Insights from Quantitative Risk Monitoring Model Development During LPSD Period

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한국전력기술

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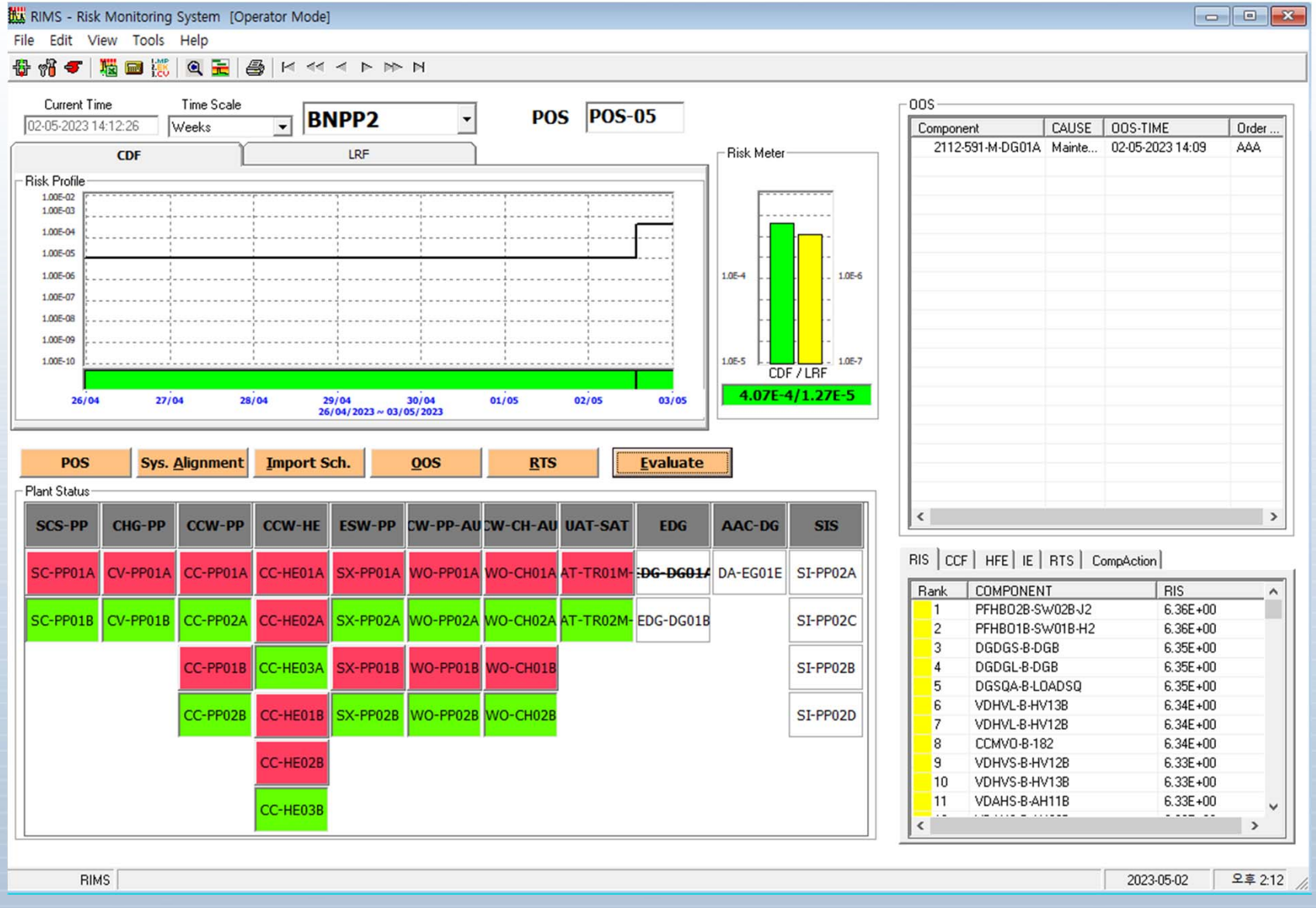
Contents

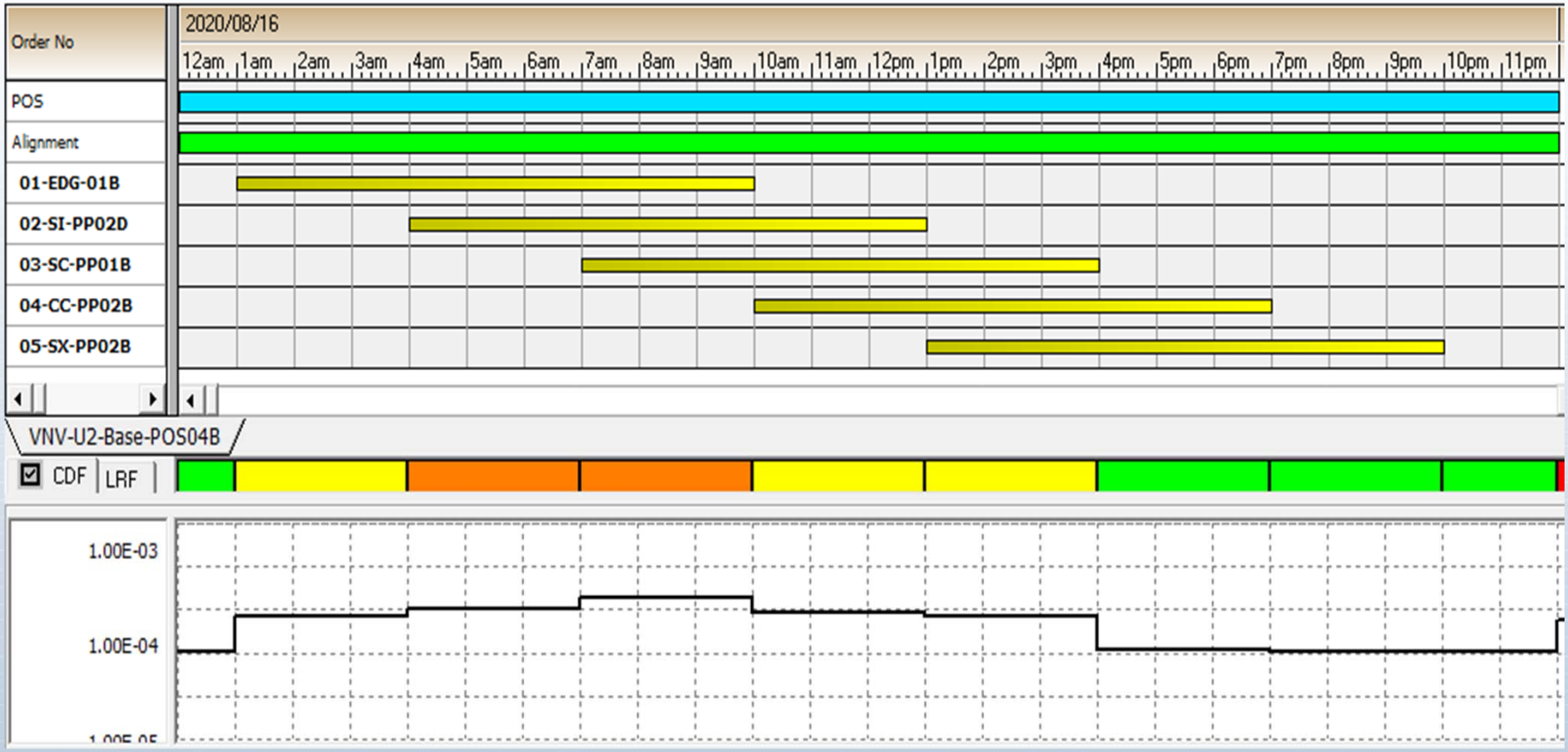
Introduction

- Quantitative Risk Monitoring Models are used to manage Risk in NPPs mainly for
  - Risk monitoring for operational occurrences with current plant configuration (system alignment) and
  - Test and Maintenance Scheduling with acceptable risk profile

Introduction



Introduction



Introduction

- To address regulatory issues in an overseas country, a Quantitative Risk Monitoring Model for LPSD period was developed for APR1400

- So far, several Quantitative Risk Monitoring Models have been developed in Korea. However, they are all for full power operation period

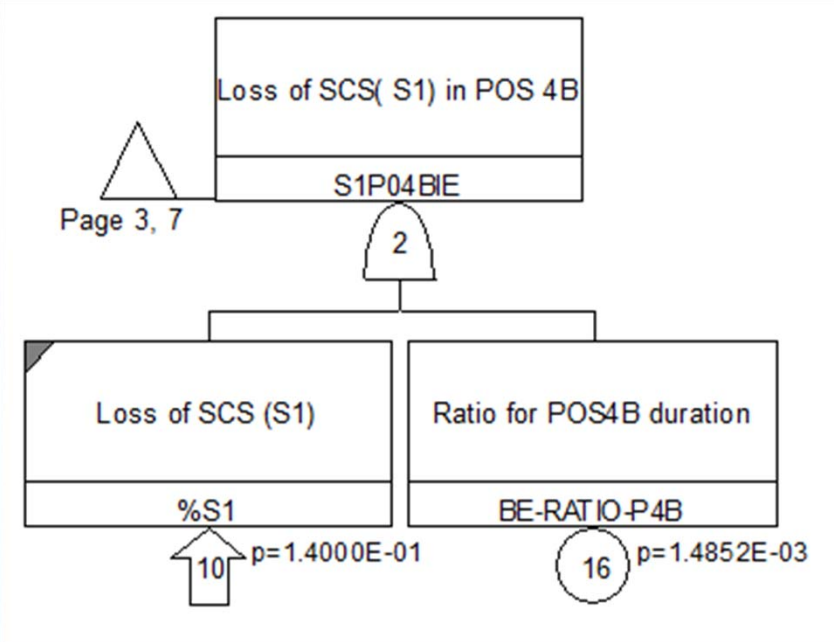
- The insights gained from the Quantitative Risk Monitoring Model development for LPSD period can provide PSA practitioners with very useful information for future QRMM development during LPSD operation period in Korea.

Model Development Process

- Step 1: PSA modifications for single database and single recovery rule file
- Step 2: **Initiating event frequency adjustment**
- Step 3: Systems alignment model development
- Step 4: Support systems initiating event FT (fault tree) development
- Step 5: **LPSD operation characteristics implementation**
- Step 6: **Symmetricity implementation**
- Step 7: Single top FT development for CDF (Core Damage Frequency) and LRF (Large Release Frequency) for each POS (Plant Operation Status)
- Step 8: LPSD quantitative RMM database development

Insights – IEF Adjustment

- Initiating event frequency adjustment
  - Calendar year basis ➔ POS operation year basis
  - Generally performed by changing POS ratio basic event probability to 1.0



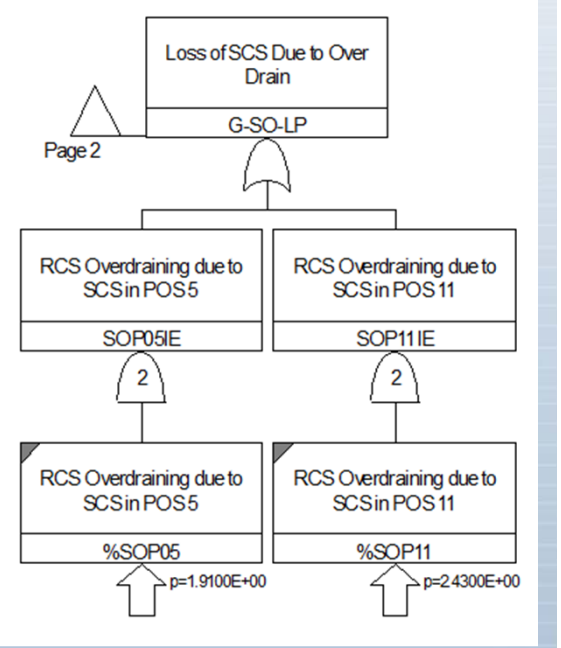
Insights – IEF Adjustment

- Demand-based Initiating events
  - For example, RCS over-drain induced Loss of Decay Heat Removal or PSV stuck open during pop-up test
  - Three options for QRMM
    - Option 1: Average POS duration
    - Option 2: Actual Task (Operation or Test) Duration
    - Option 3: Separate Treatment (Delta CDP or LRP Calculation)
  - IEF for QRMM
    - Option 1: IEF in Base PSA * O/H duration / POS duration
    - Option 2: IEF in Base PSA * O/H duration / Task duration

Insights – IEF Adjustment

- Demand-based Initiating events
  - Option 1 or 2 can be used in the aspect of providing risk information for operation staff in NPPs.
  - For actual risk-informed application, option 3 should be used.
  - Option 1 was selected temporarily and IEF for QRMM was implemented in the fault tree

➔ /AMCS of FTREX options should be used



Insights – LPSD Characteristics

- LPSD operation characteristics implementation
  - Different configurations during each POS for different O/Hs.
  - In base PSA, the modeled plant configurations are average-based. ➔ High possibility of plant configuration changes for each plant refueling overhaul.
  - It is essential to implement the variations of plant configuration for each POS into QRMM
  - Characteristics of the variations
    - Subject to a specific POS
    - Not subject to a specific POS
  - All the operational variations are modeled using flag events in base PSA

Insights – LPSD Characteristics

- LPSD operation characteristics implementation
  - Therefore, flag events are classified as
    - Case 1: Subject to a specific POS
    - Case 2: Not subject to a specific POS
  - For case 1, flag events should be remained as they are in base PSA model for LPSD quantitative RMM development.
  - For case 2, should be changed and incorporated into the LPSD quantitative RMM. Thus, QRMM user can control the plant configuration with these flag events reflecting actual plant configuration.

Insights – LPSD Characteristics

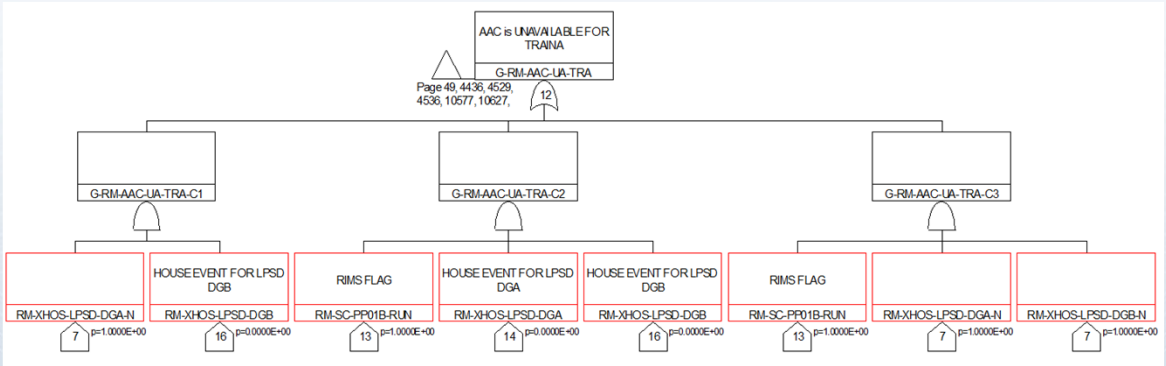
- LPSD operation characteristics implementation
  - Flag events not directly subject to a specific POS condition
    - Most of SSCs OOS.
    - Component Operation Status ➔ Implemented in the system alignment model development
  - Flag events directly subject to a specific POS condition
    - Plant parameters mostly related to the definition of POS

Insights – Symmetricity

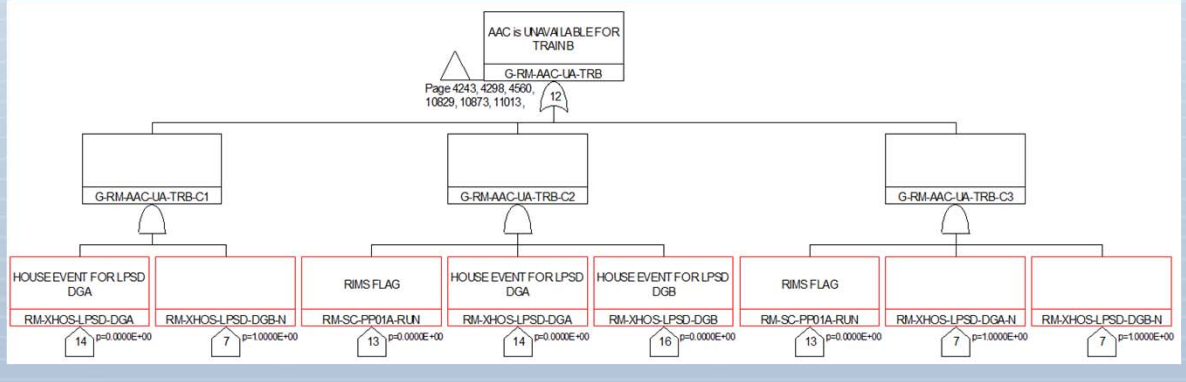
- Symmetricity Implementation
  - Asymmetry in PRA model is mainly caused by
    - Assumptions of failure location for initiating event
    - Asymmetric alignment for shared/swing components or systems.
  - For LPSD PSA, the biggest asymmetry can be caused by assumption of AAC DG alignment because it plays an important role for mitigating SBO (Station Black Out).
  - To reduce asymmetry in Risk results, with regard to AAC DG alignment, the principles below were implemented
    - AAC DG is aligned to a train with the EDG (Emergency Diesel Generator) being OOS.
    - If both EDGs are OOS or in service, AAC DG is aligned to a train with an SC(Shutdown Cooling) pump is running

Insights – Symmetricity

- Symmetricity Implementation
  - To implement the principles above, 4.16kV train Alpha has the flag combination logic below.



  - To implement the principles above, 4.16kV train Bravo has the flag combination logic below.



Insights – Application

- Risk Monitoring Modeling Application
  - Difficulties for LPSD quantitative RMM applications are related to the setting of risk color.
  - For at-power quantitative RMM, average CDF and LRF are just a little higher than no maintenance CDF and LRF.
  - On the other hand, for LPSD quantitative RMM, average CDF and LRF are much higher than no maintenance CDF and LRF. In addition, the instantaneous CDF and LRF are much higher than base PSA because the instantaneous CDF and LRF are calculated per POS year basis rather than calendar year basis.
  - Therefore, risk color should be determined considering the delta CDF and LRF between no maintenance, typical POS average maintenance for each POS independently considering the variations among O/Hs.

Conclusions

- In this paper, a general process for an LPSD QRMM development was listed
- Insights gained in relation to technical issues and solutions for during LPSD QRMM development were described
  - Initiating event frequency adjustment
  - LPSD operation characteristics implementation
  - Symmetricity Implementation
  - QRMM application
- It is believed that the insights described in the paper can provide
  - PSA practitioners with very useful information for future LPSD quantitative RMM development.
  - LPSD QRMM application staff with useful information for risk management strategy

Thank You

Thank You

Q/A

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