RESPONSE TO AUDIT ISSUES

APR1400 Topical Reports

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. PROJ0782

Review Section	**TR Realistic Evaluation Methodology for LBLOCA of the APR1400**
Application Section	**Topical Report: APR1400-F-A-TR-12004 Realistic Evaluation Methodology for Large-Break LOCA of the APR1400**
Issue Date	**08/13/2015**

Audit Issues No. 14

NUREG/CR-5429, Section 2.1 establishes an acceptable approach for the documentation of the phenomena identification and ranking table (PIRT). A large number (i.e., 83 parameters) of phenomena or processes are ranked 4 or higher in the APR1400 PIRT. However, the application of CAREM actually uses only 30 uncertainty parameters as shown in topical report Table 5-1.

a. A description of the process followed to determine the 30 uncertainty parameters that are actually ranged for the simple random sampling (SRS) calculations from the entire possible set (i.e., 83 parameters) based on the PIRT is needed.

b. An explanation and justification of the approach used (i.e., conservative or best estimate values) for the remaining parameters not included in the uncertainty analysis is needed.

Response

a)

The presentation material attached [1] describes the entire process to determine the 30 uncertainty parameters out of the 82 phenomena/processes determined from the APR1400 PIRT. As described in the material, the phenomena already considered by other uncertainty parameters, phenomena treated conservatively and phenomena treated as biases are not considered as uncertainty parameters. The phenomena are considered to be treated conservatively when it is not easy to be included. Sensitivity calculations can be performed to determine the conservative case. When the sensitivity calculations are not possible, a parameter generally believed to reduce PCT when it is included in the calculation is not considered for conservatism. The APR1400 PIRT contains some errors mostly related to the definition of time periods and is revised in association with audit issue no. 15.

b)

The explanation and justification of the parameters are described in the topical report and these are summarized in Table 1 as follows. Among the 82 phenomena/processes in the APR1400 PIRT, two phenomena are not mentioned in the topical report. [

]TS The SIT line and SI pump line merges at an expanded cross-sectional area pipe, thus the SIT injection cannot be interrupted by SI pump inherently. It has been found that the APR1400 PIRT contains errors as to the time period definitions, and the revised to the APR1400 PIRT is shown in the attached document [2]. The missing or insufficient rationale of the PIRT is reinforced in accordance with the revised PIRT.

Table 1. Description of each process/phenomena in the topical report (1/3)

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Table 2. Description of each process/phenomena in the topical report (2/3)

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Table 3. Description of each process/phenomena in the topical report (3/3)

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Reference

[1] Presentation Material, "PIRT to Uncertainty Parameter," presented at the face to face meeting with NRC, 2016. 1. 12 ~ 2016. 1. 15. (Modifications are made in accordance to the reference [2]), Revision 1.

[2] Presentation Material, "APR1400 PIRT revision," attached document of the response to the audit issue no. 15, July, 2016.

Impact on DCD

There is no impact to the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Report

Topical report will be revised as discussed in this response.

There is no impact on Technical or Environmental Report.

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Table 3-2 Phenomena Identification and Ranking Table (1/3)

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Table 3-2 Phenomena Identification and Ranking Table (1/3)

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Table 3-2 Phenomena Identification and Ranking Table (2/3)

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Table 3-2 Phenomena Identification and Ranking Table (2/3)

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Table 3-2 Phenomena Identification and Ranking Table (3/3)

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Table 3-2 Phenomena Identification and Ranking Table (3/3)

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1. Introduction

Phenomena identification and ranking table (PIRT) is used to identify major phenomena that occur during relevant accidents of the reference plant, and to prioritize the phenomena according to their effects on major safety parameters. PIRT is essential to understand the phenomena or processes that occur during the accident, and to determine code capability and uncertainty parameters.

The PIRT for a large-break loss-of-coolant accident (LBLOCA) of APR1400 was developed based on the LBLOCA PIRT for “Korea Next Generation Reactor (KNGR)” by Wilson et al. 2001 [1]. KNGR was the name for ARP1400 at its early developmental stage. KNGR PIRT was prepared by Idaho National Engineering and Environment Laboratory (INEEL) for Korea Institute of Nuclear Safety (KINS), the regulatory body of Korea. APR1400 PIRT has been established by adopting KNGR PIRT and reflecting the final design features of APR1400 and the results of the experiments specific to APR1400.

This appendix explains KNGR PIRT and its modifications. KNGR PIRT is explained in Chapter 2 and the adjustments of the rankings are explained in Chapter 3. The determined APR1400 PIRT is provided in Chapter 4.

and all the adjustments made was reviewed by the peer review process.

2. PIRT for “Korea Next Generation Reactor”

KNGR PIRT was prepared through 15 processes starting with defining the purpose of the PIRT and finishing with documenting the final PIRT. Figure 1 shows the development process of KNGR PIRT. The PIRT process used for KNGR is similar to those used in other preceding PIRT developments. Examples of prior PIRT efforts can be found in other references [2]-[8]. Applications of the process have repeatedly demonstrated that the collective knowledge of experts group significantly increase the probability of phenomena or processes of importance being identified. The KNGR PIRT panel has about 150 man-years of collective experience in nuclear reactor research and operation. The panel members were:

Dr. Brent E. Boyak (Los Alamos National Laboratory)

Dr. Bub-Dong Chung (Korea Atomic Energy Research Institute – KINS Representative)

Dr. Lawrence E. Hochreiter (Pennsylvania State University)

Dr. Jose N. Reyes (Oregon State University)

Mr. Gary E. Wilson (Idaho National Engineering and Environmental Laboratory – Panel Chairman)

The scenario selected for KNGR PIRT was an LBLOCA of a double-ended guillotine break in a cold leg with the assumptions of loss of off-site power and failure of one diesel generator. The assumptions led to the availability of only one, out of two, hydraulic division of the safety injection system. Each division included two safety injection pumps; and only two, out of four, safety injection pumps were credited in the scenario.

The relative importance of phenomena is time-dependent as an accident progresses. For KNGR PIRT, the panel divided the LBLOCA scenario into four temporal periods. These periods, termed blowdown (1), refill (2), reflood (3), and long-term cooling (4) were defined by the core and lower plenum liquid mass fractions as delineated in Table **1**. The numbers in parentheses were used as indices of the periods in the PIRT. The blowdown period begins when the break occurs and ends when the lower plenum begins to refill. The refill period ends when the liquid level in the vessel lower plenum approaches the core inlet and remains full thereafter. The reflood period ends when the entire core is quenched, that is, all fuel rod cladding temperatures are at or slightly above the and Uncertainty" by B. Boyack et al. 1989 [3] were referenced. Sections 3.1 and 3.2 explain the modification of the four temporal periods and subsequent adjustment of the ranking, respectively.

3.1 Definition of Time Phases

The LBLOCA scenario of APR1400 is divided into four temporal periods. The definitions of each period are described in Table 4. The periods are termed blowdown (1), refill (2), early reflood (3), and late reflood (4). The numbers indicated in parentheses are used as indices in the PIRT to denote each period.

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(1) The blowdown period starts when the break occurs and ends when SIT injection initiates.

(2) The refill period ends when the ~~liquid~~ level in the vessel lower plenum approaches the core inlet and remains full thereafter.

(3) The early reflood period ends when SITs are emptied.

(4) The late reflood period continues after SITs are emptied.

3.2 Adjustment of the Rankings

It is necessary to adjust the relative importance of phenomena or processes after modifying the definition of temporal periods. In addition, finalization of the APR1400 design and the findings of the experiments and code simulations, which have been performed after the development of KNGR PIRT, need to be reflected.

The same ranking scale used for the relative importance of phenomena or processes of KNGR PIRT, described in Table 2, is used for APR1400 PIRT. It should be ensured that the phenomena or processes of [ ]^{TS} are considered in the calculation. For these phenomena or processes, relevant uncertainty parameters were identified and their uncertainties were reflected in plant calculations in principle. In cases where the identification of uncertainty parameters was not probable, [ ]^{TS} Relevant uncertainty parameters for [ ]^{TS} were not identified. As described in Table 2, [ ]^{TS} allow modeling of the phenomena or processes with inaccuracy or moderate accuracy. As the RELAP5 code has best-estimate features, those phenomena or processes [ ]^{TS} can be modeled with moderate accuracy if the phenomena or processes are not ignored in the calculation. Modeling of these phenomena or processes includes [ ]^{TS}, and so on. Phenomena or processes of ranks lower than [ ]^{TS} are paid no attention.

Among the phenomena or processes of KNGR PIRT, those phenomena or processes, of which the importance ranking is equal to or higher than [ ]^{TS} in any temporal period, are considered when adjusting the rankings. This selection criterion was established in order to prevent omitting significantly important phenomena or processes. Phenomena or processes of [ ]^{TS} can be modeled by applying the models and correlations as they are in the code or by the nodalization capability of the RELAP5 code. The uncertainty of all the other phenomena or processes, or the combined effect of not-considered low ranked phenomena or processes can be accounted for in [ ]^{TS} of this method.

Modifications on KNGR PIRT are described below, item-by-item, along with the rationale. The indices for each time period used in the following tables are "1" for the blowdown, "2" for the refill, "3" for the early reflood, and "4" for the late reflood periods as described earlier.

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4. PIRT for APR1400

APR1400 PIRT is described in Table 5. Findings from further code simulations and experiments performed after the preparation of KNGR PIRT are incorporated. Final features of the APR1400 design are also reflected. [ ]TS phenomena or processes from [ ]TS components are ranked as important. The number of phenomena or processes for each component is as follows:

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Table 3 KNGR PIRT (1/8)

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Table 3 KNGR PIRT (3/8)

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Table 3 KNGR PIRT (4/8)

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Table 3 KNGR PIRT (5/8)

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Table 4 Definition of Time Phases for APR1400 PIRT

Phase (Number)*)	Starts at	Ends at
Blowdown (1)	Break initiation	Initiation of SIT injection
Refill (2)	~~End of blowdown~~ Initiation of SIT injection	Initiation of core recovery (~~liquid~~ Mixture level at bottom fuel rod heated length)
Early Reflood (3)	~~End of refill~~ Initiation of core recovery	End of SIT injection
Late Reflood (4)	End of SIT injection	Stable core quench

*) The numbers indicated in parentheses are used as indices in the PIRT to denote each phase in that table.

Table 5 APR1400 PIRT (1/3)

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Table 5 APR1400 PIRT (2/3)

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Table 5 APR1400 PIRT (3/3)

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Table 5 APR1400 PIRT (3/3)