

# Development of Preliminary Review Guideline for Multi-Unit PSA

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## Introduction & Purpose

- After the Fukushima accident, domestic and foreign interest in the safety of multi-unit has been increased. In Korea, a total of 25 nuclear power plants are currently in operation at four sites: Kori, Wolsung, Hanul, and Hanbit. In addition, each site is a multi-unit site in which at least five units are operating, and the population density near nuclear power plants is relatively high compared to other countries, raising public concerns about the safety of multi-unit site.
- When the Nuclear Safety and Security Commission deliberated on the construction permit for Shin-Kori Units 5,6, the need for safety evaluation of multi-unit risk within a single site was raised. Accordingly, the Nuclear Safety and Security Commission launched a Multi-Unit Risk Research Group(MURRG), which is conducting research on regulatory methods and evaluation methodologies for site risk assessment. Therefore, in this study, as a part of the development of the site risk assessment regulatory methodology of MURRG, a review guideline(draft) for Multi-Unit PSA(MUPSA) was developed.

## Domestic conformity assessment to establish MUPSA review guideline

- In this section, a system was developed for the domestic conformity assessment of preliminary candidates for MUPSA review guideline, and the diagram is shown in Figure 1 below.

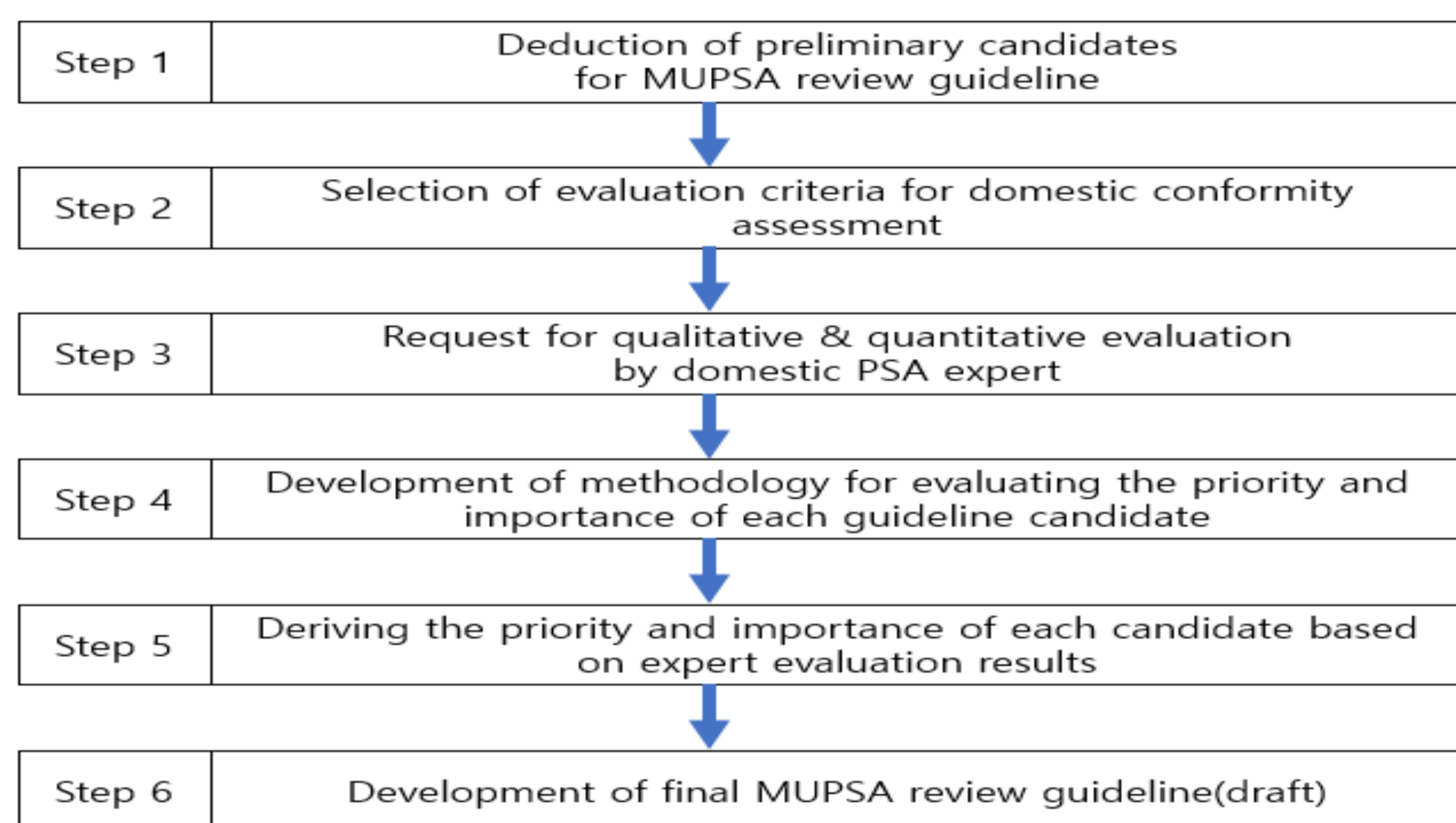


Fig. 1. Domestic conformity assessment system for MUPSA review guidelines

- The details of each step based on the assessment system(Fig.1) are as follows,
  - ✓ Step 1) Deduction of preliminary candidates for MUPSA review guideline
    - In 2020, IAEA safety report series No. 96 and other domestic and foreign documents which are related to MUPSA were reviewed to derive preliminary candidates for MUPSA review guideline. In addition, this study additionally derived the candidates presented in IAEA SSR-3, which is currently being revised in 2021.
  - ✓ Step 2) Selection of evaluation criteria for domestic conformity assessment
    - Evaluation criteria were selected for the evaluation of a total of 49 candidates for MUPSA review guideline derived in the step 1. Three items are selected as evaluation criteria: 'Analysis possibility (current level of technology)', 'Regulatory necessity (whether or not overlapping with Single-unit PSA requirements, etc.)', and 'Licensee acceptability'. The reasons for selecting each evaluation criteria are as follows.
      - 'Analysis possibility' is the criteria to evaluate the technical level of each candidate. Each evaluator evaluates the relevant items as 'possible' or 'impossible' by judging whether the analysis of the candidate is analyzable at the present time based on the experience of single-unit and multi-unit PSA.
      - The 'Regulatory necessity' is the stage to evaluate the regulatory necessity for each candidate based on the current domestic regulatory environment. This item evaluates 'Yes' or 'No' by comprehensively considering redundancy and consistency with the current PSA regulatory requirements for single-unit.
      - 'Licensee acceptability' is a stage to evaluate the acceptability of licensee for each candidate and comprehensively evaluate the cost-benefit of applying the requirements. In this item, the evaluator classifies licensee acceptability into 'high', 'medium', or 'low'.
    - ✓ Step 3) Request for qualitative & quantitative evaluation by domestic PSA expert
      - The preliminary MUPSA candidates analyzed in step 1 are requested to be reviewed by PSA experts in Korea Institute of Nuclear safety (KINS) based on the evaluation criteria selected in step 2. The evaluation was conducted by a total of 11 experts, ranging from members with at least 3 years of PSA review and research experience to experts with up to 30 years of experience. When it is difficult to judge the evaluation of each sub-item during expert evaluation, it is possible to select 'Neutral' to avoid biased analysis.

- ✓ Step 4) Development of methodology for evaluating the priority and importance of each guideline candidate
  - Step 4 is to develop a methodology that can evaluate the priority and importance by collecting the evaluation results of the preliminary MUPSA review candidates evaluated by each expert in the step 3. The methodology used to collect and analyze the evaluation results is similar to that of general survey statistics. The response rate for each evaluation criteria was analyzed, and the final score was calculated using the weight for each evaluation criteria.
- ✓ Step 5) Deriving the priority and importance of each candidate based on expert evaluation results
  - This step is to derive the priority and importance for each candidate based on the methodology developed in step 4. Examples of priorities and importance evaluation among preliminary candidates for the MUPSA Review Guidelines are as follows.
  - Table 1 shows the results of each expert's evaluation of the candidate No. 5 for the MUPSA review guideline drawn as a result of the study.

Table 1. Expert evaluation result for preliminary candidate No. 5

| 5. When screening and removing initiating events, it should be checked whether the MUCDF contribution is less than 1% for multiple sites and is an initiating event affecting two or more units. | Analysis possibility   |            |         |
|--|------------------------|------------|---------|
|  | Possible               | Impossible | Neutral |
|  | 82%                    | 9%         | 9%      |
|  | Regulatory necessity   |            |         |
|  | Yes                    | No         | Neutral |
|  | 45%                    | 18%        | 36%     |
|  | Licensee acceptability |            |         |
|  | High                   | Medium     | Low     |
|  | 20%                    | 70%        | 10%     |

Table 2. Weight and detailed score for each evaluation criteria

| Evaluation Criteria                  | Answer     | Score |
|--------------------------------------|------------|-------|
| Analysis possibility (Weight: 0.5)   | Possible   | 1     |
|                                      | Impossible | 0     |
|                                      | Neutral    | 0.5   |
| Regulatory necessity (Weight: 0.3)   | Yes        | 1     |
|                                      | No         | 0     |
|                                      | Neutral    | 0.5   |
| Licensee acceptability (Weight: 0.2) | High       | 1     |
|                                      | Medium     | 0.5   |
|                                      | Low        | 0     |
|                                      | Low        | 0     |

- Using the expert evaluation results in Table 1 and the weights in Table 2, the score for candidate No. 5 of the preliminary review guideline can be calculated as follows.
  - Scoring Equation for Preliminary MUPSA Review Guideline No.5 : [Analysis possibility(0.5) × {possible(82) × 1+Neutral(9) × 0.5}]+ [Regulatory necessity(0.3) × {Yes(45) × 1} + Neutral(36) × 0.5] + [Licensee acceptability(0.2) × {High(20) × 1 + Medium(70) × 0.5}] = 73.15
- ✓ Step 6) Development of final MUPSA review guideline(draft)
  - In this step, the final review guidelines were derived based on the priority and importance derived through steps 1 to 5 and the qualitative review opinions of each expert.

## Development of MUPSA review guidelines(draft)

- In this chapter, the MUPSA review guidelines(draft) were derived based on the contents described in previous chapter. The preliminary MUPSA review guideline candidates were reclassified by each PSA step and detailed element, and the results of the expert's qualitative evaluation are reflected as follows.

Fig. 2. preliminary review guideline for multi-unit PSA

- English version of preliminary review guideline for multi-unit PSA can be found in the article.('Development of Preliminary Review Guideline for Multi-Unit PSA')

## Conclusion

- In this study, domestic conformity evaluation system for candidates of preliminary MUPSA review guideline was developed, and expert evaluation was performed to develop the MUPSA review guideline(draft). The priority and importance of each preliminary candidate were derived using the expert evaluation results, and detailed reviews were performed on the preliminary candidates that obtained less than the specific score. The final MUPSA review guideline(draft) were developed by comprehensively analyzing the expert evaluation results and domestic single-unit PSA review guideline.
- The developed MUPSA review guideline is expected to be used as a basis for review when evaluation of MUPSA is required as a national policy in the future.