*Transactions of the Korean Nuclear Society Spring Meeting*
*Jeju, Korea, May 10-11, 2007*

# Preliminary Analysis of the Common Cause Failure Events for Domestic Nuclear Power Plants

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## 1. Introduction

It is known that the common cause failure (CCF) events have a great effect on the safety and probabilistic safety assessment (PSA) results of nuclear power plants (NPPs). However, the domestic studies have been mainly focused on the analysis method and modeling of CCF events. Thus, the analysis of the CCF events for domestic NPPs were performed to establish a domestic database for the CCF events and to deliver them to the operation office of the international common cause failure data exchange (ICDE) project. This paper presents the analysis results of the CCF events for domestic nuclear power plants.

## 2. Components for Analysis and Procedures

Components for the collections and analysis of the CCF events are emergency diesel generators (EDGs), centrifugal pumps (CP), motor-operated valves (MOV), check valves (CV), circuit breakers (C/B) for the Korean Standard Type NPPs, Yonggwang Units 3&4 and Ulchin Units 3&4, and the Westinghouse type NPPs, Kori Unit 3&4 and Yonggwang Units 1&2.

First, we determined and classified the components to be collected and analyzed into common cause component groups (CCCGs) according to the ICDE coding guidelines such as component manufacturers, testing interval, testing strategy, etc. A CCCG is a set of components that are considered to have a high potential for failures due to a common cause. In most cases the components of CCCGs are redundant, identical components of a system, all performing the same function. Next, we identified the independent failure events and the CCF events based on the reviews of the component database for the PSA and its related documents, and consultations with NPP staff.

## 3. Determination of CCCG

As for the analysis of the CCF events, we used the component data collected for the PSA for each NPP mentioned above. Based on the ICDE coding guidelines, we used the following guidelines to determine and to classify the components into the same CCCG:

- Components modeled into the PSA logic of each NPP are considered as the scope of the CCCG.
- Main failure modes considered are; fail to start, fail to run, fail to open, and fail to close
- For running components with two redundancy, demand type CCF events are not considered.
- Criteria for the classification of the same CCCG are:
  - Same type components within the same system
  - Same manufactures
  - Same testing types (staggered vs. non-staggered)
  - Same test intervals

Table 1 shows the number of CCCGs for each NPP. Total number of the CCCGs for the eight NPPs was determined as 454. Number of the CCCGs for each component is: 8 CCCGs for EDG, 40 CCCGs for C/B, 72 CCCGs for CP, 164 CCCGs for MOV, 170 CCCGs for CV.

Table 1. CCCGs of Components for each NPP

| NPP | EDG | C/B | CP | MOV | CV | Sum |
|---|---|---|---|---|---|---|
| XX-1 | 1 | 4 | 10 | 17 | 21 | 53 |
| XX-2 | 1 | 4 | 10 | 17 | 21 | 53 |
| XX-3 | 1 | 4 | 10 | 17 | 21 | 53 |
| XX-4 | 1 | 4 | 10 | 17 | 21 | 53 |
| XX-5 | 1 | 6 | 8 | 25 | 23 | 63 |
| XX-6 | 1 | 6 | 8 | 25 | 23 | 63 |
| XX-7 | 1 | 6 | 8 | 23 | 20 | 58 |
| XX-8 | 1 | 6 | 8 | 23 | 20 | 58 |
| Sum | 8 | 40 | 72 | 164 | 170 | 454 |

## 4. Analysis Results

Based on the PSA data for each NPP, we identified the independent failure events of each component. Table 2 shows the identified independent failure events. Total number of individual failure events for each component is 127; 39 failures for EDG, 4 failures for C/B, 62 failures for C/P, 19 failures for MOV, 3 failures for CV.

Table 3 shows the summary information of the details of the CCF events. 14 CCF events occurred; 2 failures for EDG, 3 failures for MOV, and 9 failures for CP. There is no CCF event in the C/B and CV. The ratio of the number of CCF events to that of individual failure events was identified as approximately 10 percent. However, an in depth review of the CCF events showed that most failure severities of them were identified as an ‘incident’, which can be interpreted as the failure symptoms, or as partial CCF events, which can be interpreted as some component failures within the CCCGs. Number of complete CCF events is only 2.

Root causes of the CCF events were identified as 9 internal piece part failures, 2 human errors, 2 design deficiencies, 1 procedure inadequacy. It could be concluded that the major root causes of the CCF events were internal piece part failures.

## 5. Conclusions

After a re-examination of the CCF events, we will deliver the study results to the operation office of the ICDE project. As future studies, it is required that the analysis on the CCF events for the safety/relief valves and reactor trip circuit breakers, and for the CANDU be performed.

## Acknowledgements

This work has been carried out under the Nuclear R&D Program by Ministry of Science and Technology of Korea.

## References

[1]OECD Nuclear Energy Agency, "International Common Cause Failure data Exchange",ICDE General Coding Guidelines", NEA/CSNI/R (2004)4, January 2004

[2]Daeil Kang and Sang-Hoon Han, " Collections and Analysis of Common Cause Failure Data for the Korea Standard and Westinghouse Type NPPs(to be published)", KAERI/TR-3269/2006, KAERI, 2007

Table 2. Independent Failure Events of Components for each NPP

| NPP | EDG | | C/B | | | CP | | MOV | | | CV | | | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FS | FR | FO | FC | SO | FS | FR | FO | FC | IL | FO | FC | IL | |
| XX-1 | | | | 1 | | 7 | 6 | 3 | | | | | | 17 |
| XX-2 | | | | | | 3 | 3 | 3 | 1 | | | | | 10 |
| XX-3 | 3 | | | | | 8 | 4 | 2 | 1 | | | | | 18 |
| XX-4 | | | | | | 4 | | 3 | | | | | 1 | 8 |
| XX-5 | 17 | | | 2 | | 15 | 1 | 4 | 1 | | | | | 40 |
| XX-6 | 10 | | | | | 1 | 2 | 1 | | | | | | 14 |
| XX-7 | 5 | | | 1 | | 5 | 1 | | | | 1 | | 1 | 14 |
| XX-8 | 4 | | | | | 2 | | | | | | | | 6 |
| Sum | 39 | | | 4 | 0 | 45 | 17 | 16 | 3 | 0 | 1 | 0 | 2 | 14 |
| | 39 | | 4 | | | 62 | | 19 | | | 3 | | | 127 |

Table 3. Summary Information for CCF Events

| Event Code | Component | System | Failure Mode | Exposed Population | CCCG | Impairment Vector* | Root causes |
|---|---|---|---|---|---|---|---|
| XX-1-BG-92-01 | Pump | HPSI | FR | 2 | 3 | DIW | Piece parts |
| XX-2-BG-91-01 | Pump | HPSI | FR | 2 | 3 | IIW | Human |
| XX-3-HA-01-01 | Pump | Central Chilled Water System | FS | 2 | 2 | CC | Piece parts |
| XX-4-BG-92-01 | Pump | HPSI | FR | 2 | 3 | IIW | Piece parts |
| XX-4-FN-98-01 | Pump | CCWS | FR | 2 | 2 | II | Piece parts |
| XX-5-BB-96-01 | Pump | AFWS | FS | 2 | 2 | II | Design |
| XX-5-BB-98-01 | Pump | AFWS | FS | 2 | 2 | II | Piece parts |
| XX-7-CB-98-01 | Pump | ESWS | FR | 2 | 4 | CIWW | Piece parts |
| XX-7-DD-99-01 | Pump | CSS | FS | 2 | 2 | CC | Piece parts |
| XX-1-BG-91-01 | MOV | HPSI | FO | 2 | 6 | CCWWWW | Piece parts |
| XX-5-BB-95-01 | MOV | AFWS | FO | 2 | 4 | IIWW | Piece parts |
| XX-8-CA-01-01 | MOV | CCWS | IL | 2 | 4 | IIWW | Human |
| XX-5-EF-97-01 | EDG | EDG | FS | 2 | 3 | CCW | Design |
| XX-6-EF-97-01 | EDG | EDG | FS | 2 | 3 | IIW | Procedure |

*: C – critical failure, D-degraded, I- incipient failure, W- working