7B-4

WATER CHEMISTRY CONTROL AND DECONTAMINATION EXPERIENCE WITH TEPCO BWR'S AND THE MEASURES PLANNED FOR THE FUTURE

N. SUZUKI and K. MIYAMARU
Radiation Safety Control Section
The Tokyo Electric Power Company

ABSTRACT

The new TEPCO BWR's are capable of having the occupational radiation exposure controlled successfully at a low level by selecting low cobalt steel, using corrosion-resistant steel, employing dual condensate polishing systems, and controlling Ni/Fe ratio during operation. The occupational radiation exposure of the old BWR's, on the other hand, remains high though reduced substantially through the use of low cobalt replacement steel and the partial addition of a filter in the condensate polishing system. Currently under review is the overall decontamination procedure for the old BWR's to find out the measures needed to reduce the amount of crud that is and has been carried over into the nuclear reactor. The current status of decontamination is reported below.

INTRODUCTION

The new BWR's (Fukushima Daini & Kashiwazaki-Kariwa) of TEPCO have introduced radiation exposure lowering measures in terms of steel and equipment, including the use of low cobalt steel to reduce cobalt radioactivity, selection of corrosion resistant steel, and a dual condensate polishing system to reduce the feedwater crud. Chemical control of feedwater has also been employed to control Ni/Fe ratio. The above control measures, together with automation of the inspection operation, have contributed as a whole to keeping the occupational radiation exposure at a low level since the reactor start-up.

For the old BWR's (Fukushima Daiichi), various control measures have been taken to reduce the occupational radiation exposure using the experience gained from the new BWR's. With respect to steel and equipment, low cobalt steel has been used and a hollow fiber filter (HFF) partially added to the condensate polishing system. Though the occupational radiation exposure could be effectively reduced by these measures, it still remains higher when compared with the new BWR's.

PLANT DESIGN OF TEPCO's BWR's

TEPCO's plant design can be classified into two categories according to the water treatment method of the feedwater and condensate systems.

One is the new BWR's, in which the condensate polishing system is of a dual construction, with a precoated type CF or HFF installed upstream of CD to cut down the crud in the feedwater. Moreover, the new plant employs low cobalt and corrosion resistant steel in the materials and equipment to be used, lowering the Co radioactivity.

The other includes the old plants, which were originally equipped with an independent CD as a condensate polishing system. Certain plants are now either provided with HFF for partial polishing of the condensate or employ the low-Co steel for replacement. (Figure 1)

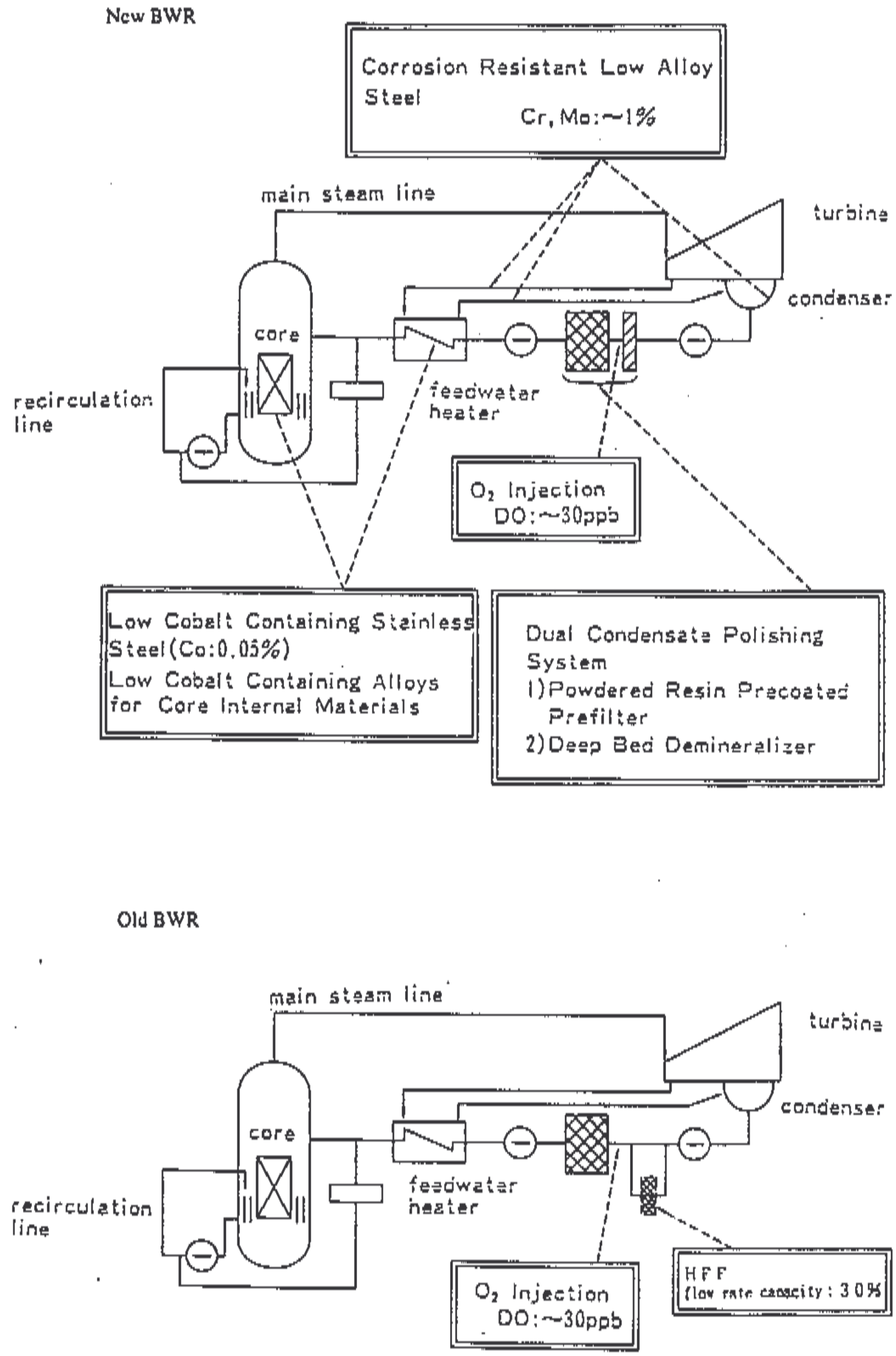


Figure 1. New vs Old BWR's

PRESENT STATUS OF RADIATION EXPOSURE DURING MAINTENANCE OUTAGE

Figure 2 shows the occupational radiation exposure during maintenance outage. The radiation exposure shown here corresponds to that during the standard maintenance works excluding additional works. The exposure level shows an annual downward trend in old plants and has been recently estimated to be around 2 - 4 man.Sv, which still remains higher than the 0.5 - 3 man.Sv for new plants.

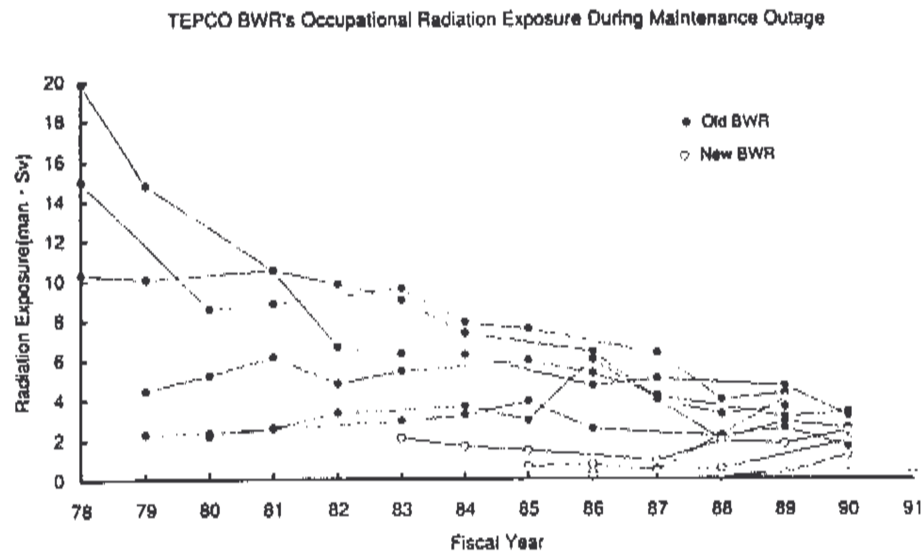
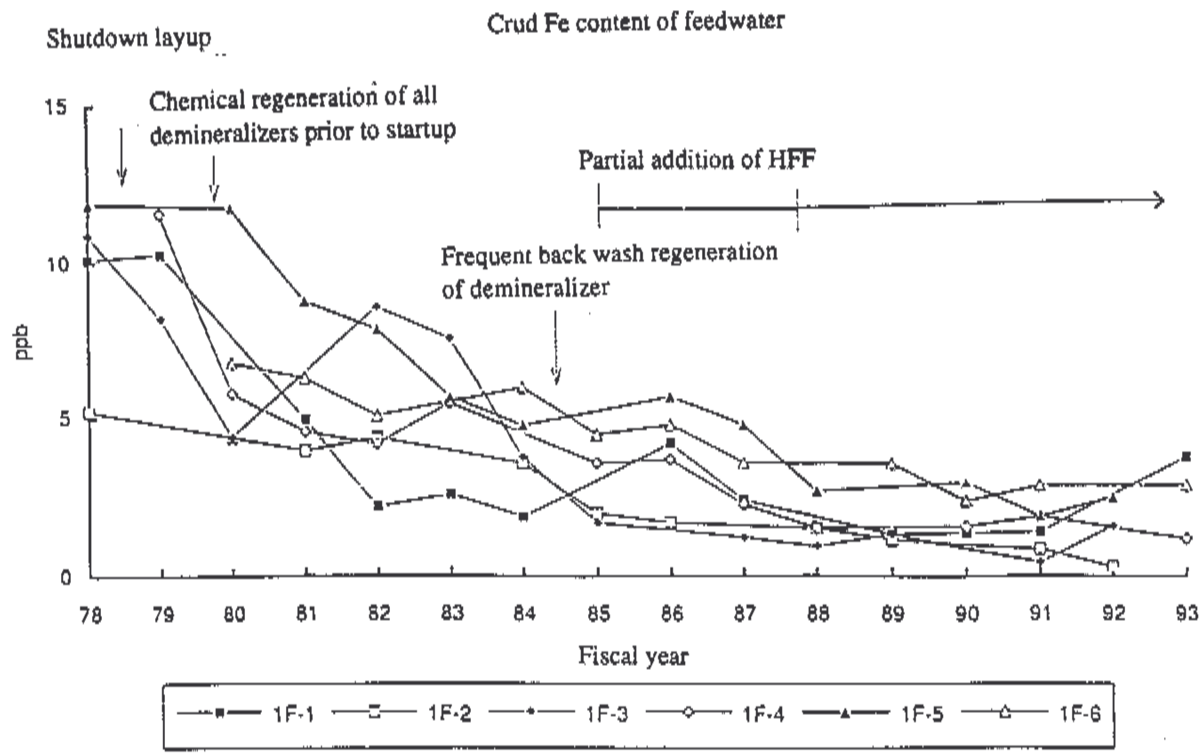


Figure 2

Such an annual decrease in radiation exposure at old plants may be attributed partially to a decrease in the radioactivity caused by crud through reduction of the crud content in feedwater. The crud content was cut down by increasing the back wash frequency of CD to improve its performance in holding down the Fe content or by adding HFF upstream of CD. Decrease in the crud content in feedwater in turn has caused a gradual decrease in the radiation exposure. (Figure 3)

A factor which still keeps the radiation exposure on a higher level in old plants than in new plants, is known to be the higher contribution of crud radioactivity (Figure 4). This has become evident from the comparison between new and old plants in terms of the dose rate of PLR piping by ion and crud.


Crud Fe content of feedwater
Shutdown layup
Chemical regeneration of all demineralizers prior to startup
Partial addition of HFF
Frequent back wash regeneration of demineralizer
ppb
15
10
5
0
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93
Fiscal year
1F-1 1F-2 1F-3 1F-4 1F-5 1F-6

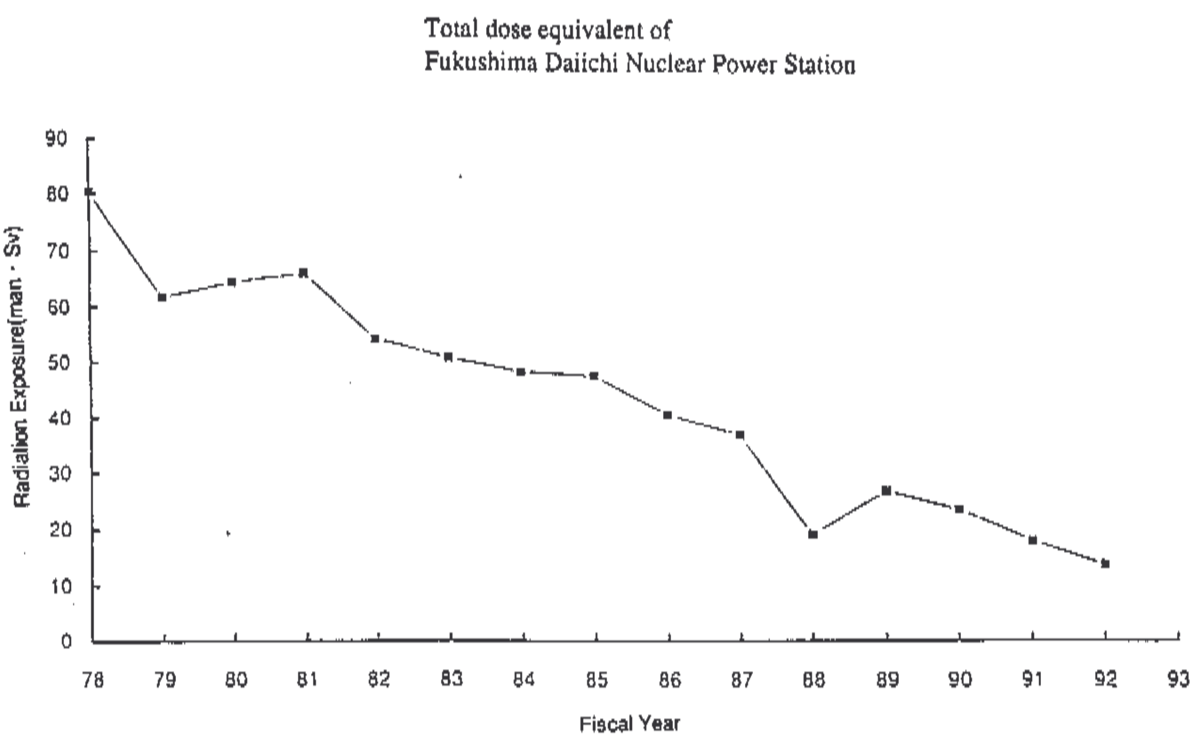

Total dose equivalent of
Fukushima Daiichi Nuclear Power Station
Radiation Exposure(man · Sv)
90
80
70
60
50
40
30
20
10
0
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93
Fiscal Year

Figure 3

Comparison of dose rate of
PLR piping surface

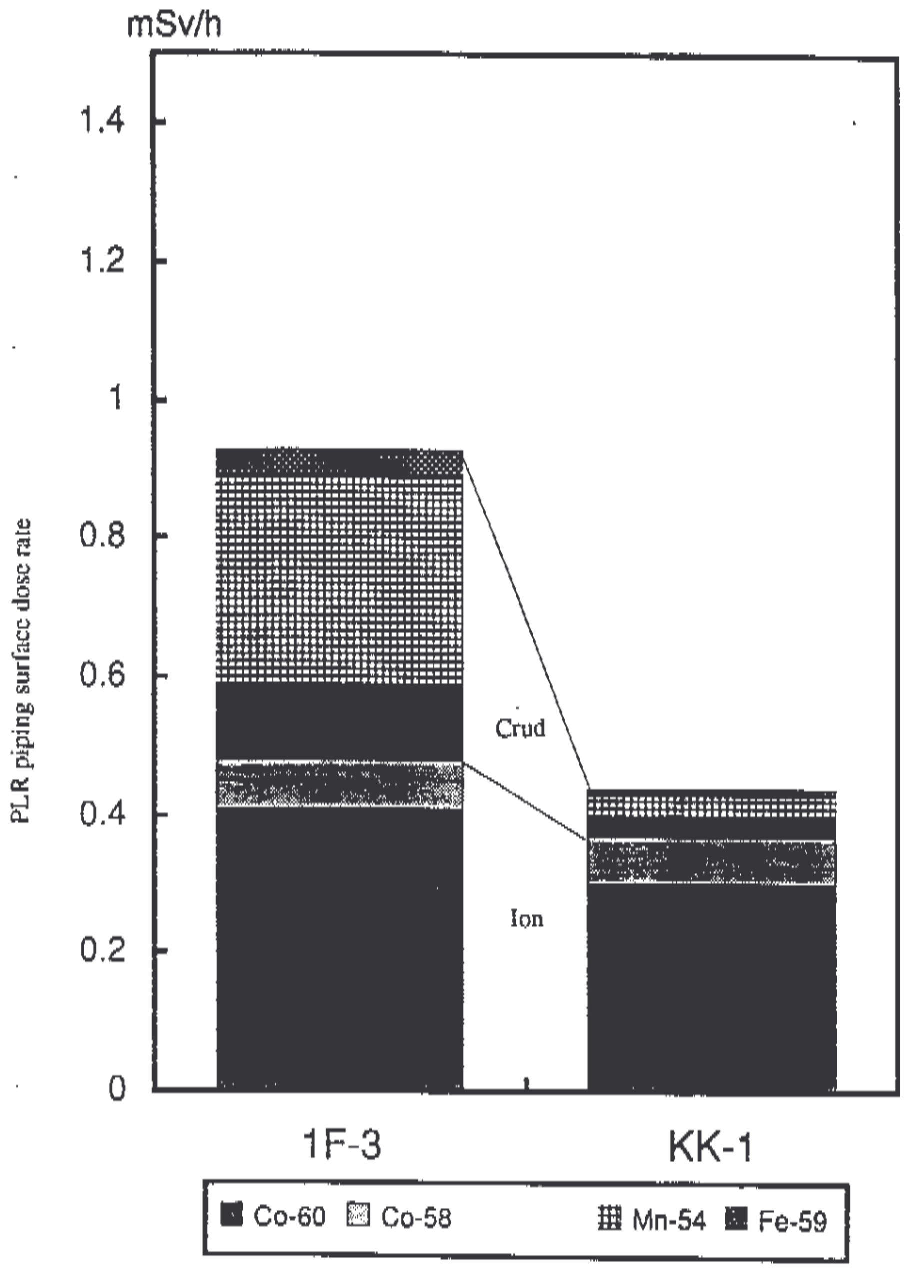


Figure 4

FUTURE RADIATION EXPOSURE CONTROL MEASURES

The radiation exposure control measures for old plants have conventionally included roughly two types. One is to promote a decrease in the crud content of feedwater and the other is to suppress the radioactivity of crud already accumulated in the reactor and systems.

Firstly, reduction of the crud content of feedwater in old plants is discussed. Two methods can be considered. One is to increase the treatment capacity of HFF by undertaking the partial polishing of the condensate while the other is to provide the CD resin with the ability to hold down the Fe content. Introduced below is the CD resin developed recently which has a greater capacity to hold down the Fe content than conventional resins.

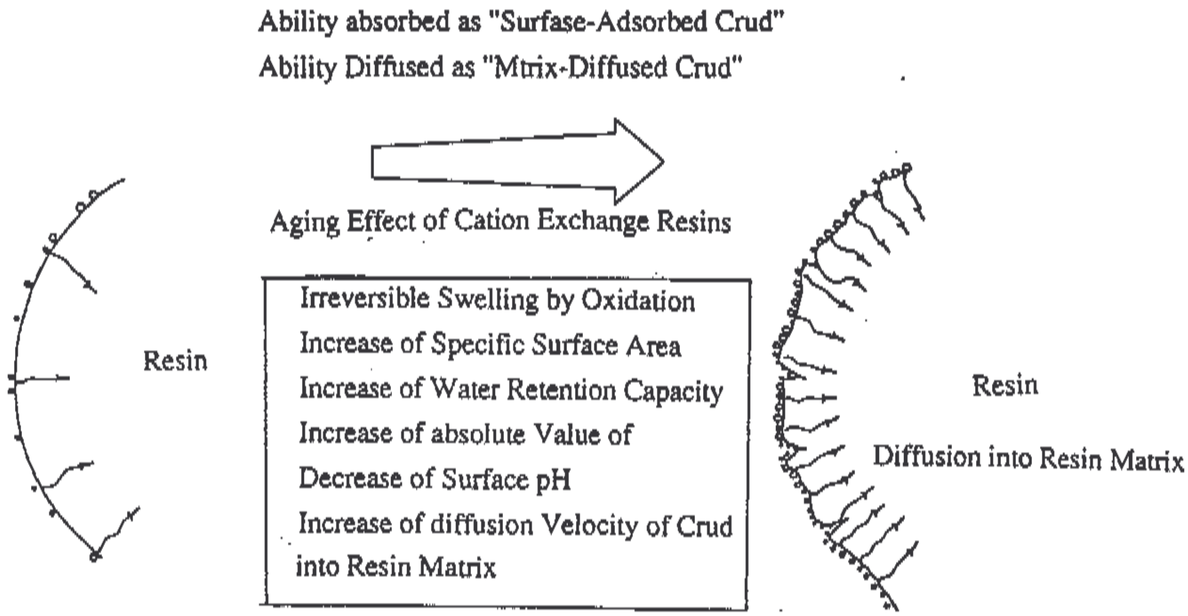
Conventionally, in old plants, the crud content of feedwater was controlled by providing the CD resin with the ability to suppress the Fe content through the aging effect. This aging effect is caused when the CD resin is subjected to chemical regeneration for use over an extended period of time while maintaining the deionizing ability. Namely, the ability of the CD resin to suppress the Fe content has been maintained on the basis of the expected enhancement of the ability diffused as "Matrix-diffused crud", which in turn was caused by an increase of specific surface area and water retention capacity during use for a long period (Figure 5). Some resins have been used for as long as 15 years.

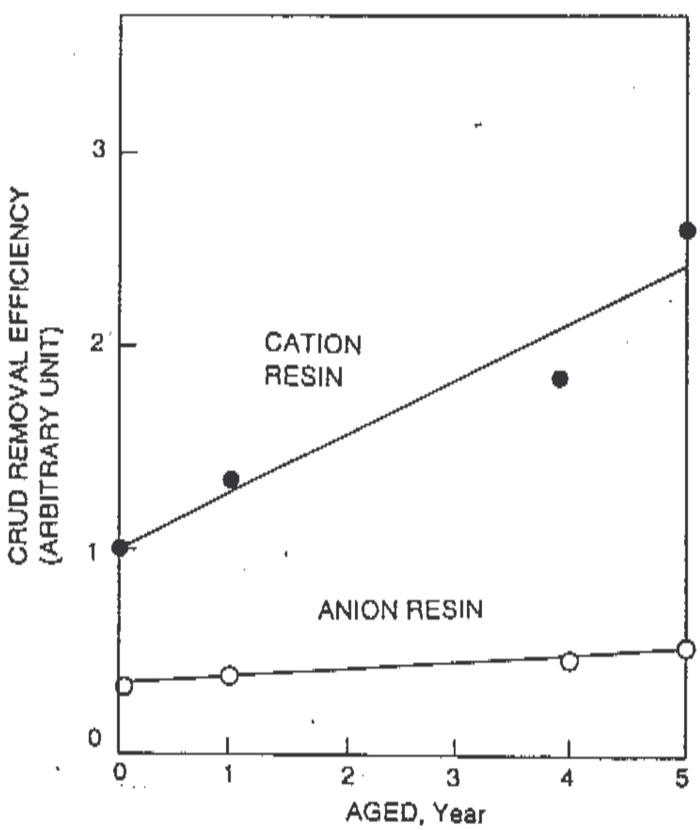
On the other hand, the resin has a general tendency to suffer a larger amount of TOC elution with increasing water retention capacity. In old plants, therefore, the phenomenon of rising reactor water conductivity tends to be observed at the start of reactor operation, which is attributable to elution of TOC from the CD resin. (The reactor water conductivity is normally around 0.3 - 0.4 μS/cm maximum, but amounts to around 0.8 μS/cm in certain old plants.) When the CD resin is replaced by the new one to suppress an increase in the reactor water conductivity at startup, the resin loses its aging effect, resulting in an increase in the crud content of feedwater and finally causing an increase in the crud radioactivity.

As a countermeasure, we have developed a resin, which shows a sharp water retention capacity distribution curve though the average water retention capacity is similar to that of the conventional resins. We have also conducted a water flow test by incorporating the newly developed resin in one (CD1) of eight actual CD's. The result shows that the newly developed resin demonstrates the ability to suppress the Fe content, approximately equivalent to that of the resin provided with the aging effect gained through 12 years of use. The result also proves the acceptability of the new resin in that it is free from any remarkable increase in the reactor water conductivity even during in-service use of the test demineralizer. (Figure 7)

We plan to introduce the above newly developed resin as a means to control the crud content of feedwater in the future.

As regards lowering of the radioactivity of the crud accumulated already in the reactor and systems, the mechanical or chemical decontamination shown in Figure 8 may be considered. These decontamination measures will be put into practice after an in-depth study on the effect of suppressing radiation exposure and the countermeasures appropriate to preventing re-contamination.





Improvement of crud removal efficiency
by aging of condensate demineralizer resins

Figure 5

Suppression of elution of new gel type resin

Water content distribution of new gel type resin

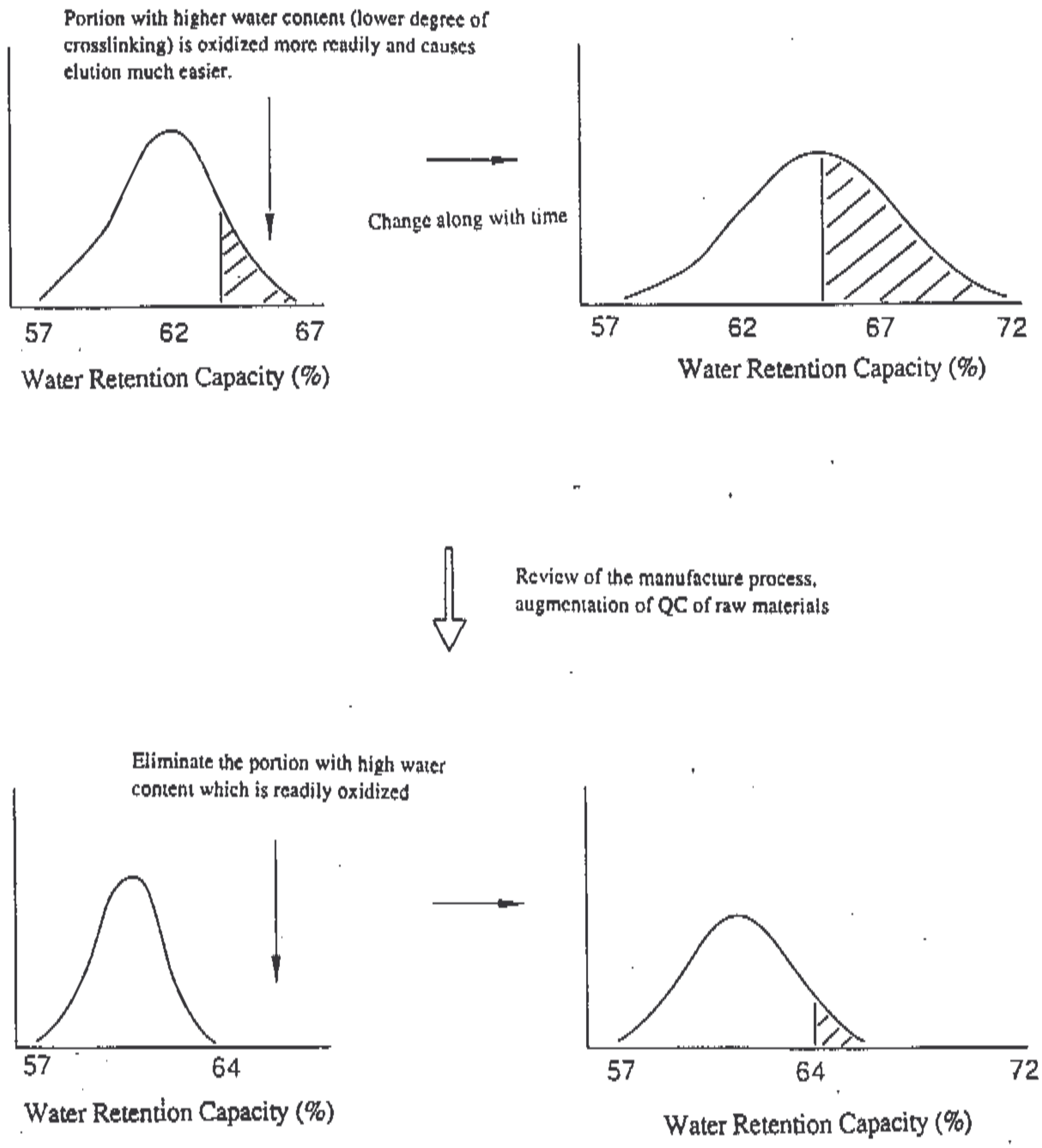
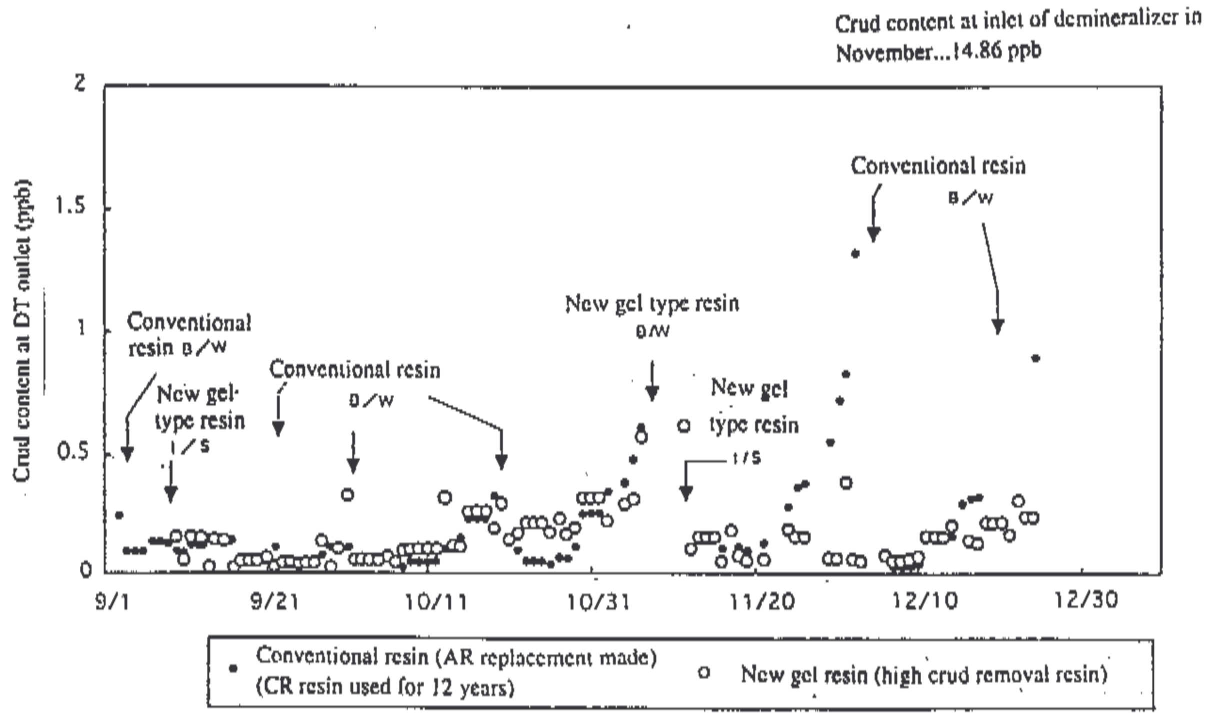
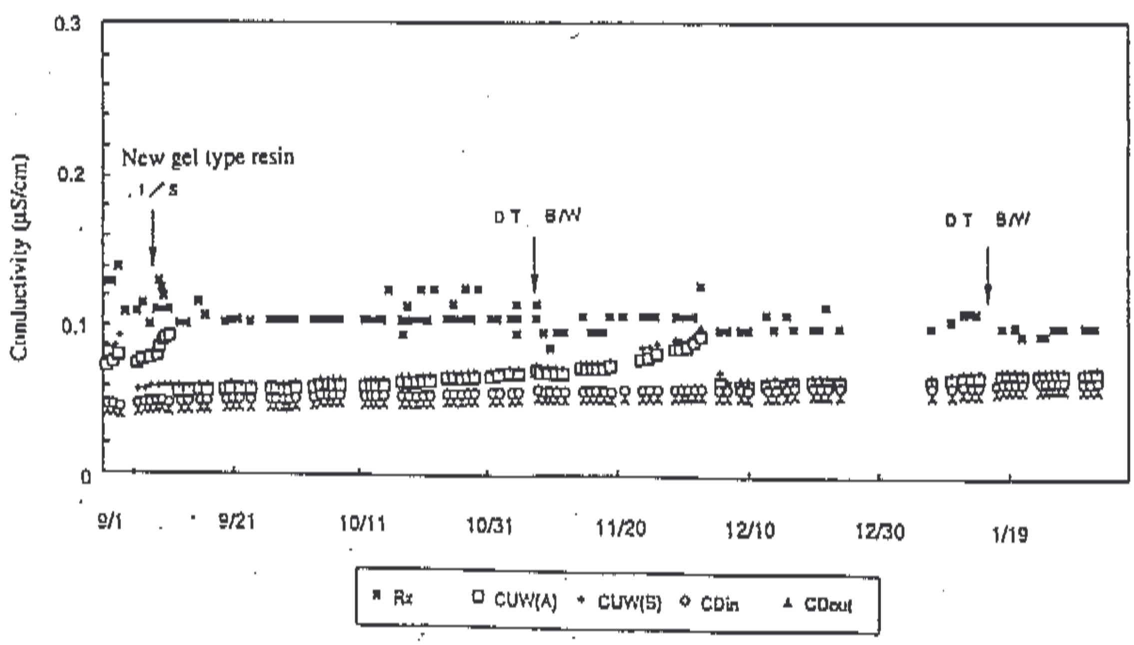


Figure 6 Suppression of elution of new gel type resin (Improved new gel type resin)



IF-2 Crud Fe content (DT outlet)



Water quality

Figure 7

Plant decontamination plan

Decontamination sequence

Water quality improvement measures

→ Elimination of radiation source

- Reactor (water spray cleaning, cleaning with brush)
- Fuel

→ Decontamination of the portions with high dose rate

- System pipings [Water jet cleaning, chemical decontamination]
- Equipment [CO_2 blast, chemical decontamination]

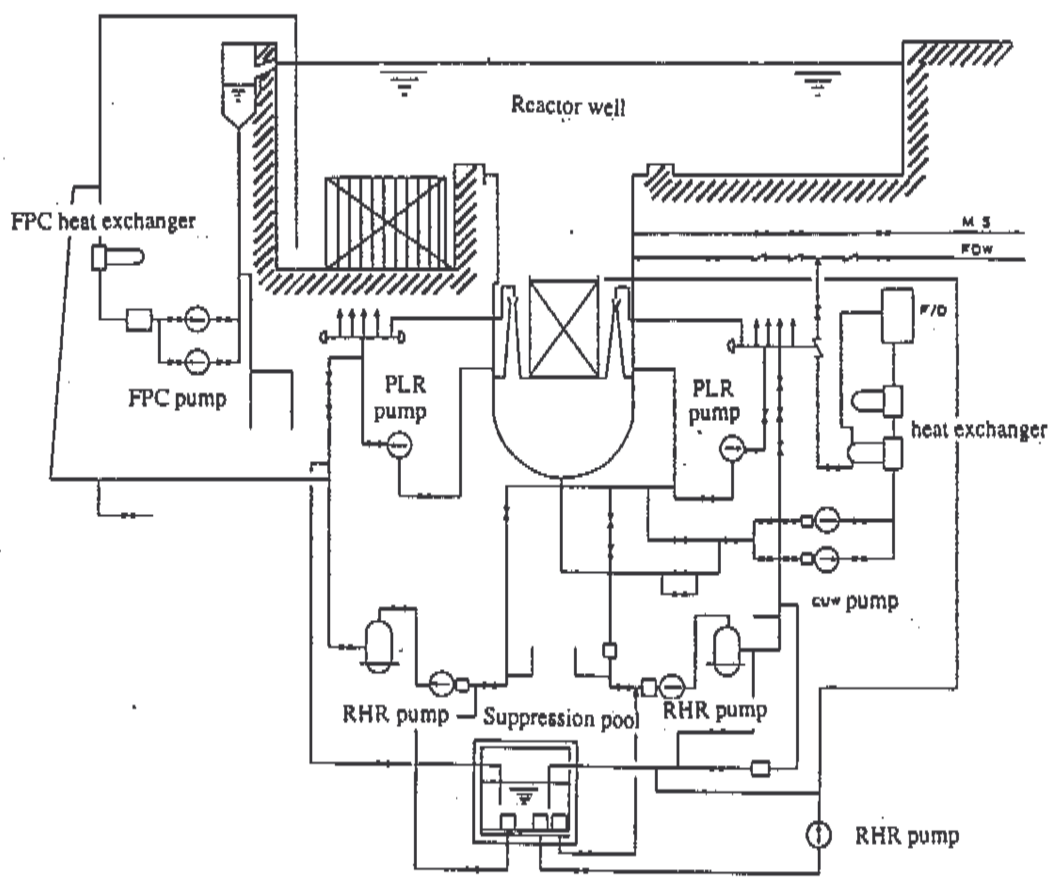


Figure 8

Summary

The old BWRs of TEPCO continue to create radiation exposure higher than the new BWR's, and the lowering of the crud content of feedwater and decontamination of the radioactivity accumulated in the reactor and systems are considered vital. For control of the crud content of feedwater, a CD resin with an improved ability to suppress the Fe content has been developed and will be applied to an actual system. On the other hand, for successful decontamination, it is essential to conduct proactive studies into the effects of suppressing radiation exposure and measures to prevent recontamination. We will proceed with these measures while checking effective decontamination methods and locations while considering crud content suppression measures to prevent recontamination.

Author Biography

Nagao Suzuki is a Deputy Manager, Head Office at the Radiation Safety Control Division of Tokyo Electric Power Company. He is in charge of monitoring of water chemistry at Fukushima Daiichi, Fukushima Daini, and Kashiwazaki Kariwa nuclear power stations. He also undertakes the planning and execution of water chemistry and equipment related measures, as required, by ALARA. In his former position, he was in charge of water chemistry, radiation, and release of radioactive waste controls at the Fukushima Daini nuclear power station. He holds a Bachelor Science in Industrial Chemistry (Engineering Department) from Meiji University.

Tokyo Electric Power Company
1-3 Uchisaiwai-cho 1-Chome Chiyodaku
Tokyo 100 Japan

Phone:	+81 03 3501 8111
Fax:	+81 03 3596 8540