CCDP Evaluation of the Fire Areas of KSNP Using CFAST

Yoon-Hwan Lee, Joon-Eon Yang and Jong-Hoon Kim
Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon, South Korea, yhlee3@kaeri.re.kr

1. Introduction

During the past decade, the nuclear power industry has been moving away from prescriptive rules and practices toward risk-informed and performance-based engineering analysis to support the decision making for plant fire protection programs. For example, the National Fire Protection Association (NFPA) prepared NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants 2001 Edition. One crucial element in supporting the risk-informed fire protection is availability of simple and reliable methods and tools for evaluating the likelihood and consequences of fire scenarios. These tools directly benefit risk-informed and performance-based fire protection and application of risk information to resolve fire protection issues.

Now the deterministic analysis results for the cable integrity is not given in case of performing the fire PSA. So it is necessary to apply the results for the fire modeling to the fire PSA model to develop the more realistic model.

This document is intended to analyze the peak temperature of the upper gas layer using the fire modeling code, CFAST , to evaluate the integrity of the cable located on the dominant pump rooms, and to assess the CCDP(Conditional Core Damage Probability) using the results of the cable integrity.

Accordingly, the fire safety assessment for the dominant fire areas using the fire modeling code will be capable of evaluating the consequences of the fire scenario, of reducing the the uncertainty, and to develop a more realistic model.

2. Parameter Determinations for the Fire Modeling

This paper dthe results of analysisthe ()The target areas are high pressure safety injection pump room A/B, low pressure safety injection pump room A/B, containment spray pump room A/B, and motor-driven auxiliary feedwater pump room A/B located on the primary auxiliary building of the nuclear power plant

The typical fire scenario is assumed that the lube oil is released from the pumps and the ignition is caused by the over-heat of the pump.

2.1. Technical Descriptions of the Selected Fire Areas

Table 1 lists relevant input and fire parameters to fire models related to the size of the enclosure and the fire size involving the heat release rate.

Table 1. Technical Description of the Fire Areas

Fire Areas and Fire Parameters		
HPSI Pump Room	Length (m)	8.14
	Width (m)	4.29
	Height (m)	8.48
	Fire Door Dimensions (m)	1.0 x 2.0
	Burning Area (m^2)	23.8
	Max. Heat Release Rate (KW)	20,802
LPSI Pump Room	Length (m)	8.23
	Width (m)	5.95
	Height (m)	8.53
	Fire Door Dimensions (m)	1.0 x 2.0
	Burning Area (m^2)	47.3
	Max. Heat Release Rate (KW)	16.844
CSS Pump Room	Length (m)	8.23
	Width (m)	5.15
	Height (m)	8.53
	Fire Door Dimensions (m)	1.0 x 2.0
	Burning Area (m^2)	40.7
	Max. Heat Release Rate (KW)	17,912
Motor-Driven Aux. Pump Room	Length (m)	11.89
	Width (m)	6.40
	Height (m)	5.00
	Fire Door Dimensions (m)	2.0 x 2.0
	Burning Area (m^2)	69.7
	Max. Heat Release Rate (KW)	3,077

The data of diesel oil instead of the lube oil data is used to simulate the fire scenario, because it is impossible to acquire the data, such as the heat of combustion and mass loss rate of the lube oil at present[1].

3.Simulation Results

The upper layer temperatures of each room are illustrated in Figure 1, respectively.

The upper layer temperature of the HPSI pump room ranges from 372℃ to 418℃ during 30 seconds, and it reaches its peak of about 434℃. The upper layer temperature of the LPSI pump room is above 400℃ from 180 sec. to 205 sec. after the fire ignition. The maximum temperature of the upper layer is about 463℃. The upper layer temperature of the CSS pump room is above 400℃ from 160 sec. to 195 sec. after the fire ignition. The maximum temperature of the upper layer is about 461℃. The upper layer temperature of the motor-driven AFW pump room ranges from 188℃ to 195℃ during 30 second, and it reaches its peak of about 249℃.

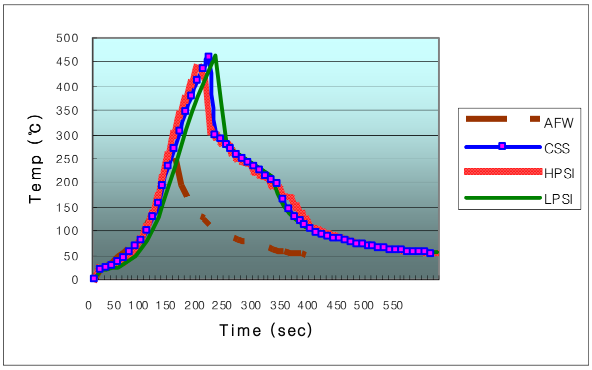

Figure 1. Upper Layer Temperature in the pump rooms as estimated by CFAST

Evaluation of the Cable Integrity

According to the data from "Fire Protection Significance Determination Process (SDP)[2]" presented by NRC (Nuclear Regulatory Commission) and "Fire PRA Implementation Guide[3]" presented by EPRI (), all these temperature values are below the damage temperature of the cable. It is appeared that the integrity of the cable located at the upper layer is maintained except for the safety pumps at the fire areas.

5. CCDP Evaluation of the Selected Fire Areas

KIRAP (KAERI Integrated Reliability Assessment code Package) is used for the assessment of the CCDP (Conditional Core Damage Probability) of the selected fire areas that is developed by KAERI.

The CCDPs for the fire areas are shown in Table 2 and Figure 2.

Table 2. The CCDPs for the Fire Areas

Fire Areas	Old CCDP	New CCDP
HPSI Pump Room A	2.19E-06	9.25E-07
HPSI Pump Room B	2.19E-06	9.26E-07
LPSI Pump Room A	2.08E-06	9.84E-07
LPSI Pump Room B	1.00E-06	9.85E-07
CSS Pump Room A	2.18E-06	9.21E-07
CSS Pump Room B	2.17E-06	9.27E-07
AFW Pump Room A	4.41E-06	3.07E-06
AFW Pump Room B	4.26E-06	3.09E-06

According to the CCDP values of the HPSI pump room A using the CFAST simulation results, CCDP of 2.19E-06 is reduced to 9.25E-07. The CCDPs are changed from 2.08E-06 to 9.84E-07 for the LPSI pump room A, from 2.18E-06 to 9.21E-07 for the CSS pump room A, and from 4.26E-06 to 3.09E-06 for the motor-driven AFW pump room A, respectively.

According to the analysis results, the CCDP is reduced to about half than the original value.

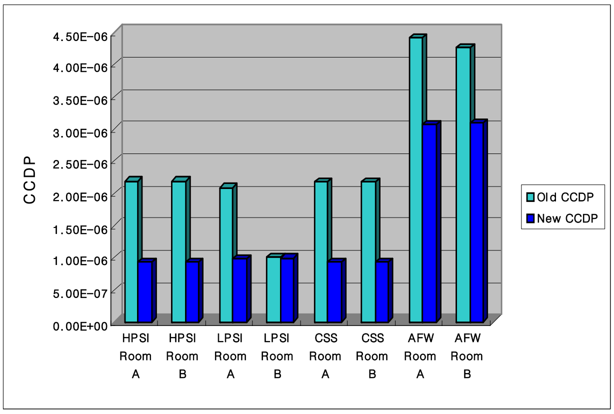

Figure 2. Comparison of the CCDPs

6. Conclusions

According to the analysis results, the cable integrity of the pump rooms is maintained and CCDP is reduced to about half than the original value. Accordingly, the fire safety assessment for the dominant fire areas using the fire modeling code will be capable of reducing the the uncertainty and developing a more realistic model.

It is necessary to reconfirm the cable integrity using the CFAST result that is simulated by another fire scenario, and to compare the CFAST results with the results of the field model, like FDS (Fire Dynamic Simulator).

It is considered that the CCDP values using the fire modeling codes directly benefit the risk-informed and performance-based rules in NPP fire protection and applications of risk information to resolve the fire protection issues and these tools are needed to support the fire protection inspection and assessment by determining the safety significance of performance indicators or inspection findings.

References

1. Yoon-Hwan Lee *et al.*, "CCDP Evaluation of the Fire Area of NPPs Using Fire Model CFAST", Transactions of Korean Institute of Fire Science & Engineering, Vol. 18, No. 4, pp 64-71, 2004.
2. Supporting Guidance for Implementation of IMC 0609 Appendix F-Fire Protection Significance Determination Process (SDP), U. S. NRC, 2004.
3. Fire PRA Implementation Guide, TR-105928, EPRI, 1995