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Reliability Assurance Program for the APR1400 DC

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1. Introduction

KHNP is preparing the APR1400 design for U.S.NRC Design Certification (DC), for which the reference plant is Shin-Kori units 3 and 4, by applying the code and standards of NRC issued before submitting the APR1400 design control documents. One of the important design activities, comparing to the licensing of the domestic licensing of new plants, is the requirement for Reliability Assurance Program (RAP). RAP is required in RG 1.206 and the associated acceptance criteria is described in SRP 17.4 and ISG DC/COL-ISG-018. The RAP for the APR1400 during the design phase is performed in accordance with the U.S. regulatory requirements and associated guides. This paper provides the methodology, implementation process, and preliminary results of the APR1400 RAP.

2. Implementation of RAP

KHNP has established the APR1400 RAP which consists of the risk management policy and RAP implementation procedures.

2.1 Risk Management Policy

The Risk Management Policy is established to utilize the Probabilistic safety assessment(PRA) results in the process of decision making related to overall risk assessment, risk application and risk management engineering works in support of design, construction, and operation of nuclear power plants. The Risk Management Policy provides a policy level framework. KHNP and other entities involved in the APR1400 project need to implement RAP, PRA, and severe accident mitigation design alternatives (SAMDA) in accordance with the established risk management policy for the APR1400 project.

Three procedures, in support of the APR1400 RAP, developed to implement the RAP are as follows:

- Implementation of the RAP Procedure: It describes the program to implement the requirements of the design phase RAP. It includes RAP program implementation, Design and PRA change evaluations, Identifying within-scope RAP SSCs, Expert Panel administration and Audit plan. The procedure also deals with the quality controls for identifying within-scope SSCs, including quality controls for the analyses used to identify these SSCs to be maintained by the QA program. The procedure describes the review process of design and PRA change to assess the potential impact on the RAP, where the evaluation results are presented to the Expert Panel for review and approval.
- Expert Panel Roles and Responsibilities Procedure: It describes the roles and responsibilities of the RAP Expert Panel (EP) established at KHNP in support of APR1400. The EP is a group of experienced individuals representing Design Engineering, Operations, Maintenance, PRA and QA. The EP interprets and assures effective implementation of the RAP. The responsibilities of EP are reviews and approvals of all changes to RAP scope and RAP risk significance basis, and reviews and approvals of the risk significance of SSCs in RAP when requested by the RAP coordinator. The procedure of EP also describes the EP member qualification requirements.
- Risk Significance Determination of RAP SSCs Procedure: It describes an acceptable methodology for evaluating, identifying, and prioritizing SSCs according to the risk significance as determined by using a combination of probabilistic, deterministic, or other methods of analysis. This methodology includes, but not limited to, the use of information obtained from risk evaluations, industry operating experience, and EP member's expertise. The risk significance (i.e., High Safety Significant (HSS) or Low Safety Significant (LSS)) of SSCs is determined based on the RAW and F-V importance measures. The importance measure criteria (based on NEI 00-04) used to identify HSS SSCs is as follows:
  1) Sum of F-V for all basic events modeling the a SSC of interest, including common cause events > 0.005
  2) Maximum of component basic event RAW values > 2.0
  3) Maximum of applicable common cause basic events RAW values > 20

If any of these criteria are exceeded, the SSC is considered a candidate safety-significant. Alternatively, the risk significance of within-scope RAP SSC(s) may be determined by the method specified in NUMARC

93-01, "Industry Guideline For Monitoring The Effectiveness Of Maintenance At Nuclear Power Plants;" or NEI 00-04, "10CFR 50.69 SSC Categorization Guideline."

2.3 RAP implementation

PRA information is essential elements to ensure the quality of RAP. In order to incorporate deterministically evaluated DID (defense-in-depth) and the PRA results of internal and external events into SSCs risk significant determination, three EPs in RAP are planned. The first phase RAP was performed with PRA results of internal events May 22 and 23, 2012 at KHNP Central Research Institute. The second EP will be performed to complement the SSCs determined at the first EP with the PRA results of external events October 2012. The last EP will be performed to finalize the within-scope SSCs of the APR1400 November 2012.

The member of the first EP consists of RAP chairman, RAP coordinator, and experts from system designer, architecture engineer, PRA, QA, operation, maintenance, and maintenance rule. KHNP CRI distributed Expert Panel Training/Qualification record to the member, which includes essential required reading materials and personal experience record sheet.

The total number of the basic events evaluated, excluding common cause failures, was 1,206 which were presented at the EP meeting. The results of the first EP are as follows:

- Total number of events: 1,206 (1,763 including CCF)
- RAP SSCs: 153 (12.7%)
- Non RAP SSCs: 1,053 (87.3%)
  - TBD: 414 (34.3%)

The first EP shows that 153(12.7%) of basic events are identified as RAP SSCs, and 1,053(87.3%) as Non-RAP SSCs, among which 414(34.3%) are designated as TBD (i.e., to be determined) because the additional discussion and information were needed to disposition these items. The first EP result shows that the most risk significant SSC, which has the highest value, is IRWST sump. Its main failure modes are sump strainer plugging and debris induced loss of long term cooling due to downstream chemical effect in the core. In the APR1400 design, the GSI-191 issues are being addressed through utilizing the international technical studies and a planned KHNP in-vessel fuel test. The RAP SSCs will be further evaluated through the second EP and the third EP.

2.4 ITAAC for RAP

The ITAAC for the RAP provides a reasonable assurance that the plant is designed in a manner that is consistent with the key safety assumptions and risk insights for the within-scope SSCs. In the APR1400 DC, three elements of ITAAC are as follows:

<u>Design Commitment</u>: For SSCs within the scope of the RAP (i.e., RAP SSCs), the design is consistent with key safety assumptions and risk insights.
<u>Inspections, Tests, and Analyses</u>: An analysis will demonstrate that the initial design of all RAP SSCs (for procurement and installation) has been completed in accordance with the RAP requirements.
<u>Acceptance Criteria</u>: The initial design of all RAP SSCs identified at the time of the COL issuance has been subject to the applicable reliability assurance activities of the RAP.

3. Conclusions

In this paper, the RAP for the APR1400 design for U.S. NRC design certifications (DC) is presented. In order to perform RAP, the Risk Management Policy was established to utilize PRA results in the process of risk-informed decision making for the RAP as required by the regulation. Next, three RAP implementation procedures were developed under KHNP Quality Assurance Manual. Next, the RAP was performed according to the implementing procedures. The results of the first phase RAP shows that 12.7% of the basic events of the internal PRA model are risk significant and are RAP SSCs. These SSCs will be further evaluated through the second and third phase RAP. Finally, the three elements of ITAAC for the RAP, "Design Commitment," "Inspections, Tests, and Analyses," and "Acceptance Criteria" are described.

REFERENCES

[1] SECY-95-132, "A Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs."
[2] DC/COL-ISG-018, "Interim Staff Guidance on NUREG-0800 Standard Review Plan Section 17.4, 'Reliability Assurance Program."
[3] REG. GUIDE 1.206, C.I.17, "Quality Assurance and Reliability Assurance."
[4] NEI 00-04, "10CFR50.69 SSC Categorization Guideline," Nuclear Energy Institute, Rev 0, July 2005.
[5] EPRI 1023008, "Advanced Nuclear Technology: Design Reliability Assurance Program Implementation Guidance," December 2011.
[6] KHNP-APR1400, "Quality Assurance Manual for the APR1400 DC," Rev. 0.
[7] DC-DG-01, KHNP, "Implementation of the Reliability Assurance Program (RAP)," Rev. 0.
[8] DC-DG-02, KHNP, "Expert Panel Roles and Responsibilities," Rev. 0.
[9] DC-DG-03, KHNP, "Risk Significance Determination of RAP SSCs," Rev. 0.
[10] NUMARC 93-01, "Industry Guideline For Monitoring The Effectiveness Of Maintenance At Nuclear Power Plants," Rev. 3.