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Regulatory Perspectives on Safety-related Heat Exchanger

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1. Introduction

The Periodic Safety Review (PSR) for Nuclear Power Plants (NPPs) is a comprehensive safety assessment system that is performed to enhance safety by reflecting operational experience and the latest technology development outcomes while preventing safety from being degraded by aging.

In November 2003, the Korea Institute of Nuclear Safety (KINS) issued the safety improvement item of the PSR for Kori-1 nuclear power plant, to implement the management program of safety-related heat exchangers. This program is also being implemented at most of the Korean NPPs reviewed for PSR.

2. Status of US NRC regulation

The US Nuclear Regulatory Commission (NRC) requires that licensees and applicants take effective actions to ensure that their service water systems are in compliance with 10 CFR Part 50, Appendix A, General Design Criteria 44, 45 and 46 and Appendix B, section XI. The latter requires licensees and applicants to establish a test program 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.

On July 18, 1989 the US NRC staff issued Generic Letter (GL) 89-13, "Service Water System Problems Affecting Safety-related Equipment," which recommended that licensees and applicants perform five recommended actions or provide assurance that the heat removal requirements of service water system are satisfied by use of alterative actions or programs. Recommended Action Ⅱ of GL 89-13 requested licensees and applicants to conduct a test program to verify the heat transfer capability of all safety-related heat exchanger cooled by service water.

On April 4, 1990 the NRC issued a supplement to GL 89-13. This supplement contains questions and answers related to GL 89-13. With regard to Recommended Action Ⅱ, this supplement addressed questions relating to testing methods, maintenance of heat exchangers, number of heat exchangers to be tested, frequency of testing or maintenance, inclusion of closed cycle system, etc.

On December 12, 1992 the NRC issued Temporary Instruction 2515/118, "Service Water System Operational Performance Inspection." The Temporary Instruction was issued to guide comprehensive reviews of service water system components and system performance including design requirements; maintenance and performance history ; and implementation of corrective actions at licensed nuclear facilities.

On January 11, 1994 the NRC issued Information Notice 94-03, "Deficiencies Identified during Service Water System Operational Performance Inspections." This information notice alerted licensees to deficiencies identified by the NRC during several pilot inspections.

In March 1998, Electric Power Research Institute (EPRI) reported the final report (TR-107397, "Service Water Heat Exchanger Guidelines") to provide engineers with guidance for performing heat transfer tests on service water cooled heat exchanger. Nowadays, most of American licensees and applicants are performing this test program according to the EPRI report (TR-107397).

3. Problems of heat exchanger

The results of the study, which were published in NUREG-1275, indicated that out of 980 operational events involving service water reported from 1980 to 1987, the majority of the events with generic safety significance (58%) involved system fouling ; the fouling mechanisms included corrosion and erosion (27%), bio-fouling (10%), foreign material and debris intrusion (10%), sediment deposits (9%), pipe coating failure and calcium carbonate deposits (1%), and the others (1%).

4. Increasing the temperature of cooling water

Generally speaking, the heat exchangers of Korean NPPs were designed in sea water of 26-29℃. Nowadays, the temperature of cooling sea water keeps rising. The reasons of the phenomenon are as follows.

Global warming called greenhouse-effect means the average temperature of the earth keeps rising. In the Korean east sea, the temperature of the surface sea water rose about 1.3℃ from 1968 to 2007, which was based on the data that was reported on November 5, 2008 by National Fisheries Research & Development Institute.

There are more than four units in one NPP site. The more units there are at one site, the higher the temperature of the surface sea water will rise near the NPP.

5. Acceptance criteria for test results

In advance, KINS will make a special request that licensees and applicants check four items recommended

in KEPIC 2000 MOF 3410 ; system flow, head, thermal capacity and overall heat transfer coefficient on safety-related heat exchanger. The system tolerances in Table 1 may be used for the acceptance criteria for the heat exchanger test results. In addition, we shall check the allowable differential pressure on heat exchanger in order to confirm the design criteria of cooling water system.

Table 1. System tolerances

System design parameters	Allowable tolerance range
System flow	+10%
Head	+10%
Thermal capacity	-10%
Overall heat transfer coefficient	-10%

6. Conclusion

The heat exchangers of the Korean NPPs were designed in cooling sea water of 26-29℃. Nowadays, the temperature of cooling sea water keeps rising.

Accordingly, KINS will request that licensees and applicants check the four items recommended in KEPIC 2000 MOF 3410 ; system flow, head, thermal capacity and overall heat transfer coefficient on safety-related heat exchanger. In addition, we shall check the allowable differential pressure on heat exchanger in order to confirm the design criteria of cooling water system.

REFERENCES

[1] US NRC Generic Letter (GL) 89-13, “Service Water System Problems Affecting Safety-related Equipment”
[2] US NRC Temporary Instruction 2515/118, “Service Water System Operational Performance Inspection” (1992.12.12)
[3] US NRC Information Notice 94-03, “Deficiencies Identified During Service Water System Operational Performance Inspections” (1994.1.11)
[4] Electric Power Research Institute (EPRI) TR-107397 “Service Water Heat Exchanger Guidelines” (1998.3)
[5] KEPIC MOF 3410 (2000)