Development of aging management standard guidelines for HVAC facilities of NPPs in Korea

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1. Introduction

The air conditioning facilities consisting of a variety of systems and equipments aim at controlling the thermal load of each building, establishing a pleasant work environment and preventing radioactive contamination in order to ensure a safe nuclear power plant through the ventilation, cooling/heating and air conditioning functions for all the buildings within the plant. Inspection and maintenance activities for air conditioning facilities within the plant are managed mainly for active facilities, and as the years of operation pass, a method for detecting in advance aging-related integrity problems of passive facilities and taking necessary measures against them is required.

Therefore, this paper establishes a standard aging management guideline for air conditioning facilities by selecting systems for which those facilities are to be managed, analyzing degradation mechanisms and reviewing the current status of aging degradation management.

2. Scope and analysis of degradation mechanisms

2.1 Scope

Targets for aging degradation management of air conditioning facilities are safety related systems and non-safety related systems which may have impact on safety. Quality grade Q classified as safety related and A classified as safety impact related have been selected as management targets according to the quality assurance rules, and facilities which have been indicated/recommended by the periodic safety review and process and filter radioactive contaminants to ensure public health and safety and those for which related areas maintain differential pressure compared with the surrounding areas to prevent contaminants from spreading have been additionally selected. As a result, air conditioning systems of radioactive waste buildings and machine shops have been additionally included.

2.2 Analysis of degradation mechanisms

For the selected systems and equipments, 21 aging degradation mechanisms have been reflected by considering the mechanisms according to the classification of ASME Section III appendix W and the characteristics of air conditioning facilities. The following aging degradation mechanisms have been drawn according to the analysis on the aging degradation mechanism of air conditioning facilities, According to the analysis, mechanisms which may occur in air conditioning facilities include general corrosion, pitting, crevice corrosion, erosion-corrosion, wear, MIC, stress relaxation, fouling, rupture, elastomeric deterioration and crack at the duct welding

3. Review of plant status and environment

3.1 Current status of aging degradation management

According to the review on the current status of aging degradation management for air conditioning facilities of nuclear power plants, it has been found that fan bearings are checked by the vibration inspection procedure and air conditioning units are managed by the internal leak test and performance inspection. Fire dampers are managed through visual inspection and performance inspection, and other air conditioning facilities are checked in advance for degradation impacts through the site inspection for the system. However, it has been found that as the detailed inspection list and inspection details are not documented for each part, trend analysis is not possible and aging degradation management is to be performed for each detailed part to optimize the management of aging degradation.

3.2 Addition of aging degradation management targets

It has been found that although each power plant has established procedures, etc. for site inspections, tests, etc. related to the operational performance of air conditioning facilities, detailed inspection procedures or lists, check points, etc. have not been prepared for parts where impacts of aging degradation are expected in the long run, which makes it impossible to perform trend analysis for aging degradation and quantitatively prove integrity. Therefore, it has been confirmed that analysis for air conditioning facilities in the entire nuclear power plant and quantitative identification of trends are required by performing internal and external visual inspection for those facilities. It has been also confirmed that site inspection is to be performed basically for additional equipments such as fans, filters, dampers, ducts and coils, and the air cleaning/conditioning units are also to be classified as additional equipments for inspection.

3.3 Review of forms and environments

Aging degradation management forms to be applied within the plant for air conditioning facilities divided into components such as fans, dampers, ducts and air conditioning units have been drawn, and for each additional equipment, degradation mechanisms and environments have been examined through detailed classification.
Minor units which compose air conditioning facilities are fans, filters, charcoal filters, coils, ducts and dampers. Materials /environments and mechanical properties have been also reflected to identify the sign of aging degradation for additional equipments during long-term operation and classify management forms. Bearings and filters have been excluded from this review as they are periodically monitored and immediately corrected in case of problems, and the filter frames and gaskets at the interface contacting active parts have been included.

4. Development of HVAC standard guideline

For the aging degradation management of air conditioning facilities, additional equipment-specific forms and degrees of degradation have been classified for recording and periods(each period, every third period, every six period) have been selected for the performance of inspection in order to identify the progress and degree of degradation during the next inspection and modify and apply the initially set period according to the accumulated results of degradation inspection, which makes it possible to optimize the procedure of degradation management.

The major inspection method for aging degradation impacts is visual inspection, and evaluation grades have been classified into Grade I (little or no degradation of the plating film), Grade II (a little degradation of the plating film, but it does not have a large impact on performance as it is due to the galvanic corrosion of the film) and Grade III (severe degradation of the film).

Inspection periods are changed and applied according to the surface status of the inspection targets, and selection criteria for inspection periods conform to the grade of degradation of each standard degradation form Acceptance criteria of surface monitoring is that according to the results of visual inspection, the surface of target equipments shall have no damaged or fallen coating, corrosion, wear, crack, breakaway, sign of leak or have good physical status, and judgment on degradation grades for aging degradation forms of ducts(galvanized steel sheet) such as lift defect, rust, crack, delamination and wear and determination of evaluation grades (Ⅰ, Ⅱ, Ⅲ) conform.

If inspection results do not satisfy acceptance criteria or impacts on the physical status of equipments are expected later, corrective measures such as the replacement of corresponding facilities, establishment of action plans and adjustment of visual inspection periods shall be performed. Corrective measures shall satisfy Nuclear Safety and Security Commission Notice No. 2012-17(Nuclear Reactor.026).

5. Conclusions

This paper has established a standard guideline for systematically performing the aging degradation management program for HVAC facilities by classifying and regrouping the configuration of various HVAC facilities for nuclear power plants.
According to the review of additional equipment-specific aging degradation mechanisms and the current status of management to apply the aging degradation program to air conditioning facilities, it has been found that internal and external visual inspection procedures for fans, dampers, coils, filters and housings have to be added.
It has been confirmed that among additional equipments, fire dampers, fan bearings and belts and air cleaning/conditioning units with charcoal filters do not require additional inspection as they are periodically inspected. It has been found, however, that air cleaning/conditioning units without charcoal filters are to be inspected along with fans, ducts and coils.
According to the review of applicability to the aging degradation management program, it is expected that the integrity of air conditioning facilities within nuclear power plants can be maintained through the systematic aging degradation management procedures by periodically performing and maintaining the details as shown in Table 1 within the program.

REFERENCES

[1] U.S. Nuclear Regulatory Commission, NUREG-1800, Rev.2, Standard Review Plan for Review of License Renewal Applications for Nuclear Power
[2] U.S. Nuclear Regulatory Commission, NUREG-1801, Rev.2, Generic Aging Lessons Learned(GALL) Report, 2010.12

Table 1. Visual inspection of selected HVAC components

Item	Location inspected	Parameter inspected	Selected reason
Fan	-internal/external surface -connecting gasket	-fresh air suction fan -fan status of rear AHU	Aging occurrence possibility of AHU - exposing to the fresh air situation or directly suctioning , material - internal/external duct dewfall appearance at the rear area of cooling coil and AHU -humidity incoming to the internal duct - scattering of condensating water in cooling coil
Damper	-internal/external frame -blade surface -connecting gasket	-fresh air induction area - humidity environment of rear AHU	
Duct	-internal/external surface -connecting gasket -welding area -access gate	-fresh air induction area - humidity environment of rear AHU	
Coils	-external surface -frame surface	-condensating water environment of cooling coil	
Filter	-frame external surface -frame gasket	-filter gasket and deformation of frame	
Housing	-internal/external surface -connecting area gasket -bolting area gasket	-corrosion environment	