Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 25-26, 2007

Long Term Asset Management (LTAM) Strategy for Feedwater Heater at Kori 3 & 4 Nuclear Power Plants

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1. Introduction

As the electric power industry becomes more competitive, Long-Term Asset Management (LTAM) strategy of systems, structures, and components (SSCs) becomes more important to keep nuclear power plants economically viable throughout their remaining licensed operating terms, whether 40 or 60 years. This paper provides an optimized LTAM plan for the feedwater heater at Kori 3&4 nuclear power plants.

2. Procedures

Based on Life Cycle Management(LCM) sourcebook, LCM implementation guide conducted by EPRI, and Exelon's LTAM strategy, LTAM plans are implemented for providing early identification and reduction of risks and vulnerabilities to power production from long-term aging degradation and obsolescence that may not be addressed by existing plant programs.

The Long Term Asset Management (LTAM) process is intended to provide an effective long-term planning tool for minimizing unplanned capacity loss and optimizing maintenance programs and capital investments consistent with plant safety and an identified plant operating strategy. Such an operating strategy might include license renewal or retaining the option for license renewal. LTAM plan addresses such issues that are aging management, preventive maintenance, technical obsolescence, and the replacement or redesign of an SSC important to safety and plant operation. Therefore, LTAM planning is a variable process to systematically identify and examine the important SSCs, optimize their contribution to plant performance, reliability, safety, and value, and prepare long-term maintenance management plans through the technical and economic evaluation.

2.1 Basis for Selection of Feedwater Heater for LTAM Planning

Basis for selection of feedwater heater are that feedwater heaters are important to power production and plant efficiency, and are subject to significant operating stress and degradation. Also, they have a history of chronic maintenance problems and improvements in feedwater heater operation directly affect the plant thermal cycle.

2.2 Feedwater Heater Function and Scopes

The purpose of the feedwater heating system is to increase plant thermal efficiency by preheating the condensate/feedwater prior to its entering the steam generator. The system is comprised of various components and controls, which provide the following functions.

- Maintain proper water levels in the feedwater heater and drain for maximum efficiency of the system
- Supply heating steam to the feedwater heaters
- Provide a flow path for the return of the condensed extraction steam drains to the feedwater and condensate system
- Allow collection from all feedwater heater drains
- Prevent the entrapment of non-condensable gases

The feedwater heaters contain a number of sub-components including tubes, tubesheets, baffles, shields plates (or impingement plates), tube tie and spacers, tube supports, the drain nozzles, and the steam inlet and outlet nozzles. The scope of this paper includes only the passive mechanical components and sub-components of nuclear plant feedwater heaters such as shell, tubes, tube support and impingement plate:

2.3 Operating and Maintenance Experience

The environments and operating conditions in which feedwater heaters operate can cause significant problems such as fatigue, erosion, corrosion, cracking, and vibration. If not properly monitored, inspected, and maintained, the feedwater heaters will incur damage over time, causing a negative impact to plant efficiency.

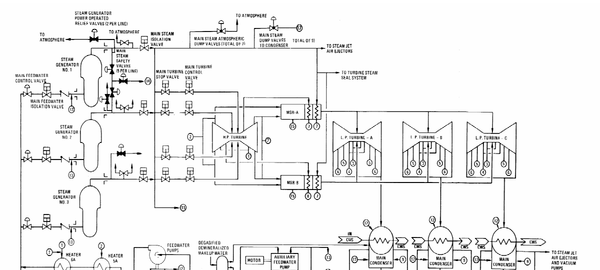

Figure 1. Basic outline of plant feedwater heater arrangement at Kori 3 & 4.

From EPRI 1003470, 29 incident event items pertaining to the feedwater heater are presented. Of these events:

- Seventeen events (59%) involved inspection and disc overy of shell thinning (near the nozzle inlet area)
- Nine events (31%) involved tube leakage
- Two events (7%) dealt with manways and gaskets
- One event (3%) dealt with partition plate repairs

The operating history for the feedwater heater was assembled from the plant's scram and trip reports, and operating and maintenance experience report for the year 2003-2006 at Kori 3 & 4. The event causing plant's scram and trip is not reported. But, there are two event reports addressed by operating and maintenance experience. Plant-specific events by operating and maintenance experience are presented as in Table. 1.

Table 1. Plant events database information on feedwater heaters at Kori 3 & 4

Date	Event Description	PD or FD
2004-09-16	High level alarm is occurred at LP Heater 1A for normal operation. Through derated maintenance, one LP Heater string is isolated. Then, five damaged tubes are found at LP Heater 3A. After ECT inspection, 28 tubes are plugged.	FD
2005-09-04	During a maintenance outage, HP Heater 6A shell was disassembled and inspected inside internal instrument. Due to un-installing impingement plate, six tubes and tube support plate are damaged by high-temperature and pressure steam.	PD

* Note : PD-Planned Derate and FD-Forced Dereate

2.4 Determination of Current Maintenance Activities

Most of the preventive activities are performed during a refueling outage. These are applied for the determination of appropriate Preventive Management (PM) frequencies, taking into account the past operating experience, feedback from the craft, safety and non-safety service, cyclic duty and environment as well as the refueling cycle. At the end of last year, KHNP made PM Template to maintain efficiently the integrity of components and systems based on recommendation of EPRI and Exelon. This PM Template is classified into three categories which include critical, duty cycle, and service condition of Kori 3&4 Functional Important Determination (FID). Table 2 shows the template of the current preventive maintenance activities. For performance monitoring, it is conducted to monitor decreasing performance occurred by corrosion, erosion, tube crack, scale or deposition impurity and to analyze trending of Terminal Temperature Difference, TTD. For NDE inspection, it is implemented to investigate the internal and external erosion, tube scale, tube crack or tube defection, inlet nozzle condition of shell, shell wall thinning using ECT, PT, UT, and VT. Lastly, operator's round include activities like connection, external leakage sense, operating parameters, level, and drain flow rate surveillance. Also, tube damage and internal leakage are inspected for prohibiting decreasing of heat transfer area caused by dust, corrosion, and damage.

2.5 *LTAM Strategy*

Major failure mechanisms of FW Heater are tube erosion, shell thinning, and impingement plate damage by tube-and-tube collision, fretting, support plate fault steam erosion, FAC, improper impingement plate installation plate installation.

The maintenance and monitoring condition of FW Heater generally retain good shell thickness condition at Kori 3 & 4. But, currently, tube plugging rate for LP #4B of Kori 3 unit and LP #4C of Kori 4 unit is 8.1% and 8.4%, respectively and is approaching to 10 % plugging rate which is a plugging limit. Therefore, Long & Middle Facility Investment plan should be scheduled for monitoring continuous condition and replacing the FW Heaters. For preventing FW Heater failure, the proper re-tubing and re-bundling plan with erosion resistant shell and tube material is required and the whole replacement plan of FW Heater is considered referring to an expected FW Heater lifetime that is approximately 20 years less than overall plant lifetime. In the near future, LTAM strategy alternative will be driven to a large extent by the plant operating strategies that are being followed or evaluated, and by the current reliability of the FW Heaters. Then, through the economic evaluation using the net present value (NPV), the optimum LTAM strategy will be identified.

Table 2. PM template for the feedwater heater at Kori 3 & 4

Rev.	0	PM Template							Main Class.	Heat Exchanger
Rev. Date	06.12.31.								Code	HEFW
Functional Importance Determination (FID)									Feedwater Heater	
Critical	Critical				Minor					
Duty Cycle	High	Low	High	Low	High	Low	High	Low		
Service Condition	Severe		Mild		Severe		Mild			
PM TASK	CHS	CLS	CHM	CLM	MHS	MLS	MHM	MLM		
Condition Monitoring Task										
Performance Monitoring	1M	-	1M	-	-	-	-	-	EPRI, Exelon	
NDE Inspection	6Y	-	12Y	-	-	-	-	-	Exelon	
Operator 's Walkdown	1S	-	1S	-	-	-	-	-	EPRI	
Time Directed Task										
Internal Inspection	6Y	-	12Y	-	-	-	-	-	Exelon	
F ailure Finding Task										
Applied to HP Heater to CHS and Applied to LP Heater to CHM based on FID										

3. Conclusions

The approach to improving the long-term asset management and long-term condition of FW Heaters are summarized as follow based on the economic evaluation in the near future.

- Plan replacement by considering tube plugging limit, a measurable effect on thermal performance, and tube experiencing a failure mechanism.
- Require the use of FAC and erosion resistant material of shell and tube.
- Develop monitoring the condition of the heater such as NDE inspection using PM Template.

REFERENCES

[1] EPRI, Feedwater Heater Maintenance Guide, 1003470, May 2002
[2] EPRI, Life Cycle Management Sourcebook – Volume 10 : Feedwaters, 1009073, December 2003.
[3] EPRI, Life Cycle Management Planning Sourcebook – Overview Report, 1003058, December 2001.