# Current Status and Activity for In-service Coating Monitoring Program in Korean Operating Nuclear Power Plants

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**ABSTRACT**

Though the construction of Ul-jin Nuclear Power Plants Units 3&4 were built as Korean standard Nuclear Power Plants(KSNP) in 1998, the production and design independency of nuclear coatings were carried out in the late of 1980s beginning with Yong-gwang 3&4 in accordance with the national policies to utilize local technologies in Korea. Since then, the quality control for the design and construction of nuclear coatings has been performed using local technologies and materials. However, it appears that the quality control levels in the operating Nuclear Power Plants have not reached such levels applied to KSNP's construction stage. The importance of quality control of nuclear coatings has being issued being recognized as an important safety factor in the operating NPPs. The Reg. Guide 1.54, Rev.1[1] which has been revised in 2000 requires establishing the coating inspector's education and training program, coating personnel's qualification and certification procedures, the repair-ability test procedures, the coating history survey for the coating condition's monitoring and assessment for maintaining the in-service integrity of the nuclear coating. Therefore, nuclear coating industry in Korea has to make additional activities to improve quality of the in-serve nuclear coatings.

## INTRODUCTION

This paper illustrates the present condition of the program to monitor the coating integrity achieved in Korean operating NPPs and various activities performed by organizations related to the industry for improving the quality of the nuclear coating. Solutions and additional plans to perform the in-service coating monitoring program are also suggested in this paper.

### In-Service Coating Monitoring Program

Since the first commercial operation of Ko-ri Unit 1 with the capacity of 58.7 MW in April 1978, 20 nuclear power plants have been operated in Korea. In addition, 4 new nuclear power plants with the capacity of 1000 MW are under construction, and 2 new nuclear power plants named as Shin-Ko-ri Unit #3 & 4 with the capacity of 1400 MW are being designed. The coating quality of instruments and structures was controlled in accordance with ANSI N101.4[2] which had been documented in 1972. The Guidance for maintenance and monitoring of safety-related protective coatings during operation has not been clearly indicated in the ANSI regulations, so the safety-related protective coatings have been maintained by qualified applicators and inspectors with insufficient quality assurance.

The Reg. Guide 1.54 (Rev.1) for safety-related protective coatings has been revised and was published in 2000 and USNRC GSI-191[3], "Assessment of Debris Accumulation on PWR Sump Pump Performance" was published in connection with quality assurance for the safety-related protective coatings in 2001. After that, the maintenance and monitoring program for safety-related protective coating in operating nuclear power plants has been actively studied by Architect/Engineer's Technology Development Task[4], etc. The differences between regulation of Guide 1.54 (Rev. 0) in 1972 and Reg. Guide 1.54 (Rev. 1) in 2000 are as follows:

1. As the coating process is classified as a special process, the work of safety-related protective coating shall be accomplished by coating applicators and specialists according to the enforced code & standards. The specialists shall be trained theoretically and technically according to the qualification procedures set up by the persons who have the specialties in coatings.

2. In connection with the maintenance and monitoring of the coating conditions in operating nuclear power plants, the supervising activities shall be performed by procedures and by specialists according to the related code & standard under the management program. The quality of safety-related protective coating in operating nuclear power plants can be enhanced with managerial attentions. It is essential to make sure of the safety of coating to carry out the efficient coating process and to accomplish maintenance and monitoring program for assuring coating quality. In this article, the various activities in Korea concerning "Establishing Procedures to monitor Performance of Coatings in NPPs" in ASTM D5163[5] will be described in detail.

## ACTIVITIES IN KOREA

The quality assurance of the safety-related protective coatings can be performed with the adequate combination of proper materials, surface treatments, application, inspection, personnel, procedures and documentation. For high quality of safety-related protective coating in nuclear power plants, the following is needed.

- History investigation
- Radiation related examination
- Training and qualification of coating related manpower
- Reliability verification examination for maintenance and monitoring
- Periodic condition investigation and evaluation
- Management of quality related coating documents

### Corrosion Science Society of Korea (CSSK)

CSSK was founded in 1971, for the purpose of the exchange of knowledge and information about corrosion and protective activities to promote the related industry's technology. Its English journal "Corrosion Science and Technology" is published 6 times in a year and also 2 times in a year in the Korean journal "Corrosion and Protection". CSSK offers the regular education course to diffuse the knowledge and information about corrosion annually. This society is currently doing a national project to obtain the database of the level of corrosion in regional and industrial structures from 2006 under the name of "Corrosion Survey". The related corrosion information of nuclear power plant coating engineers can be obtained by the corrosion seminar which is similar to "Basic Corrosion" hosted by NACE Int. in the US.

Fig. 1 : "Corrosion" training Course in CSSK


Fig. 2 : Experiment for corrosion theory in CSSK

### Korean Association of Coating Engineers (KACE)

KACE was founded in 1999 to enhance the coating quality of general industrial facilities like ships and bridges. KACE mainly trains the testing manpower for coating and it has been qualified to train and educate the special personnel. The training course has basic, intermediate and advanced courses offered to coating inspectors. Also, the different educational courses for Korean ship construction industry, such as FROSIO, have been offered. KACE issues its own certificate to the trainees who accomplish each curriculum for coating inspectors and FROSIO coating work inspectors.

It hosts the coating symposium every year. It takes charge of a role in exchanging coating technical intelligence in Korea. In 2004, it trained 302 persons in the basic classes for coating inspectors, in intermediate and advanced classes, 79 inspectors and 68 inspectors, respectively, the total of 41 persons have been certified as KACE coating inspectors[6].

Coating inspectors who have only KACE certificate or FROSIO coating inspector certificate are not able to perform the coating investigation for Korea nuclear power plant, because some parts of essential training curriculum that is provided in ASTM D5498[12] are left out of KACE inspector training courses.

Fig. 3 : Measurement of Coating Dry Film Thickness

Fig. 4 : Shop training for the Field Coating Inspection

**Korea Coating Experts Society (KOCES)**

KOCES was founded in 2005, for the purpose of exchanging knowledge and information about coating and cultivation coating experts to promote the related industry. Training courses for the coating work inspectors by KACE contains general coating techniques and inspection skills. However those are somewhat insufficient to the safety-related special protective coatings in nuclear power plants.

To complement the insufficiency of nuclear coating technologies in the KACE training program, KOCES separately operates the training program of coating work inspector for nuclear power plants and safety-related protective coating techniques in terms of quality assurance.

It is a fundamental process for the qualification of coating work inspector in nuclear industry to confirm the coating inspectors qualified by both KACE and KOCES. In addition, it operates the program for the coating applicator qualification according to ASTM D4227[7] and ASTM D4228[8].

Fig 5. : Coating Applicator's Exam. for Concrete Surfaces

Fig 6. : Coating Applicator's Exam. for Steel Surfaces

The association has been manufacturing samples and testing for coating applicator qualification management which are required by the two code & standards mentioned above to confirm the ability of the coating applicator. Through those activities, the association offers an efficient method to educate coating applicators in nuclear power plants. Also, this association accomplishes the works for condition monitoring and evaluation like Radiation test and the DBA to assure coating reliability verification in nuclear power plants which are currently being operated in Korea.

**Korea Power Engineering Co., Inc. (KOPEC)**

KOPEC is a company which has been designing nuclear power plants in Korea as a total A/E. The company has been performing the design of safety-related protective coating and technical evaluation business. The company has the experiences of the condition investigation, evaluation and reliability verification of coating. KOPEC has also coating specialists according to the EPRI TR-109937 and ASTM D7108-05.

The technical independence in the coating design has been established since Yong-gwang Unit #3 & 4 which were constructed prior to Ul-jin Unit #3 & 4. The coating design with its own technology was applied to new nuclear power plants under construction. Also, KOPEC has been developing the maintenance and monitoring program for safety-related protective coating of nuclear power plants. It accumulates abundant database and related documents such as DBA test results and other testing results. In addition, KOPEC recently carried out a radiation test, DBA test, contact angle test, adhesion test and EIS test in relation to the aging of phenolic epoxy coating system over inorganic zinc primer. It analyzes the physical changing course of inorganic zinc and phenolic epoxy resin through the radiation examination. In addition, KOPEC started studying the reason of coating fault analytically and has carried out various tests to analyze degradation of epoxy coating caused by aging acceleration effects as well.

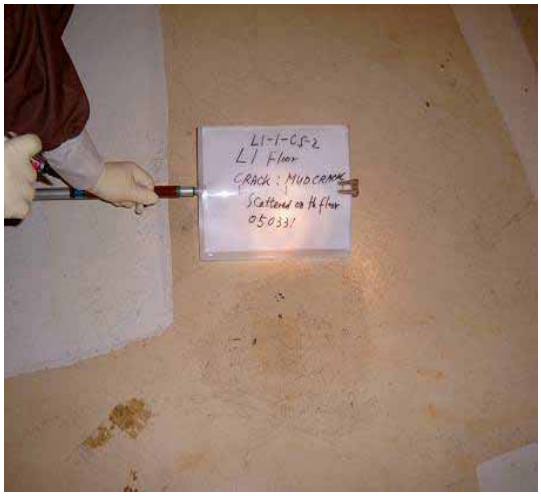


Fig 7. : Investigation of the coating condition-1

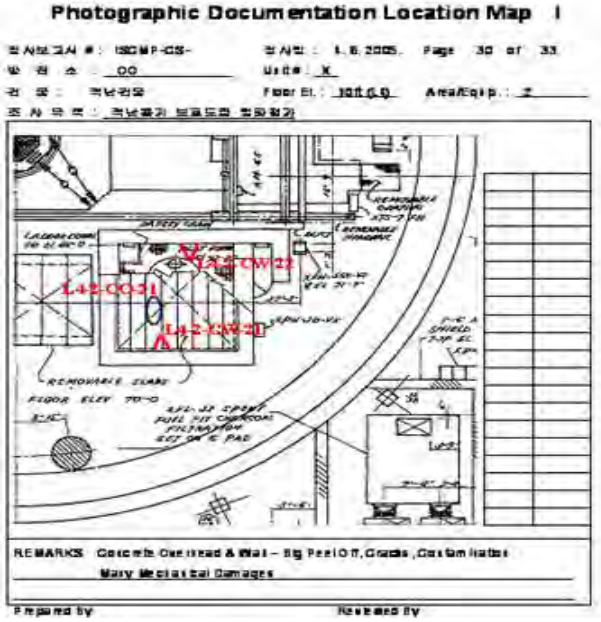


Fig 8. : Photographic Documentation Location Map

**Korea Electric Power Industry Code (KEPIC)**

KEPIC was founded in 1987, as part of standardization in the policy of Ministry of Commerce, Industry and Energy and of the Ministry of Science and Technology. To assure security and reliability of electric power industry equipment, the machinery has been developing detailed code & standard for execution and inspection. It arranges regular meetings for coating engineers of nuclear power plants with running nuclear protective coating division under the structure committee. Those are the activities for enhancing quality of safety-related protective coating in nuclear power plants.

**Korea Hydro & Nuclear Power Co., Ltd. (KHNP)**

KHNP has been managing 20 nuclear power plants in Korea. It also controls the quality assurance of safety-related

protective coating by Reg. Guide 1.54 (Rev.1) for four other nuclear power plants which are under construction.

Also, the company has been qualified coating applicators according to ASTM D4227, ASTM D4228 and coating inspectors be trained and qualified according to ASTM D4537[11] and ASTM D5498[12] . By these means, it assures that special coating works should be done by qualified expert. It also accomplishes the coating condition investigation and history evaluation of the long haul in operating nuclear power plants by ASTM D5163[13]. KHNP recently starts separately reliability verification examinations for the repaired coating systems of old nuclear power plants.

**Miscellaneous**

The DBA test has been accomplished in accordance with ASTM D3911[14] as a part of the qualification test of safety-related protective coating. The test agencies which have the autoclaves for this examination are KIMM (Korea Institute of Machinery & Materials), KEPRI (Korea Electric Power Research Institute) and KCC (Korea Chemical Corp.).

Using their own radioactive source, KAERI (Korea Atomic & Energy Research Institute) carries out official certification examination for radiation tolerance of safety-related protective coatings according to ASTM D4082[15] .

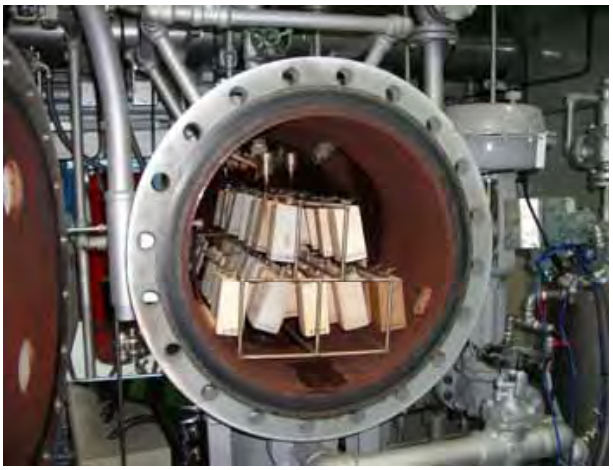

Fig. 9 : Autoclave for the DBA Test

**CONCLUSIONS**

As previously described, various activities have been carried out by Korean nuclear industry for improving the quality assurance of coatings which has been neglected in the past. The quality assurance of safety-related protective coating in nuclear power plants can be attained by verified process and qualified human resources. For quality enhancement, consequent research and investment will be continued in the future in relation to the following areas:

- History investigation and database construction for structure and equipment coatings in operating nuclear power plants
- Establishing a management system of the records of domestic coating qualification tests and database construction
- Improving coating technology by periodical meeting with nuclear power plant coating experts
- Developing In-Service Coating Monitoring Program (ISCMP) apposite to the Korean case
- Developing Code & standard of Korean style safety-related nuclear coatings
- Developing test methods for quantitative analysis of coating aging result

Apart from performance verification of safety-related protective coating in accordance with ASTM code & standard, the research of natural performance degradation in long term period will be done. In the research, EIS (Electrochemical Impedance Spectroscopy) or FIB-SEM (Focused Ion Beam-Scanning Electron Microscopy) will be introduced and a change of physical properties like adhesion property over a long term period will be correlated with the research in the Ko-ri Unit #1. With such activities, quality enhancement of safety-related protective coatings in operating Korean nuclear power plants will be continued.

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