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《Technical Report》

Radioactive Liquid Waste Management of Typical PWR's

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1. Introduction

The review of the present radioactive liquid waste management systems of PWR's shows that the amount of waste generation in the nuclear facilities are greatly under-estimated, and the wastes are miss-managed. In this paper the generation of radioactive liquid wastes is systematically reviewed and the characteristics of each waste stream is evaluated for logical processing. Presently it is very conventional to collect the wastes in a single surge system and commonly process them through a system, which results in an expensive and insufficient management of the liquid radwaste.

The proposed management scheme encompasses the collection and processing facilities to handle radioactive waste water resulting from the operation of typical 1,000 MW class PWR plants. The present philosophy imposed on the design of this system requires that the wastes be segregated, collected and processed to its chemical and radiochemical characteristics. Processing components are proposed to provide both chemical and radiochemical decontamination factors which will produce water of such quality that will permit its cycle within the plant, and all wastes are assumed to be treated on a batch basis. The proposed radioactive liquid waste management system is designed in accordance with the requirements of 10 CFR part 20 and Appendix I to 10 CFR part 50 [1,2].

Radioactive wastes generated during the operation of a PWR plant can be classified into seven categories, namely

1) non-aerated reactor coolant drains and leakages (normally processed in the Boron Recycle System),
2) aerated equipment drains (relatively high radioactivity, borated water),
3) miscellaneous wastes (floor drains, decontamination wastes, etc. which are normally low radioactivity with high dissolved solids content),
4) detergent wastes (low activity and high detergent content),
5) chemical wastes (low volume, nigh chemical concentration and/or high radioactivity),
6) demineralizer regenerant waste (high coductivity, large volume and low radioactivity),
7) steam generator blowdown waste (high conductivity, and low radioactivity).

The design utilizes the above categorization for segregation and processing.

2. Processing Schemes

Six separate process trains are considered. All process trains are to be designed to continuously recycle a portion of the process flow back to the collection tank during processing, which assures the tank contents are maintained in a mixed condition. Collection systems are to be designed to provide the ability to completely isolate a collection tank prior to mixing, sampling, chemically adjusting, and processing while maintaining the capability of collecting continuing inputs to a given process train. This eliminates the possibility of uncontrolled inputs contaminating a batch after waste preconditioning and during processing.

The strategic system crossties are proposed in order to provide operating flexibility and system reliability during unexpected plant conditions. The reprocessing within each treatment system is permitted in the event that process water quality does not meet the desired standards.

2.1 High Level Waste Train

The aerated equipment drains could be collected and processed through the high level waste train. This waste is potentially high in radioactivity and contains boric acid. This waste is not usually accepted in the boron recycle system because of air contents. However based on the nature of the waste stream it is more desired to treat the high level stream in the boron recycle system. At least it is recommended that the high level waste train is cross-tied with the boron recycle system, which can serve as a backup to the high level waste train.

In order to achieve the desired decontamination factor (DF) the evaporation process followed by demineralization is recommended. The maximum DF of 10^6 [3] can be achieved through this combination. Figure 1 shows the proposed schematic diagram. In the diagram it is proposed that the evaporator package and mixed-bed demineralizer is cross-tied to the Boron Recycle System. In normal operation, non-aerated wastes are processed in the BRS and aerated wastes are treated through the high level waste train. However they could serve as backup systems each other by cross-tie. Mixing this level clean waste with the other wastes is not recommended.

The evaporator package could serve for the miscellaneous waste also if additional DF is required. Especially when the radioactivity concentration of the miscellaneous wastes is high, the downstream of the reverse osmosis unit could be processed through this evaporator package.

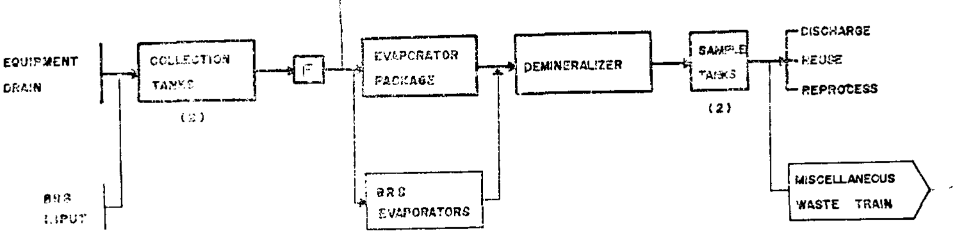

Fig.1. High level waste train

2.2 Miscellaneous and Detergent Waste Train

The miscellaneous waste train collects and treats the decontamination waste, floor drains, sampling line purges, hot chemical lab rinses, resin dewatering waste, and other waste streams. The miscellaneous waste could contain detergent, oil and organics which could cause fouling and forming in evaporators. The reverse osmosis (R/O) units are proposed to pretreat the wastes and to protect the demineralizers since they are effectively removed by reverse osmosis. A DF of 10 can be credited to the R/O element and a filter is used upstream of each R/O unit to remove suspended solids larger than a certain size. Figure 2 shows the typical treatment for the miscellaneous train, and the detergent waste train R/O element is proposed for the backup system. When the radioactivity level is high, the evaporator packages for the high level waste train will be utilized to get an additional DF.

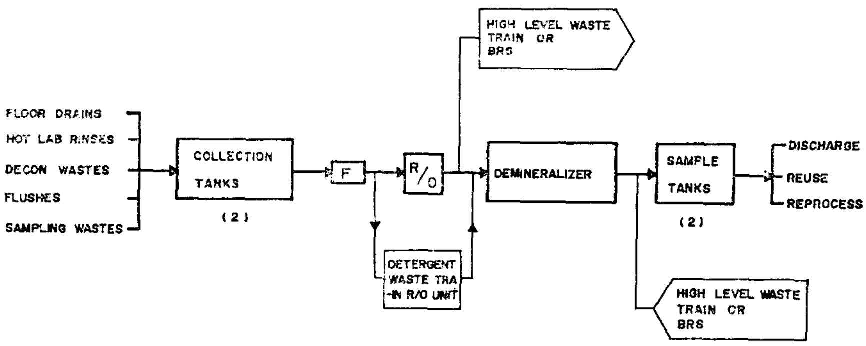

Fig. 2. Miscellaneous waste train

Input to the detergent waste train consists of laundry and hot shower drains. The reverse osmosis units are also proposed for processing detergent waste. The DF for the R/O unit is 30 when used for laundry waste[3]. Figure 3 shows the schematic process block diagram of the of detergent waste train.

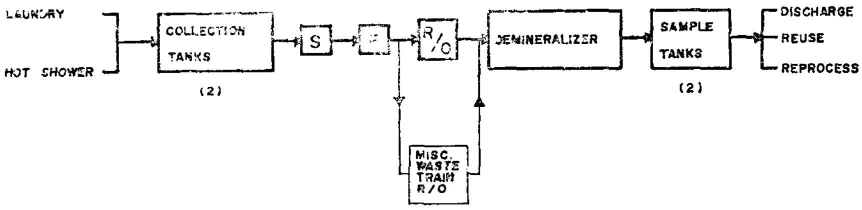

Fig. 3. Detergent waste train

2.3 Other Waste Trains

The selected hot lab drains are sent to the solid waste system for direct solidification because of its small voume. The volume of waste generation should be kept as small as possible and the lab rinse is recommended to be directed to the miscellaneous waste train in order to reduce the volume of solidification.

The demineralizer regenerant waste train is considered only with plants utilizing deep-bed demineralizers for full-flow condensate polishing. The amount of waste that should be considered for treatment as a radwaste is a function of the steam generator type, the design of the steam generator blowdown treatment system, and the allowable quantity of radioactivity leaking into the secondary system. Provisions should be incorporated into the design to provide the option of treating this source either as a non-radioactive waste (conventional fossile power plant treatment) or as a radioactive waste. Adoption of this system should be carefully considered based on cost-benefit study in accordance with the requirements set forth in Appendix I to 10 CFR part 50.

Based on the amount of steam generator leakage, the necessity of the blowdown and demineralizer regenerant treatment should be detemined. The treatment may not be needed during the early life of the plant, however the continuous close monitoring will be required and the future retrofit should be considered. Figures 4, 5 and 6 shows the schematic block diagrams of chemical, demineralizer regenerant and steam generator blowdown waste trains, respectively.

Fig. 4. Chemical waste train

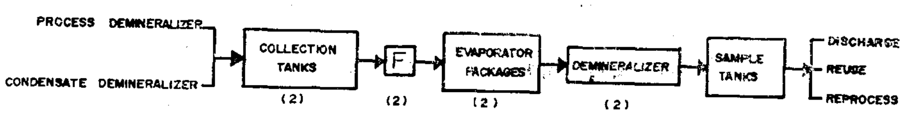

Fig. 5. Demineralizer regenerant waste train

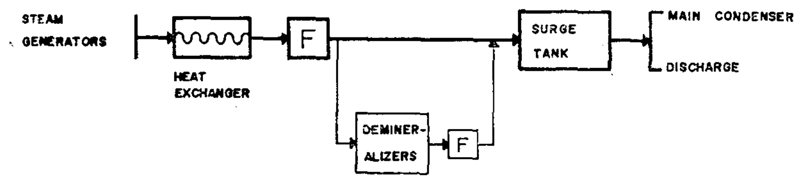

Fig. 6. S/G Blowdown waste train

3. Conclusions

Three process schemes; evaporators, reverse osmosis units and demineralizers are proposed to treat the radioactive liquid wastes. Evaporators are recommended for the clean high level wastes, and R/O units are proposed for miscellaneous and detergent wastes. And the small amount of hot lab wastes are directly solidified.

For redundancy, the evaporator packages are cross-tied between high level and boron recycle systems, and R/O elements are cross-tied between miscellaneous and detergent waste trains. They serve as the backup components each other.

References

1. USNRC, Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations Part 20-Standards for Protection against Radiation (1978)

2. USNRC, Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations Part 50, Appendix I-Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "ALARA" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents (1978)
3. Calculation of Release of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors, 2-41, 42, USNRC(1976)