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Research Program on Corrosion of Secondary Pipes in PWRs

Seong Sik Hwang, Kyung Mo Kim
Nuclear Materials Research Division, Korea Atomic Energy Research Institute,
1045 Daedeog-daero, Yuseong-gu, Daejeon, 305-353,
sshwang@kaeri.re.kr

1. Introduction

A lot corrosion degradation of carbon steel pipings due to flow accelerated corrosion(FAC) or erosion corrosion(EC) in PWRs has been reported around the world. This problem led to costly outages or replacement at many plants. It also caused concern about integrity of the plants. A pipe-rupture accident in a secondary system at Surry Unit 2 occurred in 1986. USA has a management procedure under the cooperation of the industry and NRC. Japan has a guideline of PWR utilities from 1990. Another accident, however, occurred at Mihama unit-3 in 2004[1]. A secondary piping ruptured and high temperature secondary cooling water flowed out, so the reactor shut down automatically. Some Korean plants have been suffered from similar corrosion problems in secondary pipes of PWRs.

The objective of the present work is to review of the FAC and to find controlling parameter to combat the corrosion mechanism. The review result will be utilized for essential key parameters to develop an evaluation facility for better understanding of the corrosion mechanism.

2. Case study

2.1 Secondary piping rupture at Mihama unit-3

An accident occurred at Mihama unit-3 in 2004[1]. A secondary piping ruptured and high temperature secondary cooling water flowed out, so the reactor shut down automatically.[2] The accident was one of so called secondary piping rupture accidents of a

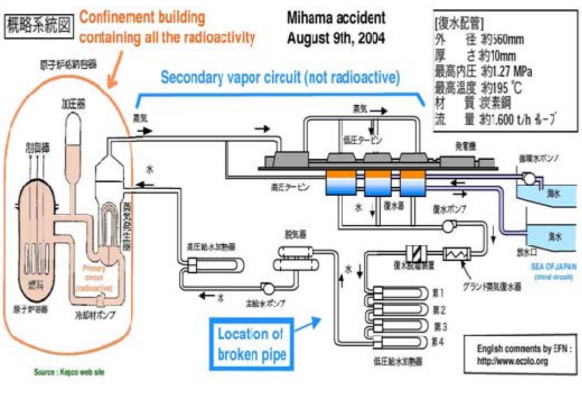

Fig. 1 Major system of PWR and the ruptured area of Mihama-3.(From KEPCO website)

pressurized water reactor (PWR). The accident resulted in a serious consequence that was unprecedented at a nuclear power plant. That is, of the workers working in the turbine building, 5 were killed and 6 were injured.

The inspection result confirmed a fracture opening in the ruptured portion, which extended a maximum of 515 mm in the axial direction and 930 mm in the circumferential direction of the pipe, and 0.4 mm at the thinnest portion of the pipe.

The cause for the pipe rupture in question was estimated to be so-called erosion/corrosion, which has gradually reduced the pipe wall thickness with the lapse of operation time. At last, the pipe strength became insufficient and the pipe ruptured under the load during operation.

Main parameters of the rupture event were (1) Orifice downstream piping, Material: JIS G3103 SB42, (2) Flow rate about 1,700 t/h, Pressure about 0.93 MPa (10 kgf/cm2), Temperature of 142°C, Flow velocity about 2.2 m/sec, (3) Operation time about 185,700 hours (4) Water chemistry of pH: 8.6 to 9.3, dissolved oxygen concentration less than 5 ppb.

A special task group for pipe wall thinning issues was established under the Main Committee on Power Generation Facility Codes (MC-PGFC) in 2004 [3]. The objective in establishing the rule was to lessen or to remove the risk of pipe rupture caused by pipe wall thinning. The rules for PWR and BWR are completed in 2006. MC-PGFC completed the road map for the R&D studies to support the technical rules in 2007.

2.2 EU programs for FAC prevention [4]

Effective measures to reduce FAC effects in EU programs were (1) Optimizing the water chemical treatment, (2) Apply improved material concepts for replaced components or lines and/or sufficient wall thickness margins, (3) Apply qualified repair technologies. In case of changes in system operation

Fig. 2 Six parameters form the columns of an effective FAC program(AREVA COMSY program)[4].

conditions (e.g. power uprate) the effect on FAC degradation rates should be analyzed before implementation and appropriate precautions should be initiated.

2.3 Korean program and plans for FAC research in KAERI

KEPRI has a Thinned Pipe Management Program to find out the locations within the secondary piping systems.[5] The objectives of the program are to provide criteria for thickness measurement, wear calculation, to reduce the possibility of unexpected failure of piping system and/or unplanned shutdown.

Seoul National University has developed Wall thinning screening system (WalSS). The main feature of the system is to develop a wall thinning measurement technique by using traditional DCPD. The technique adopted an equipotential switching DCPD method (ES-DCPD) for eliminating of leakage current and sensor interference. The research team demonstrated the performance of the DCPD technique by using SNU FAC Dry Test Loop (DRYTEL). Fig. 3 is an example of the comparison result of ES DCPD with wall thing rate of carbon steel pipes.

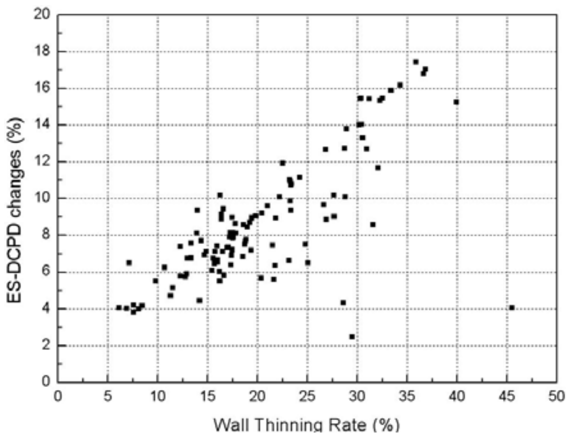

Fig. 3 comparison result of ES DCPD with wall thing rate of carbon steel pipes.[6]

Korea Atomic Energy Research Institute (KAERI) began a research project on Integrity evaluation of materials and components of nuclear facilities in 2011. As a first stage of the project, FAC facility will be developed and then SG mock will be designed. The overall feature of the project is shown in Figure 4.

3. Conclusions

FAC events and the causes were reviewed. FAC related research program in Japan an EU. The purpose of the project on Integrity evaluation of materials and components of nuclear facilities in KAERI is to obtain integrity evaluation technology for corrosion susceptible components such as secondary pipes, steam generator tubes by using the mock-up.

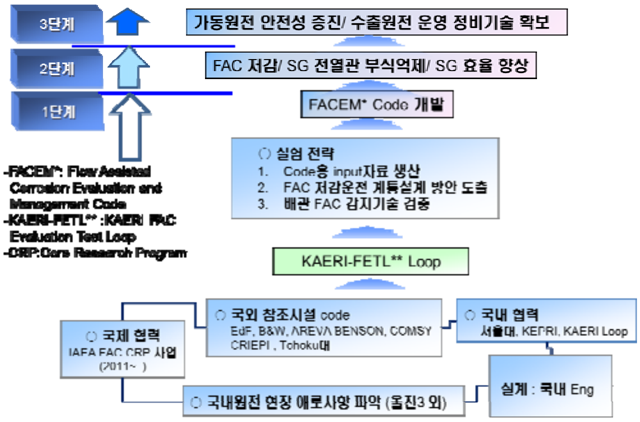

Fig. 4 General view of the research project on Integrity evaluation of materials and components of nuclear facilities

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