Evaluation of Primary and Secondary Water Chemistry Management at Operating NPPs

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1. Introduction

Water chemistry management programs operating at nuclear power plants(NPP) are optimized to reduce the occurrence of corrosive radiation sources, ensure material and fuel integrity, and improve steam generator integrity. These water chemistry management programs need to continuously verify their effectiveness through power plant operation results and need to be improved and optimized based on the latest operational experience and research results. In this study, the adequacy of water chemistry management was diagnosed for NPPs in operation in Korea.

2. Methods and Results

For the evaluation, the water chemistry and radioactivity analysis results of the last 1 cycle of the 24 units in operation in Korea were collected, and the diagnostic evaluation method was established with the following procedure.

- Selection of units and items to be evaluated
- Establishment of measurement data base for each diagnostic parameter
- Outlier detection and exclusion processing
- Trend analysis according to EFPD(Effective Full Power Days) and statistical value calculation
- Conducting evaluation by unit and reactor type

2.1 Evaluation parameters

Each evaluation parameter was selected in accordance with the Final Safety Analysis Report, Technical Specification and Operation Procedure of domestic operating NPPs and PWR Primary/Secondary Water Chemistry Guidelines of the US Electric Power Research Institute [1,2]. Each evaluation parameter was derived by referring to EPRI's PWR Chemistry Monitoring and Assessment, and the influencing factors and evaluation parameters classified accordingly are shown in the table below [3,4].

Table I: Primary system evaluation criteria

	Evaluation criteria
Material Integrity	Anions(Cl^-, F^-, SO_4^{2-}), Dissolved oxygen, Dissolved hydrogen, Lithium, Boron, pH_t, Conductivity, Si, Suspended Solid
Fuel Integrity	Specific activity, Liquid/gas/crud activity
Radiation fields Integrity	Activity of each radionuclide
Demineralizer Integrity	Chemical and Volume Control System demineralizer decontamination Factor

Table II: Secondary system evaluation criteria

	System	Evaluation criteria
Steam Generator tube Integrity	Steam Generator Blow Down	Na, Cl, SO_4, Si, Cation conductivity, pH, pH control agent,
Main System Integrity	Feed Water	pH, pH control agent, Dissolved oxygen, Hydrazine, Fe, Cu
	Condensate Water	Dissolved oxygen
Aux. System Integrity	Stator Cooling Water	Dissolved oxygen, Total conductivity, Cu
	Condensate Storage Tank	Cl, SO_4, Si
Main management index	SG integrated Exposure Redox evaluation Sludge deposition	

2.2 Evaluation contents and criteria

The main evaluation contents for the derived evaluation items are as follows.

- Exceeding limit values and abnormal trends during periodic operation for each unit
- Evaluation of cycle operation statistics (average, maximum, minimum, median value and distribution map) for each unit/reactor type

The evaluation criteria refer to the khnp chemical performance index evaluation criteria, and generally follow the criteria below.

Table III: Evaluation criteria for water chemistry

	Classification	Remark
Excellent	Above 90% of Target value	Evaluation of the average value for one cycle
Good	75~90% of Target value	
Average	Less than 75% of Target value	
Poor	Exceeding limit value	

2.3 Data Processing

Abnormal data that can cause distortion in data analysis may exist in the NPP water chemistry and radioactivity database built on the basis of a vast amount of SAP data due to various reasons such as incorrect entry and unit confusion. In this diagnostic evaluation, correction or removal was performed by applying the interquartile range review as an outlier processing method for the analysis results. Statistically, it was judged as an outlier if it was out of the upper/lower 1.5 Inter Quartile Range (IQR).

- (lower outlier) Q1 - 1.5×IQR
- (upper outlier) Q3 + 1.5×IQR
  IQR = 3rd quartile - 1st quartile
  = Q3-Q1

2.4 Results

In this study, a comprehensive evaluation of primary and secondary system water chemistry management was performed on an operating cycle basis. The status and adequacy of water chemistry management of domestic NPPs were evaluated by conducting diagnosis by unit and cycle and comparative evaluation among reactor types. As a result of the evaluation, it was evaluated that ALARA (As Low As Reasonably Achievable) Chemistry was achieved by not only satisfying the management standards in all water chemistry evaluation items, but also maintaining most of the items below 10% of the management standard values.

3. Conclusions

Water chemistry measurement results are key data for operation/design of NPPs and have high asset values, so quality data management is very important. Through this water chemistry operation diagnosis evaluation, it is expected to contribute to the establishment of a more standardized chemical management system by reviewing the water chemistry management results for each cycle of domestic NPPs and mutually diagnosing the management level.

REFERENCES

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