Water Chemistry Guidelines of Light Water Reactors

Background

In recent years,various technical options of water chemistry appear, and water chemistry technology is further diversified and complicated by the increase in nuclear power plants of different generations. For this reason, it is required to clarify systematically the knowledge, experience, and technical bases about the water chemical management cultivated so far. Moreover, it is also required to pass on water chemical management technology correctly to the next generation. Based on such a background and the request of Federation of Electric Power Companies, Central Research Institute of Electric Power Industry drew up light water chemical guidelines.

Objectives

For the purpose of realizing the water chemistry operation guide of light water reactor power plants, to systematically compile knowledge about the water chemistry of Japanese light water reactors, which are at a globally high level, and to draw up BWR and PWR water chemistry guidelines.

Principal Results

1. Constitution of light water chemistry guidelines.

BWR water chemistry guidelines consist of three volumes, i.e., (1) “BWR water chemistry guideline”, (2) “BWR water chemistry at startup and shutdown, a cold-and-warmth shutdown, and hydrogen injection”, (3) “Zinc injection and Noble-metals injection” aiming at the reduction of radiation exposure and SCC inhibition, as shown in Table -1. On the other hand, PWR water chemistry guidelines consist of four volumes. From a viewpoint of the integrity of nuclear reactor structural material and fuel cladding, (4) “PWR primary water chemistry guideline”, (5) “ PWR primary water chemistry guideline at startup and shutdown “ were drawn up. From the viewpoint of steam generator integrity and dose-rate reduction, (6) “PWR secondary water chemistry guideline” and (7) “PWR secondary water chemistry guideline at startup and shutdown” were drawn up.

2. BWR water chemistry guidelines

As an example, the limited value of water qualities during the normal operation time is shown in Table -2.

A setup of limited values of water qualities was defined from the three points of view, i.e., the integrity of structural material integrity, and the soundness of fuel cladding, and the exposure reduction, and the technical bases were specified. The permissible maximum value of water qualities was defined in order that “a level 1” might maintain the integrity of a plant, and “a level 2” are the limited values for maintaining the integrity of a plant.

“The recommendation value 1” is a desired limited value defined in order to usually maintain an operating standard. On the other hand, “the recommendation value 2” is a policy objective value on the water chemistry control which can be attained over a long period of time in good operational condition. Concerning the new technology of Zinc injection and Noble-metals injection, it focused on arranging the present knowledge.

3. PWR water chemistry guidelines

As an example, the recommended pH control method of PWR primary coolant is shown in Fig. -1. The pH control method was determined from the three points of view, i.e., the integrity of nuclear reactor structural material, the soundness of fuel cladding, and the dose-rate reduction. On the other hand, the limited value of secondary system was defined from a viewpoint of the integrity of a steam generator and secondary system instrument.

Future Developments

Seven guidelines drawn up so far will be revised and combined together into three volumes: BWR, PWR primary system, and PWR secondary system. Moreover, water chemistry standardization will be attained about “water quality analysis”, “water chemical management”, and “corrosion potential distribution in LPR and in-core”.

Main Researchers:

Hideo Hirano, Ph.D., Senior Research Scientist and Masafumi Domae, Ph.D., Research Scientist, Materials Functions and Mechanism Creation Sector, Materials Science Research Laboratory

Reference

1. BWR Water Chemistry Guideline - Zinc injection and Nobel Metal Chemical Addition - CRIEPI Report W03802 (March, 2004)(In Japanese)
2. PWR Water Chemistry Guideline - Start-up and Shutdown- CRIEPI Report W03803 (March, 2004)(In Japanese)

Table 1 Constitution of Light Water Chemistry Guidelines

Type of Reactor		Operation Condition
BWR		Normal Operation
		Startup and Shutdown, Cold- and Warmth- Shutdown, Hydrogen Injection
		Zinc Injection, Nobel Metal Injection
PWR	Primary System	Normal Operation
		Startup and Shutdown
	Secondary System	Normal Operation
		Startup and Shutdown

Table 2 Water Chemistry of BWR coolant

Control Item		Level 1	Level 2	Recommended Value 1	Recommended Value 2	Measurement Frequency
Item	Unit					
Conductivity	μ S/cm	≦10	≦1	≦0.4	≦0.15	Continuation
pH	(25℃)	4 ～ 10	5.6 ～ 8.6	–	–	D
Cl^-	ppb	≦500	≦100	—	≦15	W
SO_4^{2-}	ppb	—	—	≦100	≦10	M
Silica	ppb	—	—	≦1,000	—	W
Dissolved Oxygen	ppb	—	—	≦400	—	D
Impurities of Metal	ppb	—	—	≦200	—	W
I 131	Bq/g	—	—	—	—	W
Boron	ppb	—	—	≦200	—	M

Notes；D： 1 time/day-measurement, W： 1 time/week-measurement, M： 1 time/month-measurement

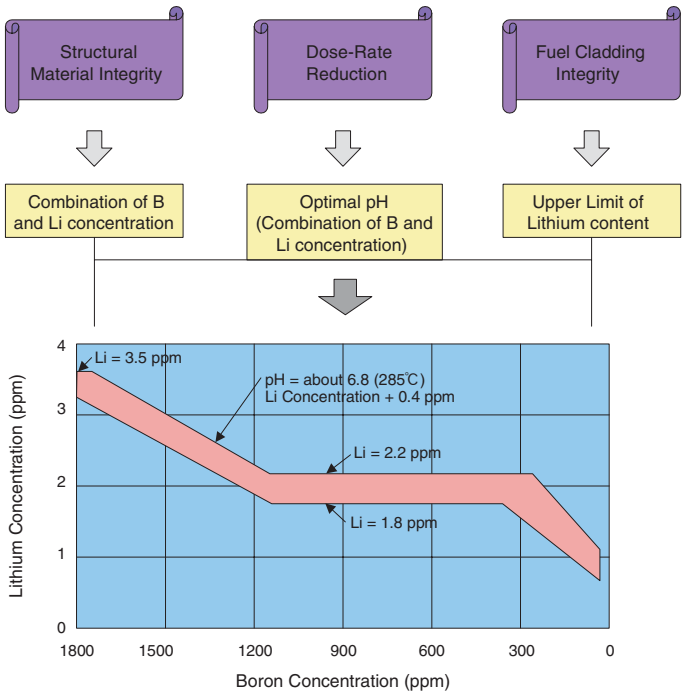

Fig.1 Recommended pH control method of PWR primary Water