Development of the Standardized Level 2 PSA Model Structure for the MPAS

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Introduction

개요 및 수행내용

☐ KINS adeveloped the Multi-purpose Probabilistic Analysis of Safety (MPAS) Level 1 PSA model for risk-informed regulation in cooperation with KAERI from 2007 to 2018.

☐ The MPAS Level 1 PSA model cannot evaluate the integrity of containment buildings and radiation materials behavior. Therefore, Developing a Level 2 PSA model for risk-informed regulation required.

☐ In this study, a Plant Damage State Logic Diagram (PDSLD), a Containment Event Tree (CET), Decomposition Event Trees (DETs), and a Source Term Category Logic Diagram (STCLD) are developed. These are the main part of a Level 2 PSA model

Containment Event Tree

표준 CET 개발

☐ Headers for the standardized CET
◉ BYPASS: Containment Bypass Accident

◉ CONISOL: Containment Isolation Failure

◉ RCSFAIL: Reactor Coolant System Status

◉ MELTSTOP: Core Melt Arrested

◉ DCF: Dynamic Containment Failure

◉ ECF: Early Containment Failure

◉ CSLATE: Status of Late Containment Spray System

◉ LCF: Late Containment Failure

◉ BMT: Containment Basemat Melt Through

◉ SCRUB: Status of Fission Product Scrubbing
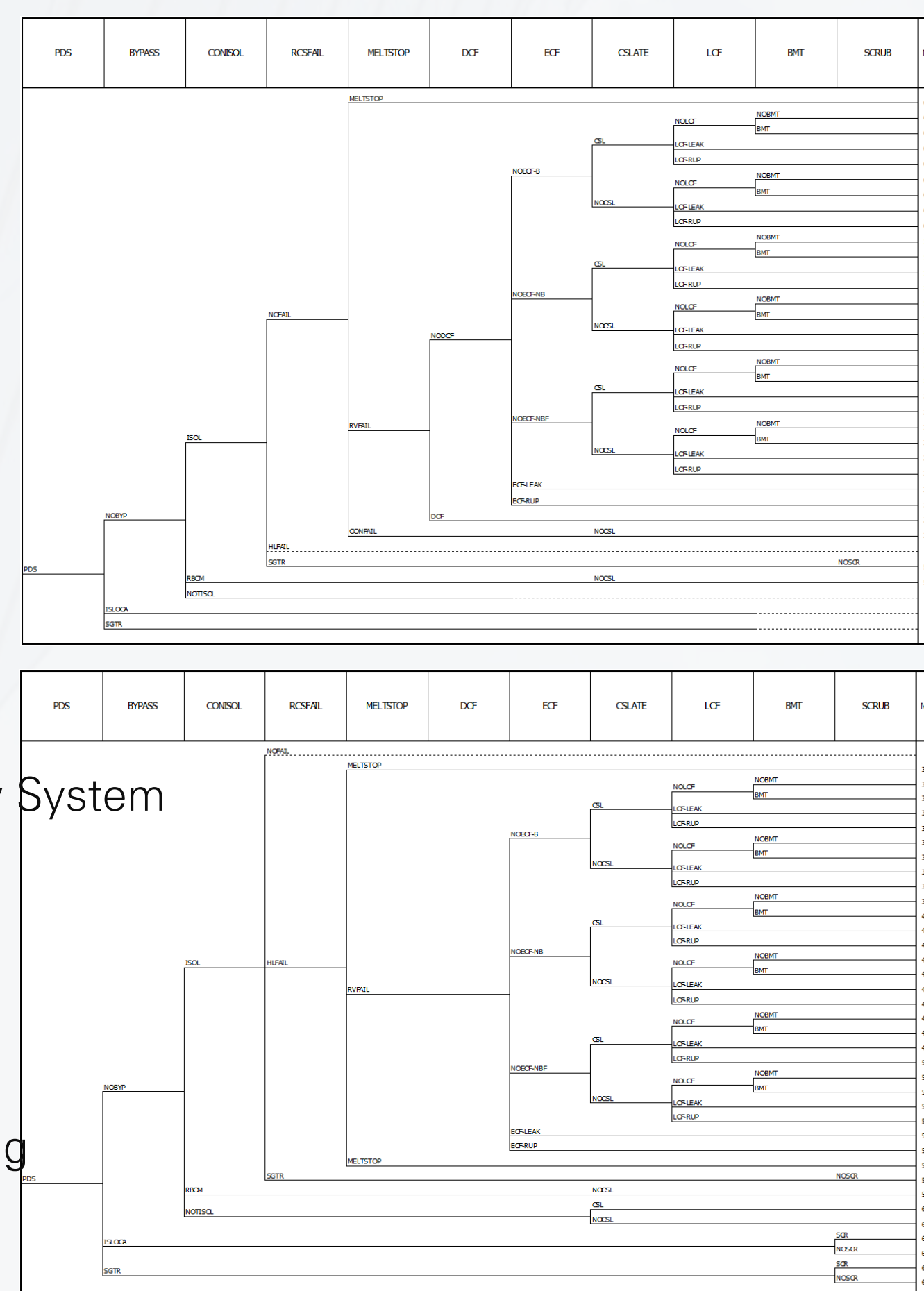
CET is similar to domestic Level 2 PSA model.
Each header is supported by DET.

☐ Considerations for other type plant
◉ WH type
In case of WH type nuclear power plant, Containment spray system doesn't have a heat exchanger. So It is necessary to consider a containment heat removal function separately.

Source Term Category Logic Diagram

표준 STCLD 개발

☐ Headers for the standardized STCLD
◉ BYPASS: Containment Bypass Accident
◉ CONISOL: Containment Isolation Failure
◉ MELTSTOP: In-Vessel Core Melt Arrest
◉ TIMECF: Time of Containment Failure
◉ MODECF: Mode of Containment Failure
◉ CSLATE: Status of Late Containment Spray System
◉ CAVCON: Containment Cavity Condition
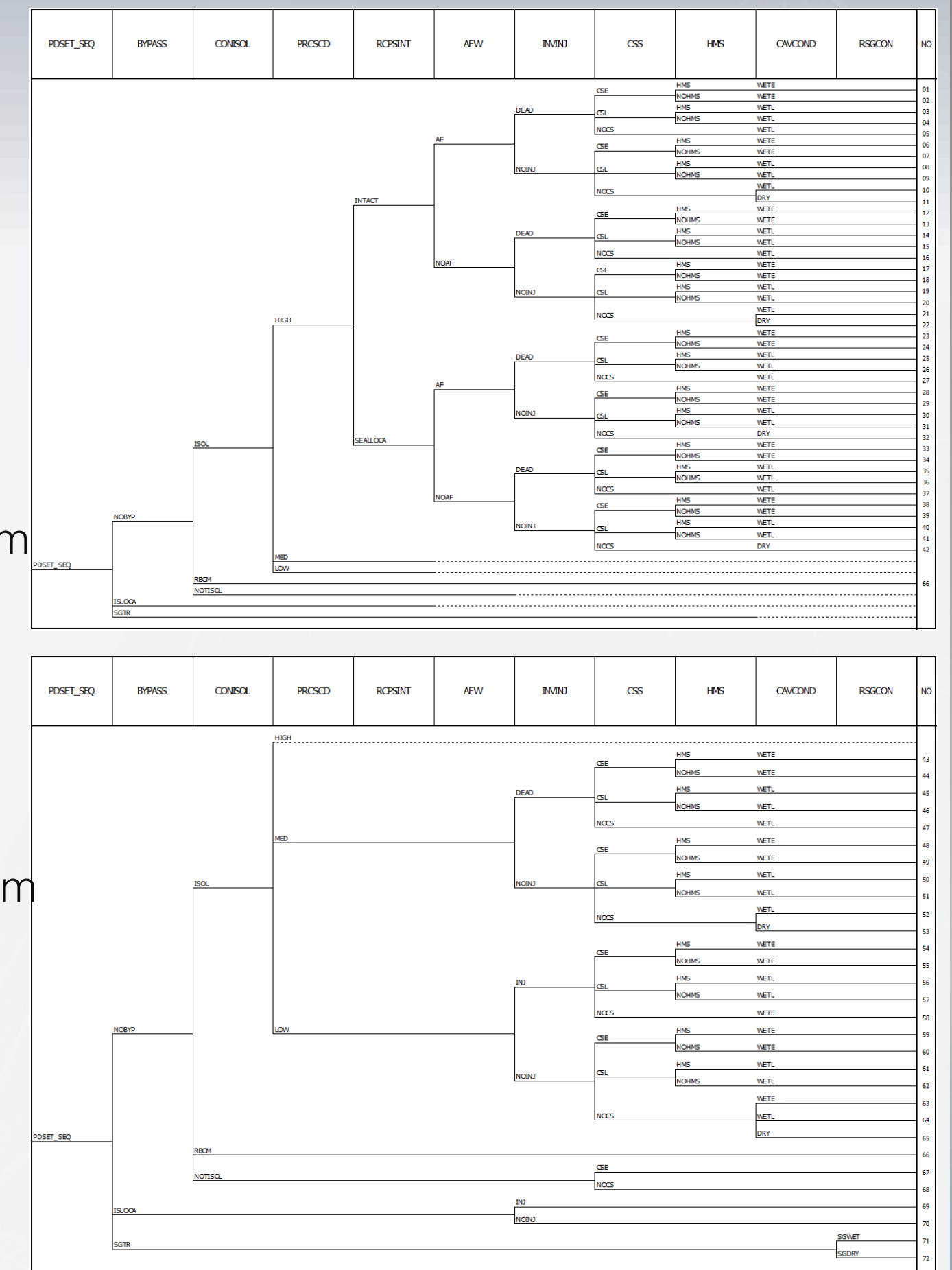◉ SCRUB: Status of Fission Product Scrubbing
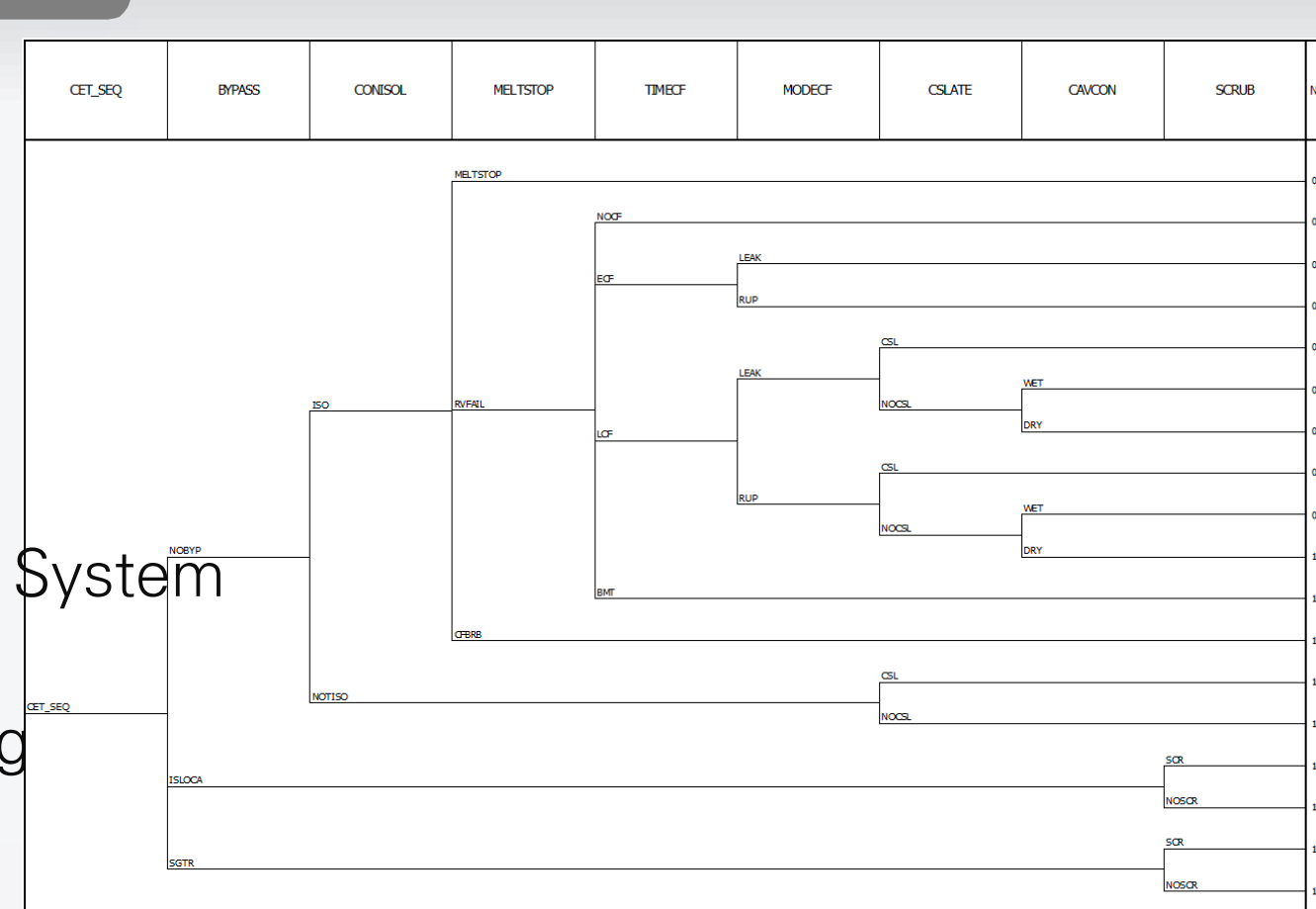
☐ Considerations for other type plant
◉ WH type
In case of WH type nuclear power plant, Containment spray system doesn't have a heat exchanger. So It is necessary to consider a containment heat removal function separately

Plant Damage State Logic Diagram

표준 PDSLD 개발

☐ Headers for the standardized PDSLD
◉ BYPASS: Containment Bypass Accident

◉ CONISOL: Containment Isolation Failure

◉ PRCSCD: RCS Pressure at Core Damage

◉ RCPSINT: Status of RCP Seal Integrity

◉ AFW: Status of Auxiliary Feedwater System

◉ INVINJ: Status of In-vessel Injection

◉ CSS: Status of Containment Spray System

◉ HMS: Status of Hydrogen Mitigation System

◉ CAVCOND: Status of Containment Cavity

◉ RSGCON: Ruptured SG Condition

☐ Characteristics of the standardized PDSLD
◉ Operation time considerations.
CSS header's branches are divided into CSE and CSL to take into account cases where they are not available at the beginning of an accident like a portable containment spray pump.

☐ Considerations for other type plant
◉ APR1400 type
In case of APR1400 type nuclear power plant, a POSRV has the function for switching hydrogen release point in RCS. This function can be affect to hydrogen burning depends on an accident progression.
◉ WH type
In case of WH type nuclear power plant, Containment spray system doesn't have a heat exchanger. A RCFC should be considered as containment heat removal system instead of containment spray system.

Decomposition Event Trees

표준 DET 개발

☐ Reflecting recent researches
◉ RCSFAIL DET
A domestic Level 2 PSA model evaluated the probability of a TI-SGTR based on NUREG-1150. The standardized RCSFAIL DET was developed in consideration of SG condition and Loop seal clearing by referring to NUREG-2195 and RASP Handbook.
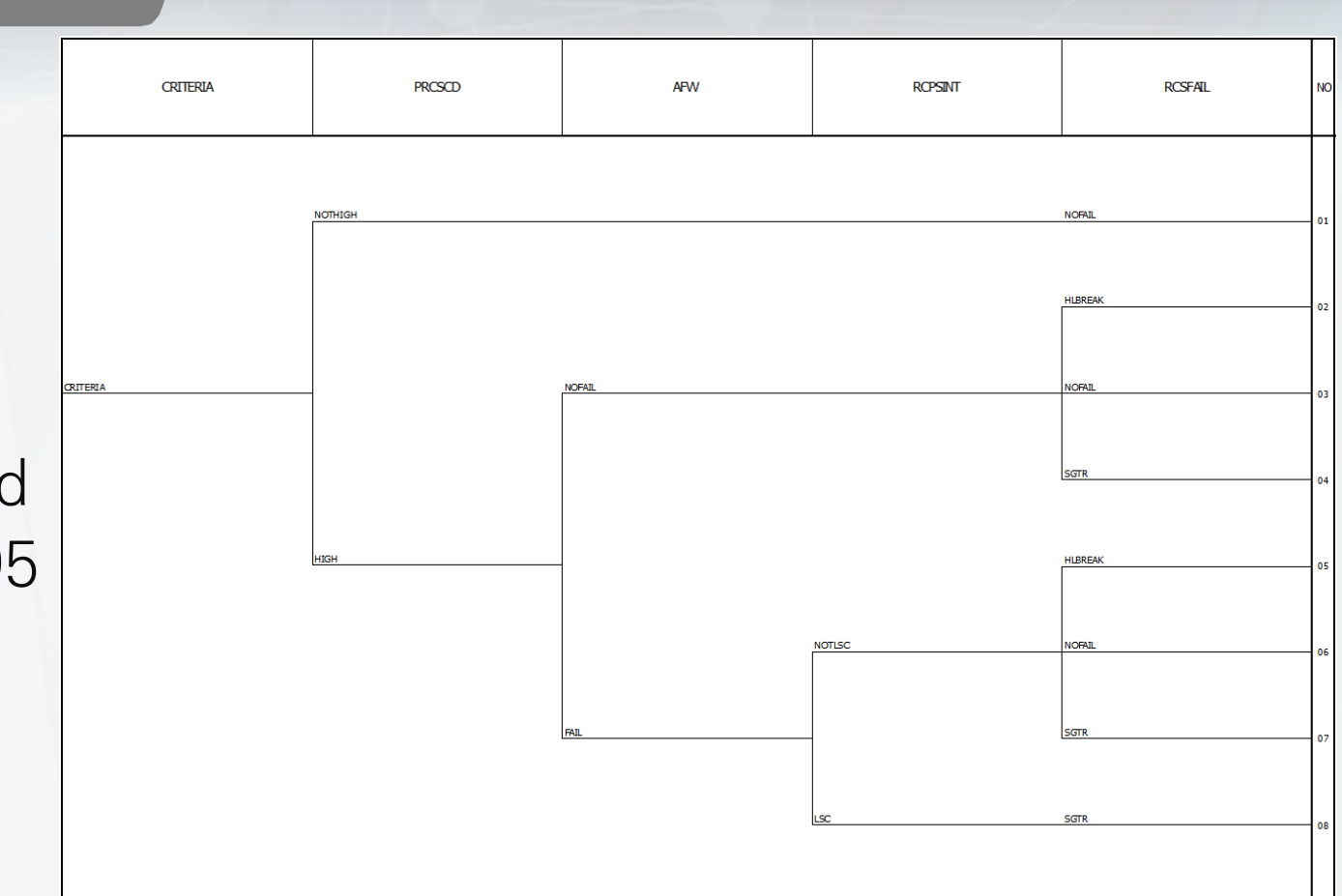
☐ Perform plant specific TH analysis
◉ Meltstop/Basemat melt-through
An Uncertainty analysis through MELCOR will be performed to find a probability of preventing core melt by safety injection and containment basemat melt-through in wet cavity

Conclusion

결론

As safety regulation of nuclear power plants becomes more important, the regulatory agency is trying to prepare a Risk-Informed Decision Making (RIDM) system through a PSA.

The MPAS PSA model currently held by the regulatory agency is limited to the Level 1 PSA model, so it is necessary to develop an MPAS Level 2 PSA model. And this model should be able to evaluate the latest accident mitigation strategies.(e.g. MACST)

In this study, the standardized PDSLD, CET, DET, and STCLD have been developed to reflect the MACST in the Level 2 PSA model.

It is planned to evaluate the effectiveness of the strategy by applying the developed standardized model when performing level 2 PSA for the MACST.