Control Element Drive Mechanism coolers
- Cooling jacket and after cooler for each Waste Gas Compressor
- HPSI Pump seal and bearing coolers
- LPSI Pump seal and bearing coolers
- Containment Penetration coolers
- Reactor Vessel Support coolers

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- Steam Generator Lateral Support coolers
- Reactor Coolant Drain tank heat exchanger
- NSSS Sample coolers
- Post Accident Sample System cooler (supplied by the Unit-2)
- The Gas Analyzer Sample coolers
- Reactor Coolant Waste evaporators
- The Steam Generator Blowdown Radiation Monitor Unit Sample cooler
- The Degasifier Vacuum pump accumulator; and
- The Miscellaneous Waste Heat exchanger (supplied by the Unit-1 Component Cooling System only)

A chemical addition tank injects Hydrazine into the system to minimize corrosion.

Under the scope of GL 89-13, the Fire Protection System is to be included in the program if the potential for microbiologically influenced corrosion exist. The Fire Protection System water at Calvert Cliffs has not shown any signs of significant corrosion. Several deep well pumps provide fresh water to the system through activated carbon filters. Surveillance tests have shown the system is free of significant corrosion or biofouling and should not be included in the scope of this letter.

ENCLOSURE (1)

BG&E RESPONSE TO NRC GENERIC LETTER 89-13

TASKS

- TASK I - Salt Water Biofouling Program
- TASK II - Test Program
- TASK III - Inspection and Maintenance Program
- TASK IV - Licensing Basis Review
- TASK V - Service Water System Program Review

The following tasks are broken down into three sections: (1) scope of NRC recommendation; (2) our current program; (3) a list of planned actions. The Generic Letter is included as Attachment 1.

The schedule for completing the tasks follows Task V.

TASK I - SALT WATER BIOFOULING PROGRAM

TASK SCOPE

Implement and maintain an ongoing program of surveillance and control techniques to significantly reduce the incident of flow blockage problems, as a result of biofouling, in the Salt Water System (open-cycle service water system). An effective program should have the following elements:

1. Visual inspection of the Salt Water intake structure and the removal of any accumulated fouling.

2. Implementation of an effective biocide treatment program.

3. Flushing and periodic flow testing, at the maximum design flow, of redundant and infrequently used cooling loops. The filling of the Salt Water System with chlorinated water before lay-up.

CURRENT PROGRAMS

1. We currently clean and inspect the Salt Water intake structures during each refueling outage. The system engineer issues a maintenance request for cleaning the intake structure prior to the outage. An inspection is performed, during the outage, after excess biofouling is removed.

2. The Salt Water System is chlorinated, when the Chesapeake Bay temperature is greater than 40°, under an existing program. The old chlorination system was unreliable, operating intermittently, and has been replaced. The new chlorination system installation is nearing completion and will soon be placed in service. Residual chlorine levels are maintained within the limits of the National Pollution Discharge Elimination System (NPDES).

3. Infrequently used, safety-related Salt Water loops are periodically flushed and flow tested. Although actual flow rates are not measured, key data such as header pressure and values from pump head curves indicate the maximum design flow rate is achieved.

PLANNED ACTIONS

1. To ensure a high priority is placed on cleaning and inspecting the intake structures, these practices will be incorporated into the preventive maintenance program.

2. In accordance with Enclosure (1) of the Generic Letter, the Salt Water System will be treated by the new chlorination system. Activities including system design review, maintenance modifications, initial testing, and procedure reviews will be performed before placing the new system in-service.

3. Once the new chlorination system is in service, a program will be implemented to sample and monitor residual chlorine levels within the Salt Water System. Components of the program include identifying representative sampling point(s), preparing the procedure for sampling, and analyzing the results.

4. After the new chlorination system is placed in-service, various methods will be used to determine its effectiveness. The amount and rate of heat exchanger fouling will be compared to historic data on heat exchanger cleaning. This comparison, along with the performance monitoring performed in Task II and the Design Bases Reconstitution created in Task IV, will be used to determine the system's effectiveness. Additional options include the development of new monitoring techniques (i.e., side stream monitoring, etc.), dual flow traveling screens, and anti-biofouling control in the intake structure.

5. We will verify the infrequently-used, safety-related Salt Water loops are flushed at the design flow rate. Actual flow instrumentation purchased for Task II will be utilized for flow measurement. A new program will be established to ensure Salt Water loops are properly layed-up with biocide if the need arises.

6. The ultimate heat sink and source for the Salt Water System at Calvert Cliffs is the Chesapeake Bay. Baltimore Gas and Electric Company uses the Bay tributaries as a cooling water supply for some of its other plants, as well. The Environmental Programs Unit in BG&E is responsible for investigating abnormal occurrences of biofouling agents at each facility. Should a abnormal biofouling concern arise at a facility that may eventually affect Calvert Cliffs, the Environmental Programs Unit will be in contact to alert us of the problem.

   Additionally, the Environmental Programs Unit will develop a program to establish communications between BG&E and other utilities that have access to the Bay or its tributaries. By being aware of potential fouling problems throughout the Bay, Calvert Cliffs can be ready to implement actions that will minimize biofouling in our service water systems.

ENCLOSURE (1)

BG&E RESPONSE TO NRC GENERIC LETTER 89-13

TASK II - TEST PROGRAM

TASK SCOPE

Conduct initial performance testing and establish a periodic retest program to verify heat transfer capability of safety related heat exchangers cooled by the Salt Water System (open-cycle service water system). The initial testing will provide baseline data.

To ensure proper heat transfer capability in the Service Water and Component Cooling System (closed-cycle service water systems), initial testing will be performed on all safety related heat exchangers within these systems.

CURRENT PROGRAMS

Currently, a program does not exist at Calvert Cliffs for measuring the heat transfer capability in the Salt Water, Service Water, and Component Cooling Systems.

PLANNED ACTIONS

1. Establish baseline performance data on the Salt Water, Service Water, and Component Cooling System heat exchangers through initial testing.

   Initial testing will verify the heat transfer capability of each heat exchanger tested and provide the baseline data for future evaluation of the heat exchangers that will be incorporated into the periodic retest, inspection, and monitoring phase.

   Each phase of the program will consist of tests and/or inspections, as appropriate to the heat exchanger type, to ensure the heat transfer rate required can be met.

   Attachment 2 is a table listing each heat exchanger within the Salt Water, Service Water, and Component Cooling System, whether it is included in the program, the type of test that will be performed on it, and the frequency for periodic testing, if required.

2. Through trend analysis, compare system performance with design/licensing basis.

3. Establish methods to continue testing and evaluation. The periodic retest, inspection, and monitoring phase will ensure that the performance of the heat exchangers does not degrade to the condition that their safety functions cannot be met. The results from the initial testing on the heat exchangers in the Salt Water, Service Water, and Component Cooling Systems will be used to determine which heat exchangers should be included in the periodic program.

   Our test program will meet the requirements of Enclosure 2 in the Generic Letter.

ENCLOSURE (1)

BG&E RESPONSE TO NRC GENERIC LETTER 89-13

TASK III - INSPECTION & MAINTENANCE PROGRAM

TASK SCOPE

Establish a routine inspection and maintenance program for the Salt Water System (open-cycle service water system) piping and components to ensure that corrosion, erosion, protective coating failure, silting, and biofouling can not degrade system performance. The program should include steps to:

1. Remove excessive accumulations of biofouling agents, corrosion products, and silt.

2. Repair defective linings and corroded system piping and components that could adversely effect the Salt Water System performance and safety function.

CURRENT PROGRAMS

1. The Salt Water differential pressure across the Service Water heat exchangers is monitored twice per shift. In the Salt Water System these heat exchangers are most susceptible to biofouling. The differential pressure is used as an indication of fouling. Additionally, the Salt Water System is periodically flow tested at conditions that approximate maximum design flow.

   When the Service Water heat exchangers are unable to pass appropriate flowrates, the heat exchangers are removed from service and their channel heads are cleaned. To remove accumulations of silt and corrosion products, the Service Water and Component Cooling heat exchanger tubes are bulleted quarterly.

   The ECCS Air Coolers have duplex strainers and when a predetermined differential pressure develops, they are removed from service and cleaned. They are also inspected quarterly and cleaned if needed.

2. The Salt Water System piping, large bore valves, and ECCS Air coolers channels are inspected using Ultrasonic Thickness (UT) measurements to identify corrosion and erosion of the components. UT inspections are performed every refueling outage on the selected piping and yearly on the selected valves and air coolers. Additionally, Salt Water System piping and heat exchanger channels are periodically inspected visually to identify problems with protective coatings.

PLANNED ACTIONS

1. The current programs for cleaning heat exchanger channels and strainers and scheduling of heat exchanger tube cleaning are based on achieving a maximum design flowrate. The instrumentation acquired in Task II will be used to measure flow. These cleaning programs and the frequency of cleaning will be verified using the periodic heat transfer data obtained in Task II. Additional programs or changes will be created as needed to address concerns that are not covered under these programs.

2. The Salt Water System inspection program will be reviewed to determine if changes need to be made. Two areas already identified include reviewing and revising the piping UT inspection program and developing a new program to perform inspections of the underground piping.

3. Based on the results of the initial testing in Task II, a routine inspection and maintenance program in accordance with this Generic Letter, may be extended to the Service Water and Component Cooling Systems.

TASK IV - LICENSING BASIS REVIEW

TASK SCOPE

Confirm system performance in accordance with the Design/Licensing basis. A reconstitution of the licensing basis will be necessary to verify the service water system's ability to mitigate design basis accidents Single active failure invulnerability will be verified by performing a combination of documentation reviews and system walkdowns.

CURRENT PROGRAM

A design basis reconstitution is currently in progress for the Salt Water, Service Water, and Component Cooling Systems.

PLANNED ACTIONS

1. The licensing basis reconstitution will verify flow rates and cooling water temperatures necessary to mitigate Design Basis Accidents. In order to quantify the flows obtainable and required, the Salt Water, Service Water, and Component Cooling systems will be modeled using a program that will calculate flow based on pump characteristics, line loss, system configuration, etc. The model will incorporate actual in-plant test data to establish a base line. Once the actual model is complete, the required heat transfer rate will be compared to the obtainable heat transfer rate to ensure successful accident mitigation. The Design/Licensing basis will be used in conjunction with the initial test data obtained in Task II to establish a foundation for programs set up in Task III.

2. The Salt Water, Service Water, and Component Cooling Systems will be reviewed using P&IDs, isometrics, field walkdowns, etc., to ensure that the systems are not vulnerable to a single active failure. Some of the information to be used in the review was generated in a FMEA (Failure Modes and Effects Analysis) done under the Calvert Cliffs Reliability Centered Maintenance Program.

ENCLOSURE (1)

BG&E RESPONSE TO NRC GENERIC LETTER 89-13

TASK V - SERVICE WATER SYSTEMS PROGRAM REVIEW

TASK SCOPE

Confirm that maintenance practices, operating and emergency procedures and training are adequate to ensure that the service water systems will function as intended and that operators will perform effect[illegible]ly.

CURRENT PROGRAM

Operating, maintenance, and emergency procedures currently exist for the service water systems. A review of the Calvert Cliffs Operations Training program was completed in 1988. The Operations Training programs are INPO accredited.

PLANNED ACTIONS

1. In reference (b), section 5.0, we committed to implementing a Procedure Upgrade Program. The program will encompass comprehensive service water systems' procedure reviews that will include technical accuracy and human factors verifications.

   The procedure reviews associated with the service water systems will also factor in changes associated with the implementation of our response to the Generic Letter.

2. The Nuclear Training Section will be informed of changes in the service water systems so that they can be evaluated for training program changes.

SCHEDULE

Both Calvert Cliffs Unit 1 and 2 are currently in extended outages. The next scheduled refueling outage for each unit will be based on when each unit returns to service from their current outage.

As required by the Generic Letter, all initial activities in Task I and II will be completed before plant startup following the next scheduled refueling outages for each unit. The establishment of programs in Task III and confirmations required in Task IV and V will be completed before plant startup following the next scheduled refueling outages for each unit. The procedure reviews under Task V will be performed in accordance with the schedule we are currently creating for the Procedure Upgrade Program.

Attachment (1)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

July 18, 1989

TO: ALL HOLDERS OF OPERATING LICENSES OR CONSTRUCTION PERMITS FOR NUCLEAR POWER PLANTS

SUBJECT: SERVICE WATER SYSTEM PROBLEMS AFFECTING SAFETY-RELATED EQUIPMENT (GENERIC LETTER 89-13)

Purpose:

Nuclear power plant facilities of licensees and applicants must meet the minimum requirements of the General Design Criteria (GDC) in 10 CFR Part 50, Appendix A. In particular, "GDC 44--Cooling Water" requires provision of a system (here called the service water system) "to transfer heat from structures, systems, and components important to safety to an ultimate heat sink" (UHS). "GDC 45--Inspection of Cooling Water System" requires the system design "to permit appropriate periodic inspection of important components, such as heat exchangers and piping, to assure the integrity and capability of the system." "GDC 46--Testing of Cooling Water System" requires the design "to permit appropriate periodic pressure and functional testing."

In addition, nuclear power plant facilities of licensees and applicants must meet the minimum requirements for quality assurance in 10 CFR Part 50, Appendix B. In particular, Section XI, "Test Control," requires that "a test program shall be established to assure that all testing required to demonstrate that structures, systems, and components will perform satisfactorily in service is identified and performed in accordance with written test procedures which incorporate the requirements and acceptance limits contained in applicable design documents."

Recent operating experience and studies have led the NRC to question the compliance of the service water systems in the nuclear power plants of licensees and applicants with these GDC and quality assurance requirements. Therefore, this Generic Letter is being issued to require licensees and applicants to supply information about their respective service water systems to assure the NRC of such compliance and to confirm that the safety functions of their respective service water systems are being met.

Background:

Bulletin No. 81-03: The NRC staff has been studying the problems associated with service water cooling systems for a number of years. At Arkansas Nuclear One, Unit 2, on September 3, 1980, the licensee shut down the plant when the NRC Resident Inspector discovered that the service water flow rate through the

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containment cooling units did not meet the technical specification requirement. The licensee determined the cause to be extensive flow blockage by Asiatic clams (Corbicula species, a non-native fresh water bivalve mollusk). Prompted by this event and after determining that it represented a generic problem of safety significance, the NRC issued Bulletin No. 81-03, "Flow Blockage of Cooling Water to Safety System Components by Corbicula sp. (Asiatic Clam) and Mytilus sp. (Mussel)."

The bulletin required licensees and applicants to assess macroscopic biological fouling (biofouling) problems at their respective facilities in accordance with specific actions. A careful assessment of responses to the bulletin indicated that existing and potential fouling problems are generally unique to each facility ("Closeout of IE Bulletin 81-03...", NUREG/CR-3054), but that surprisingly, more than half the 129 nuclear generating units active at that time were considered to have a high potential for biofouling. At that time, the activities of licensees and applicants for biofouling detection and control ranged widely and, in many instances, were judged inappropriate to ensure safety system reliability. Too few of the facilities with high potential for biofouling had adopted effective control programs.

Information Notice No. 81-21: After issuance of Bulletin No. 81-03, one event at San Onofre Unit 1 and two events at the Brunswick station indicated that conditions not explicitly discussed in the bulletin can occur and cause loss of direct access to the UHS. These conditions include

1. Flow blockage by debris from shellfish other than Asiatic clams and blue mussels.

2. Flow blockage in heat exchangers causing high pressure drops that can deform baffles and allow flow to bypass heat exchanger tubes.

3. A change in operating conditions, such as a change from power operation to a lengthy outage, that permits a buildup of biofouling organisms.

The NRC issued Information Notice No. 81-21 to describe these events and concerns.

Generic Issue 51: By March 1982, several reports of serious fouling events caused by mud, silt, corrosion products, or aquatic bivalve organisms in open-cycle service water systems had been received. These events led to plant shutdowns, reduced power operation for repairs and modifications, and degraded modes of operation. This situation led the NRC to establish Generic Issue 51, "Improving the Reliability of Open-Cycle Service Water Systems." To resolve this issue, the NRC initiated a research program to compare alternative surveillance and control programs to minimize the effects of fouling on plant safety. Initially, the program was restricted to a study of biofouling, but in 1987 the program was expanded to also address fouling by mud, silt, and corrosion products.

This research program has recently been completed and the results have been published in "Technical Findings Document for Generic Issue 51...," NUREG/CR-5210. The NRC has concluded that the issue will be resolved when licensees and applicants implement either the recommended surveillance and control program described below (Enclosure 1) or its equivalent for the service water system at their respective facilities. Many licensees experiencing service water macroscopic biofouling problems at their plants have found that these techniques will effectively prevent recurrence of such problems. The examination of alternative corrective action programs is documented in "Value/Impact Analysis for Generic Issue 51...," NUREG/CR-5234.

Continuing Problems: Since the advent of Generic Issue 51, a considerable number of events with safety implications for the service water system have been reported. A number of these have been described in information notices, which are listed in "Information Notices Related to Fouling Problems in Service Water Systems" (Enclosure 3). Several events have been reported within the past 2 years: Oconee Licensee Event Report (LER) 50-269/87-04, Rancho Seco LER 50-312/87-36, Catawba LER 50-414/88-12, and Trojan LER 50-344/88-29. In the fall of 1988, the NRC conducted a special announced safety system functional inspection at the Surry station to assess the operational readiness of the service water and recirculation spray systems. A number of regulatory violations were identified (NRC Inspection Reports 50-280/88-32 and 50-281/88-32).

AEOD Case Study: In 1987, the Office for Analysis and Evaluation of Operational Data (AEOD) in the NRC initiated a systematic and comprehensive review and evaluation of service water system failures and degradations at light water reactors from 1980 to early 1987. The results of this AEOD case study are published in "Operating Experience Feedback Report - Service Water System Failures and Degradations," NUREG-1275, Volume 3 (Enclosure 4).

Of 980 operational events involving the service water system reported during this period, 276 were deemed to have potential generic safety significance. A majority (58 percent) of these events with generic significance involved system fouling. The fouling mechanisms included corrosion and erosion (27 percent), biofouling (10 percent), foreign material and debris intrusion (10 percent), sediment deposition (9 percent), and pipe coating failure and calcium carbonate deposition (1 percent).

The second most frequently observed cause of service water system degradations and failures is personnel and procedural errors (17 percent), followed by seismic deficiencies (10 percent), single failures and other design deficiencies (6 percent), flooding (4 percent), and significant equipment failures (4 percent).

During this period, 12 events involved a complete loss of service water system function. Several of the significant causes listed above for system degradation were also contributors to these 12 events involving system failure.

The study identified the following actions as potential NRC requirements.

1. Conduct, on a regular basis, performance testing of all heat exchangers, which are cooled by the service water system and which are needed to perform a safety function, to verify heat exchanger heat transfer capability.

2. Require licensees to verify that their service water systems are not vulnerable to a single failure of an active component.

3. Inspect, on a regular basis, important portions of the piping of the service water system for corrosion, erosion, and biofouling.

4 Reduce human errors in the operation, repair, and maintenance of the service water system.

Recommended Actions To Be Taken by Addressees:

On the basis of the discussion above, the NRC requests that licensees and applicants perform the following or equally effective actions to ensure that their service water systems are in compliance and will be maintained in compliance with 10 CFR Part 50, Appendix A, General Design Criteria 44, 45, and 46 and Appendix B, Section XI. If a licensee or applicant chooses a course of action different from the recommendations below, the licensee or applicant should document and retain in appropriate plant records a justification that the heat removal requirements of the service water system are satisfied by use of the alternative program.

Because the characteristics of the service water system may be unique to each facility, the service water system is defined as the system or systems that transfer heat from safety-related structures, systems, or components to the UHS. If an intermediate system is used between the safety-related items and the system rejecting heat to the UHS, it performs the function of a service water system and is thus included in the scope of this Generic Letter. A closed-cycle system is defined as a part of the service water system that is not subject to significant sources of contamination, one in which water chemistry is controlled, and one in which heat is not directly rejected to a heat sink. If all these conditions are not satisfied, the system is to be considered an open-cycle system in regard to the specific actions required below. (The scope of closed cooling water systems is discussed in the industrial standard "Operation and Maintenance of Nuclear Power Plants," ASME/ANSI OM-1987, Part 2.)

I. For open-cycle service water systems, implement and maintain an ongoing program of surveillance and control techniques to significantly reduce the incidence of flow blockage problems as a result of biofouling. A program acceptable to the NRC is described in "Recommended Program to Resolve Generic Issue 51" (Enclosure 1). It should be noted that Enclosure 1 is provided as guidance for an acceptable program. An equally effective program to preclude biofouling would also be acceptable. Initial activities should be completed before plant startup following the first refueling outage beginning 9 months or more after the date of this letter. All activities should be documented and all relevant documentation should be retained in appropriate plant records.

II. Conduct a test program to verify the heat transfer capability of all safety-related heat exchangers cooled by service water. The total test program should consist of an initial test program and a periodic retest program. Both the initial test program and the periodic retest program should include heat exchangers connected to or cooled by one or more open-cycle systems as defined above. Operating experience and studies indicate that closed-cycle service water systems, such as component cooling water systems, have the potential for significant fouling as a consequence of aging-related in-leakage and erosion or corrosion. The need for testing of closed-cycle system heat exchangers has not been considered necessary because of the assumed high quality of existing chemistry control programs. If the adequacy of these chemistry control programs cannot be confirmed over the total operating history of the plant or if during the conduct of the total testing program any unexplained downward trend in heat exchanger performance is identified that cannot be remedied by maintenance of an open-cycle system, it may be necessary to selectively extend the test program and the routine inspection and maintenance program addressed in Action III, below, to the attached closed-cycle systems.

A program acceptable to the NRC for heat exchanger testing is described in "Program for Testing Heat Transfer Capability" (Enclosure 2). It should be noted that Enclosure 2 is provided as guidance for an acceptable program. An equally effective program to ensure satisfaction of the heat removal requirements of the service water system would also be acceptable.

Testing should be done with necessary and sufficient instrumentation, though the instrumentation need not be permanently installed. The relevant temperatures should be verified to be within design limits. If similar or equivalent tests have not been performed during the past year, the initial tests should be completed before plant startup following the first refueling outage beginning 9 months or more after the date of this letter.

As a part of the initial test program, a licensee or applicant may decide to take corrective action before testing. Tests should be performed for the heat exchangers after the corrective actions are taken to establish baseline data for future monitoring of heat exchanger performance. In the periodic retest program, a licensee or applicant should determine after three tests the best frequency for testing to provide assurance that the equipment will perform the intended safety functions during the intervals between tests. Therefore, in the periodic retest program, to assist that determination, tests should be performed for the heat exchangers before any corrective actions are taken. As in the initial test program, tests should be repeated after any corrective actions are taken to establish baseline data for future monitoring of heat exchanger performance.

An example of an alternative action that would be acceptable to the NRC is frequent regular maintenance of a heat exchanger in lieu of testing for degraded performance of the heat exchanger. This alternative might apply to small heat exchangers, such as lube oil coolers or pump bearing coolers or readily serviceable heat exchangers located in low radiation areas of the facility.

In implementing the continuing program for periodic retesting of safety-related heat exchangers cooled by service water in open-cycle systems, the initial frequency of testing should be at least once each fuel cycle, but after three tests, licensees and applicants should determine the best frequency for testing to provide assurance that the equipment will perform the intended safety functions during the intervals between tests and meet the requirements of GDC 44, 45, and 46. The minimum final testing frequency should be once every 5 years. A summary of the program should be documented, including the schedule for tests, and all relevant documentation should be retained in appropriate plant records.

III. Ensure by establishing a routine inspection and maintenance program for open-cycle service water system piping and components that corrosion, erosion, protective coating failure, silting, and biofouling cannot degrade the performance of the safety-related systems supplied by service water. The maintenance program should have at least the following purposes:

A. To remove excessive accumulations of biofouling agents, corrosion products, and silt;

B. To repair defective protective coatings and corroded service water system piping and components that could adversely affect performance of their intended safety functions.

This program should be established before plant startup following the first refueling outage beginning 9 months after the date of this letter. A description of the program and the results of these maintenance inspections should be documented. All relevant documentation should be retained in appropriate plant records.

IV. Confirm that the service water system will perform its intended function in accordance with the licensing basis for the plant. Reconstitution of the design basis of the system is not intended. This confirmation should include a review of the ability to perform required safety functions in the event of failure of a single active component. To ensure that the as-built system is in accordance with the appropriate licensing basis documentation, this confirmation should include recent (within the past 2 years) system walkdown inspections. This confirmation should be completed before plant startup following the first refueling outage beginning 9 months or more after the date of this letter. Results should be documented and retained in appropriate plant records.

V. Confirm that maintenance practices, operating and emergency procedures, and training that involves the service water system are adequate to ensure that safety-related equipment cooled by the service water system will function as intended and that operators of this equipment will perform effectively. This confirmation should include recent (within the past 2 years) reviews of practices, procedures, and training modules. The intent of this action is to reduce human errors in the operation, repair, and maintenance of the service water system. This confirmation should be completed before plant startup following the first refueling outage beginning 9 months or more after the date of this letter. Results should be documented and retained in appropriate plant records.

Reporting Requirements:

Pursuant to the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f), each licensee and applicant shall advise the NRC whether it has established programs to implement Recommendations I-V of this Generic Letter or that it has pursued an equally effective alternative course of action. Each addressee's response to this requirement for information shall be made to the NRC within 180 days of receipt of this Generic Letter. Licensees and applicants shall include schedules of plans for implementation of the various actions. The detailed documentation associated with this Generic Letter should be retained in appropriate plant records.

The response shall be submitted to the appropriate regional administrator under oath and affirmation under the provisions of Section 182a, Atomic Energy Act of 1954, as amended and 10 CFR 50.54(f). In addition, the original cover letter and a copy of any attachment shall be transmitted to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington DC 20555, for reproduction and distribution.

In addition to the 180-day response, each licensee and applicant shall confirm to the NRC that all the recommended actions or their justified alternatives have been implemented within 30 days of such implementation. This response need only be a single response to indicate that all initial tests or activities have been completed and that continuing programs have been established.

This request is covered by the Office of Management and Budget Clearance Number 3150-0011, which expires December 31, 1989. The estimated average burden is 1000 man-hours per addressee response, including assessing the actions to be taken, preparing the necessary plans, and preparing the 180-day response. This estimated average burden pertains only to these identified response-related matters and does not include the time for actual implementation of the recommended actions. Comments on the accuracy of this estimate and suggestions to reduce the burden may be directed to the Office of Management and Budget, Reports Management, Room 3208, New Executive Office Building, Washington, DC 20503 and to the U.S. Nuclear Regulatory Commission, Records and Reports Management Branch, Office of Information and Resources Management, Washington, DC 20555.

Although no specific request or requirement is intended, the following information would be helpful to the NRC in evaluating the cost of this Generic Letter:

1. Addressee time necessary to perform the requested confirmation and any needed follow-up actions.

2. Addressee time necessary to prepare the requested documentation.

If there are any questions regarding this letter, please contact the regional administrator of the appropriate NRC regional office or your project manager in this office.

Sincerely,

James G. Partlow
Associate Director for Projects
Office of Nuclear Reactor Regulation

Enclosures:
1. "Recommended Program to Resolve Generic Issue 51"
2. "Program for Testing Heat Transfer Capability"
3. "Information Notices Related to Fouling Problems in Service Water Systems"
4. "Operating Experience Feedback Report - Service Water System Failures and Degradations in Light Water Reactors," NUREG-1275, Volume 3
5. List of Most Recently Issued Generic Letters

RECOMMENDED PROGRAM TO RESOLVE GENERIC ISSUE 51

This enclosure describes a program acceptable to the NRC for meeting the objectives of the requested Action I in the proposed generic letter. Both Action I and this enclosure are based upon the recommendations described in "Technical Findings Document for Generic Issue 51: Improving the Reliability of Open-Cycle Service-Water Systems," NUREG/CR-5210, August 1988, and "Value/Impact Analysis for Generic Issue 51: Improving the Reliability of Open-Cycle Service-Water Systems," NUREG/CR-5234, February 1989. The NRC has concluded that Generic Issue 51 will be resolved when licensees and applicants implement either the recommended surveillance and control program addressed in this enclosure or an equally effective alternative course of action to satisfy the heat removal requirements of the service water system.

Water Source Type	Surveillance Techniques	Control Techniques
Marine or Estuarine (brackish) or Freshwater with clams	A	B and C
Freshwater without clams	A and D	B and C

A. The intake structure should be visually inspected, once per refueling cycle, for macroscopic biological fouling organisms (for example, blue mussels at marine plants, American oysters at estuarine plants, and Asiatic clams at freshwater plants), sediment, and corrosion. Inspections should be performed either by scuba divers or by dewatering the intake structure or by other comparable methods. Any fouling accumulations should be removed.

B. The service water system should be continuously (for example, during spawning) chlorinated (or equally effectively treated with another biocide) whenever the potential for a macroscopic biological fouling species exists (for example, blue mussels at marine plants, American oysters at estuarine plants, and Asiatic clams at freshwater plants). Chlorination or equally effective treatment is included for freshwater plants without clams because it can help prevent microbiologically influenced corrosion. However, the chlorination (or equally effective) treatment need not be as stringent for plants where the potential for macroscopic biological fouling species does not exist compared to those plants where it does. Precautions should be taken to obey Federal, State, and local environmental regulations regarding the use of biocides.

C. Redundant and infrequently used cooling loops should be flushed and flow tested periodically at the maximum design flow to ensure that they are not fouled or clogged. Other components in the service water system should be tested on a regular schedule to ensure that they are not fouled or clogged. Service water cooling loops should be filled with chlorinated or equivalently treated water before layup. Systems that use raw service water as a source, such as some fire protection systems, should also be chlorinated or equally effectively treated before layup to help prevent microbiologically influenced corrosion. Precautions should be taken to obey Federal, State, and local environmental regulations regarding the use of biocides.

D. Samples of water and substrate should be collected annually to determine if Asiatic clams have populated the water source. Water and substrate sampling is only necessary at freshwater plants that have not previously detected the presence of Asiatic clams in their source water bodies. If Asiatic clams are detected, utilities may discontinue this sampling activity if desired, and the chlorination (or equally effective) treatment program should be modified to be in agreement with paragraph B, above.

PROGRAM FOR TESTING HEAT TRANSFER CAPABILITY

This enclosure describes a program acceptable to the NRC for meeting the objectives of the requested Action II in the proposed generic letter. Both Action II and this enclosure are based in part on "Operating Experience Feedback Report - Service Water System Failures and Degradations," NUREG-1275, Volume 3, November 1988 and "Technical Findings Document for Generic Issue 51: Improving the Reliability of Open Cycle Service Water Systems," NUREG/CR-5210, August 1988. This enclosure reflects continuing operational problems, inspection reports, and industry standards ("Operation and Maintenance of Nuclear Power Plants," ASME/ANSI OM-1987, Part 2.) The NRC requests licensees and applicants to implement either the steps addressed in this enclosure or an equally effective alternative course of action to satisfy the heat removal requirements of the service water system.

Both the initial test program and the periodic retest program should include all safety-related heat exchangers connected to or cooled by one or more open-cycle service water systems. A closed-cycle system is defined as a part of the service water system that is not subject to significant sources of contamination, one in which water chemistry is controlled, and one in which heat is not directly rejected to a heat sink. (The scope of closed cooling water systems is discussed in the industrial standard, "Operation and Maintenance of Nuclear Power Plants," ASME/ANSI OM-1987, Part 2.) If during the conduct of the total testing program any unexplained downward trend in heat exchanger performance is identified that cannot be remedied by maintenance of an open-cycle system, it may be necessary to selectively extend the test program to the attached closed-cycle system.

Testing should be done with necessary and sufficient instrumentation, though the instrumentation need not be permanently installed.

As a part of the initial test program, a licensee or applicant may decide to take corrective action before testing. Tests should be performed for the heat exchangers after the corrective actions are taken to establish baseline data for future monitoring of heat exchanger performance. In the periodic retest program, a licensee or applicant should determine after three tests the best frequency for testing to provide assurance that the equipment will perform the intended safety functions during the intervals between tests. Therefore, in the periodic retest program, to assist that determination, tests should be performed for the heat exchangers before any corrective actions are taken. As in the initial test program, tests should be repeated after any corrective actions are taken to establish baseline data for future monitoring of heat exchanger performance.

An example of an alternative action that would be acceptable to the NRC is frequent regular maintenance of a heat exchanger in lieu of testing for degraded performance of the heat exchanger. This alternative might apply to small heat exchangers, such as lube oil coolers or pump bearing coolers or readily serviceable heat exchangers located in low radiation areas of the facility.

In implementing the continuing program for periodic retesting of safety-related heat exchangers cooled by service water in open-cycle systems, the initial frequency of testing should be at least once each fuel cycle, but after three tests, licensees and applicants should determine the best frequency for testing to provide assurance that the equipment will perform the intended safety functions during the intervals between tests and meet the requirements of GDC 44, 45, and 46. The minimum final testing frequency should be once every 5 years.

I. For all heat exchangers

Monitor and record cooling water flow and inlet and outlet temperatures for all affected heat exchangers during the modes of operation in which cooling water is flowing through the heat exchanger. For each measurement, verify that the cooling water temperatures and flows are within design limits for the conditions of the measurement. The test results from periodic testing should be trended to ensure that flow blockage or excessive fouling accumulation does not exist.

II. In addition to the considerations for all heat exchangers in Item I, for water-to-water heat exchangers

A. Perform functional testing with the heat exchanger operating, if practical, at its design heat removal rate to verify its capabilities. Temperature and flow compensation should be made in the calculations to adjust the results to the design conditions. Trend the results, as explained above, to monitor degradation. An example of this type of heat exchanger would be that used to cool a diesel generator. Engine jacket water flow and temperature and service water flow and temperature could be monitored and trended during the diesel generator surveillance testing.

B. If it is not practical to test the heat exchanger at the design heat removal rate, then trend test results for the heat exchanger efficiency or the overall heat transfer coefficient. Verify that heat removal would be adequate for the system operating with the most limiting combination of flow and temperature.

III. In addition to the considerations for all heat exchangers in Item I, for air-to-water heat exchangers

A. Perform efficiency testing (for example, in conjunction with surveillance testing) with the heat exchanger operating under the maximum heat load that can be obtained practically. Test results should be corrected for the off-design conditions. Design heat removal capacity should be verified. Results should be trended, as explained above, to identify any degraded equipment.

B. If it is not possible to test the heat exchanger to provide statistically significant results (for example, if error in the measurement exceeds the value of the parameter being measured), then

1. Trend test results for both the air and water flow rates in the heat exchanger.

2. Perform visual inspections, where possible, of both the air and water sides of the heat exchanger to ensure cleanliness of the heat exchanger.

IV. In addition to the considerations for all heat exchangers in Item I, for types of heat exchangers other than water-to-water or air-to-water heat exchangers (for example, penetration coolers, oil coolers, and motor coolers)

A. If plant conditions allow testing at design heat removal conditions, verify that the heat exchanger performs its intended functions. Trend the test results, as explained above, to monitor degradation.

B. If testing at design conditions is not possible, then provide for extrapolation of test data to design conditions. The heat exchanger efficiency or the overall heat transfer coefficient of the heat exchanger should be determined whenever possible. Where possible, provide for periodic visual inspection of the heat exchanger. Visual inspection of a heat exchanger that is an integral part of a larger component can be performed during the regularly scheduled disassembly of the larger component. For example, a motor cooler can be visually inspected when the motor disassembly and inspection are scheduled.

INFORMATION NOTICES RELATED TO FOULING PROBLEMS IN SERVICE WATER SYSTEMS

1. Information Notice No. 83-46: "Common-Mode Valve Failures Degrade Surry's Recirculation Spray Subsystem," July 11, 1983

2. Information Notice No. 85-24: "Failures of Protective Coatings in Pipes and Heat Exchangers," March 26, 1985

3. Information Notice No. 85-30: "Microbiologically Induced Corrosion of Containment Service Water System," April 19, 1985

4. Information Notice No. 86-96: "Heat Exchanger Fouling Can Cause Inadequate Operability of Service Water Systems," November 20, 1986

5. Information Notice No. 87-06: "Loss of Suction to Low Pressure Service Water System Pumps Resulting from Loss of Siphon," January 30, 1987

Enclosure 5

LIST OF RECENTLY ISSUED GENERIC LETTERS

Generic Letter No.	Subject	Date of Issuance	Issued To
89-13	GENERIC LETTER 89-13 SERVICE WATER SYSTEMS PROBLEMS AFFECTING SAFETY-RELATED EQUIPMENT	7/18/89	LICENSEES TO ALL POWER REACTORS BWRS, PWRS, AND VENDORS IN ADDITION TO GENERAL CODES APPLICABLE TO GENERIC LETTERS
89-12	GENERIC LETTER 89-12: OPERATOR LICENSING EXAMINATIONS	7/6/89	LICENSEES TO ALL POWER REACTORS BWRS, PWRS, AND VENDORS IN ADDITION TO GENERAL CODES APPLICABLE TO GENERIC LETTERS
89-11	GENERIC LETTER 89-11: RESOLUTION OF GENERIC ISSUE 101 "BOILING WATER REACTOR WATER LEVEL REDUNDANCY"	6/30/89	ALL BWR PLANTS & ALL LISTINGS APPLICABLE TO GENERIC LETTERS & VENDORS, ETC.
89-10	GENERIC LETTER 89-10: SAFETY-RELATED MOTOR-OPERATED VALVE TESTING AND SURVEILLANCE	6/28/89	LICENSEES TO ALL POWER REACTORS, BWRS, PWRS, AND VENDORS IN ADDITION TO GENERAL CODES APPLICABLE TO GENERIC LETTERS
89-09	ASME SECTION III COMPONENT REPLACEMENTS	5/8/89	ALL HOLDERS OF LIGHT WATER REACTOR OPERATING LICENSES
89-08	ISSUANCE OF GENERIC LETTER 89-08: EROSION/CORROSION - INDUCED PIPE WALL THINNING - 10 CFR §50.54(f)	5/2/89	LICENSEES TO ALL POWER REACTORS, BWRS, PWRS, AND VENDORS IN ADDITION TO GENERAL CODES APPLICABLE TO GENERIC LETTERS
89-07	GENERIC LETTER 89-07, POWER REACTOR SAFEGUARDS CONTINGENCY PLANNING FOR SURFACE VEHICLE BOMBS	4/28/89	LICENSEES TO ALL BWRS, PWRS, AND VENDORS IN ADDITION TO GENERAL CODES APPLICABLE TO GENERIC LETTERS

HEAT EXCHANGER TEST PROGRAM

SYSTEM	HEAT EXCHANGER	IN TEST PROGRAM	TEST TYPE	PERIODIC TEST FREQUENCY	COMMENTS
SALT WATER SYSTEM	Component Cooling Heat Exchangers	Y	I II.B.	I At least quarterly. II.B. At least once per Refueling Cycle.	Test Type II.B. will also be performed prior to and following HX bulleting. Per the recommendation of GL 89-13, periodic test frequencies will be adjusted based on results of testing.
	Service Water Heat Exchangers	Y	I II.B.	I At least quarterly II.B. At least once per Refueling Cycle.	Test Type II.B. will also be performed prior to and following HX bulleting. Per the recommendation of GL 89-13, periodic test frequencies will be adjusted based on results of testing.
	ECCS Pump Room Air Coolers	Y	I III.A. or III.B.	At least once per Refueling Cycle.	Based on the results of initial tests, the appropriate periodic test type will be selected. Per the recommendation of GL 89-13, periodic test frequencies will be adjusted based on results of testing.
	Intake Structure Air Coolers	N	---	---	These coolers do not perform a safety related function. Salt Water flow is isolated on Safety Injection Actuation Signal.

HEAT EXCHANGER TEST PROGRAM

SYSTEM	HEAT EXCHANGER	IN TEST PROGRAM	TEST TYPE	PERIODIC TEST FREQUENCY	COMMENTS
SERVICE WATER SYSTEM	Containment Air Coolers	Y	III.A. or III.B.	*	*Periodic testing will only be conducted if it is shown that a system wide corrosion induced fouling problem exists.
	Spent Fuel Pool Cooling Heat Exch.	Y	II.B.	*	
	Diesel Generator Coolers	Y	II.A.	*	
	Main Turbine Lube Oil Coolers	N	---	---	These Heat Exchangers do not perform a safety function. Service Water flow to these HXs is isolated on a Safety Injection Actuation Signal.
	Main Feed Pump Turbine Lube Oil Coolers	N	---	---	
	EHC Oil Coolers	N	---	---	
	Generator/Exciter Air Coolers	N	---	---	
	Stator Liquid Cooling Heat Exchangers (U-1)	N	---	---	
	Hydrogen Seal Oil Coolers (U-2)	N	---	---	

HEAT EXCHANGER TEST PROGRAM

SYSTEM	HEAT EXCHANGER	IN TEST PROGRAM	TEST TYPE	PERIODIC TEST FREQUENCY	COMMENTS
SERVICE WATER SYSTEM	Aux Feedpump Room Air Coolers	N	---	---	These Heat Exchangers do not perform a safety function. Service Water flow to these HXs is isolated on a Safety Injection Actuation Signal.
	Isophase Bus Duct Coolers	N	---	---	
	Condenser Air Removal Pump Seal Coolers	N	---	---	
	Waterbox Priming Pump Seal Coolers	N	---	---	
	Condensate Booster Pump Lube Oil Coolers	N	--- ---	--- ---	
	Instrument and Plant Air Compressor Coolers	N	---	---	
	Turbine Plant Sample Coolers	N	---	---	
	M/U Demin Vacuum Pump Cooler (U-1)	N	---	---	
	N_2 Compressor After Cooler (U-1)	N	---	---	
	Steam Generator Blowdown Recovery System Heat Exchanger	N	---	---	HX does not remove heat from safety related system/component. HX is safety related for pressure boundary purposes only.

HEAT EXCHANGER TEST PROGRAM

SYSTEM	HEAT EXCHANGER	IN TEST PROGRAM	TEST TYPE	PERIODIC TEST FREQUENCY	COMMENTS
COMPONENT COOLING SYSTEM	Shutdown Cooling Heat Exchangers	Y	II.B.	*	*Periodic testing will not be performed unless it is shown that a system wide corrosion induced fouling problem exists.
	HPSI Pump Seal & Bearing Coolers	Y	IV.B.	*	*Periodic testing will not be performed unless it is shown that a system wide corrosion induced fouling problem exists. Initial testing will verify adequate component cooling flow and the bearing and seal cooler temperatures can be maintained below the design limit.
	LPSI Pump Seal & Bearing Coolers	Y	IV.B.	*	
	Containment Penetration Coolers Main Steam Main Feedwater Letdown RC Sample S/G Blowdown	Y	IV.A.	*	*Periodic testing will not be performed unless it is shown that a system wide corrosion induced fouling problem exists. Initial functional tests will verify that coolers have adequate component cooling water flow and maintain the temperature of the structure below the design limit.
	Reactor Vessel Support Coolers	Y	IV.A.	*	
	S/G Lateral Support Coolers	Y	IV.A.	*	

HEAT EXCHANGER TEST PROGRAM

SYSTEM	HEAT EXCHANGER	IN TEST PROGRAM	TEST TYPE	PERIODIC TEST FREQUENCY	COMMENTS
COMPONENT COOLING SYSTEM	Reactor Coolant Waste Evaporators	N	---	---	These HXs perform no safety related function. Component cooling flow is isolated on Containment Isolation Signal.
	Control Element Drive Mechanisms Coolers	N	---	---	
	Reactor Coolant Pump Seal and Lube Oil Coolers	N	---	---	
	Reactor Coolant Drain Tank Heat Exchangers	N	---	---	
	Letdown Heat Exchanger	N	---	---	These heat exchangers perform no safety related function. They are classified as safety related for component cooling system pressure boundary purposes only.
	Waste Gas Compressor Coolers	N	---	---	
	RCW Degasifier Vacuum Pump Coolers	N	---	---	
	NSSS Sample Coolers RC Sample SG Blowdown Sample MWS Sample	N	---	---	
	Post Accident Sample System Cooler	N	---	---	

HEAT EXCHANGER TEST PROGRAM

SYSTEM	HEAT EXCHANGER	IN TEST PROGRAM	TEST TYPE	PERIODIC TEST FREQUENCY	COMMENTS
COMPONENT COOLING SYSTEM	Gas Analyzer Sample Coolers	N	---	---	These heat exchangers perform no safety related function. They are classified as safety related for component cooling system pressure boundary purposes only.
	MWS Heat Exchanger	N	---	---	
	S/G Blowdown RAD Monitor Sample Cooler	N	---	---	

HEAT EXCHANGER TEST PROGRAM

TEST TYPES

I. Monitor and record cooling water flow and inlet and outlet temperatures for all affected heat exchangers during the modes of operation in which cooling water is flowing through the heat exchanger. For each measurement, verify that the cooling water temperatures and flows are within design limits for the conditions of the measurement. The test results from periodic testing should be trended to ensure that flow blockage or excessive fouling accumulation does not exist.

II.A. Perform functional testing with the heat exchanger operating, if practical, at its design heat removal rate to verify its capabilities. Temperature and flow compensation should be made in the calculations to adjust the results to the design conditions. Trend the results, as explained above, to monitor degradation.

II.B. If it is not practical to test the heat exchanger at the design heat removal rate, then trend test results for the heat exchanger efficiency or the overall heat transfer coefficient. Verify that heat removal would be adequate for the system operating with the most limiting combination of flow and temperature.

III.A. Perform efficiency testing with the heat exchanger operating under the maximum heat load that can be obtained practically. Test results should be corrected for the off-design conditions. Design heat removal capacity should be verified. Results should be trended, as explained above, to identify any degraded equipment.

III.B. If it is not possible to test the heat exchanger to provide statistically significant results (for example, if error in the measurement exceeds the value of the parameter being measured), then

1. Trend test results for both the air and water flow rates in the heat exchanger.

2. Perform visual inspections, where possible, of both the air and water sides of the heat exchanger to ensure cleanliness of the heat exchanger.

IV.A. If plant conditions allow testing at design heat removal conditions, verify that the heat exchanger performs its intended functions. Trend the test results, as explained above, to monitor degradation.

IV.B. If testing at design conditions is not possible, then provide for extrapolation of test data to design conditions. The heat exchanger efficiency or the overall heat transfer coefficient of the heat exchanger should be determined whenever possible. Where possible, provide for periodic visual inspection of the heat exchanger. Visual inspection of a heat exchanger that is an integral part of a larger component can be performed during the regularly scheduled disassembly of the larger component. For example, a motor cooler can be visually inspected when the motor disassembly and inspection are scheduled.