Summary Report of the EPRI Standard Radiation Monitoring Program

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Abstract: The Electric Power Research Institute has re-instated the Standard Radiation Monitoring Program (SRMP). The project goal is to benchmark PWR shutdown radiation fields and correlate them to variations in materials and chemistry operations. This paper discusses the status of the SRMP and presents preliminary comparisons among plant designs.

Introduction

In 1978, EPRI began the Standard Radiation Monitoring Program (SRMP) that recorded and reported the shutdown dose rates in the loop piping and steam generator channel heads for United States and other EPRI member Westinghouse pressurized water reactors (1). This program was later expanded to include Combustion Engineering PWRs (2). However, in 1996, the program was suspended because of a lack of industry interest and funding.

Interest in the program was revitalized in part by the NEI/INPO/EPRI RP2020 initiative, an industry program that has the stated goal 'taking radiation off the table.' The RP2020 initiative has several facets related to radiation protection, and radiation source term reduction is one of the key objectives. EPRI was requested to be the technical lead in the area of source term reduction. An important requirement for understanding the causes of radiation fields is plant benchmarking of radiation fields and analyzing the differences in the plants that can cause differences in the radiation measurements. This paper describes the re-instated SRMP program, and presents the preliminary summary results obtained.

Project Goals

The project goals are summarized below:

- Maintain the history of the program by not changing the locations of the points. Many data have been acquired until 1996, and a majority of the plants kept the SRMP records privately.
- Make the procedure simple, focused, practical, and routine—a recommendation from the North American Technical Center, the SRMP procedures should be written to allow the HP technician to take consistent data while having as little burden on the plant staff as possible. One way this is done is by eliminating chemistry data requests from the SRMP procedures.
- Organize the data to allow correlation to chemistry events and plant design—The SRMP information will be included in the EPRI PWR Chemistry Monitoring and Assessment database.
- Encourage consistent sampling techniques—Guidance about when and where to take radiation measurements is provided in the procedures.

Plant Types and Measurement Points

As stated previously, the existing radiation monitoring points have considerable history. The locations of the loop piping represent the different temperatures seen in the primary coolant, as well as providing redundant points to allow exclusion of data that may be affected by external interferences. The SRMP points for the three plant types are shown in Figure 1 through Figure 4.

The SRMP program initially recorded standardized points for Westinghouse and Combustion Engineering plants, but it did not include Babcock and Wilcox (B&W) designed plants. A workshop was held with B&W plant radiation protection technicians to determine the common points for loop piping measurements, as well as determine the proper measurement of the channel head bowls.

Combustion Engineering and Babcock and Wilcox plants differ from Westinghouse designs in that they have two cold legs, reactor coolant pumps, and discharge lines and one hot leg. Unlike most PWR's, the B&W plants do not have U-tubes, they are once-through steam generators that have the hot leg coolant flowing into the top of the generator and leaving the bottom of the generator. They do not have divider plates. Instead, there is channel head bowl in the upper end of the steam generator and a channel head bowl in the lower end.

Current Data Collection Results
Surveys were distributed to the utilities at the beginning of 2006. The currently obtained plant responses are summarized in Table I.

Table I Summary of SRMP data obtained from US PWR plants

	W	*CE*	*B&W*	*Total*
Plants	33/48	5/14	5/7	43/69
Total Number of Outages	982	275	180	1437
Loop Dose Rate Measurements	733	60	48	841
Channel Head Dose Rate Measurements	538	27	42	607
% Loop Measurements Completed	74.6	21.8	26.7	58.5
% Channel Head Measurements Completed	54.8	9.8	23.3	42.2

The table shows the total possible number of outages for US PWRs, including those outages before the initiation of the program for each plant type, so it is impossible to obtain 100% of the data. This is especially true for the CE and B&W plants, as their respective monitoring programs began after the Westinghouse plants.

The summary statistics of the loop piping measurements are given in Figure 5, and the summary statistics of the steam generator channel head measurements for all plant designs are shown in Figure 6. Also note that there are fewer CE hot leg points than cold leg points.

In general, only a few observations can be drawn from the loop piping summary statistics because of the long history of the points (many of the largest values were taken from early cycles), and the large standard deviations (most of the deviations are of similar magnitude of the average of the point). The minimum value is fairly consistent between the different plant types for the loop points, ranging between 0.1 and 0.2 mSv/hr. It is noteworthy that, in general, the CE plant radiation fields are equal or less than the Westinghouse designs; however, there is considerably more variability in the Westinghouse data because the earlier points (in the 1980's) were typically much higher than current plant data. For Westinghouse plants, the cold leg points consistently have higher radiation fields than the hot legs, which is consistent with industry experience. The difference for CE plants appears contrary to this trend; however, the figure reviews only the overall average. In the next section it is shown that the difference agrees with industry trends.

The steam generator channel head points also have uncertainty, but the averages have similar values ranging between 40 and 70 mSv/hr. The minimum values of the Westinghouse plants appear to be lower than the CE plants by a factor of one-half. This can be attributed, in part, to the electropolished channel heads before installation, which prevent recontamination of the channel bowl.

The B&W design steam generator points is different from the CE and W plants because there is no divider plate, and therefore less surface area to record measurements. The requested measurement is the survey of the middle of each quadrant and the middle of the bowl at the tubesheet contact and 30 centimeter point. The largest value of the contact and 30 centimeter points is the recorded measurement.

Difference of Cold Leg and Hot Leg Values
As noted in the previous section, typically there is a difference between the cold leg and hot leg value for the same unit at the same time. The mechanism for this difference is not completely understood, one theory is that if the Co-58 or Co-60 is retrograde soluble in the temperature range of interest, then the cobalt can exchange into the outer layer of the corrosion film and can remains in the piping surface after forced oxidation.

The database was queried for the difference of the center channel head points, where the difference is defined as the cold leg minus the hot leg (point 10- point 2 for Westinghouse, point 6- point 2 for CE, and point 8- point 2 for B&W). Refer to Figure 7. For Westinghouse and CE plants, the expected trend of higher fields in the cold leg was observed. However, for B&W plants that have once through steam generators, the differences are practically negligible for the observed points. This is not expected, but it should be noted that there are limited data and conclusions are not drawn from the set of data presented.

Conclusions and Recommendations

The following conclusions are made:

- The Standard Radiation Monitoring Program has been successfully re-instated with active utility support.
- The procedures have been developed to simplify the data collection process for the HP staff.
- Babcock and Wilcox plants are now included in the program.
- The historical measurement points have been maintained for historical reference.
- The data variability is quite large over time, especially among the Westinghouse designed plants. This can be attributed to several factors in the plant history; simple summary stats, while providing limits, are not enough for a quantitative analysis of dose rates.
- The relatively consistent trend of the cold leg having higher radiation fields than the hot leg has been confirmed with the dataset, with somewhat unexpected results obtained for the B&W plants

Considering the conclusions, the following recommendations are made

- Analyze the data to evaluate the change in radiation fields over time.
- Compare the plants by chemistry operations, steam generator materials, and core duty.

With respect to these recommendations, EPRI is currently compiling the PWR Monitoring and Assessment Database that will incorporate the SRMP data with plant design information and their chemistry programs. This database will be used for detailed time-based analysis and search for cause-and-effect relationships between operations and dose rates. Future EPRI papers will discuss the results obtained from that analysis.

References

1. *PWR Radiation Fields through 1982*, NP-3432, EPRI, Palo Alto, 1983
2. *Evaluation of PWR Radiation Fields through 1996,* TR-107566, EPRI, Palo Alto, 1997

Acknowledgements

The author would like to acknowledge Leonard Rollins and Dan Stoltz of the PWR ALARA Group, David Miller and Scott Schofield of the North American Technical Center, Sam Choi and Cara Libby of EPRI Solutions, and Romain Bouchacourt for assisting with the data analysis.

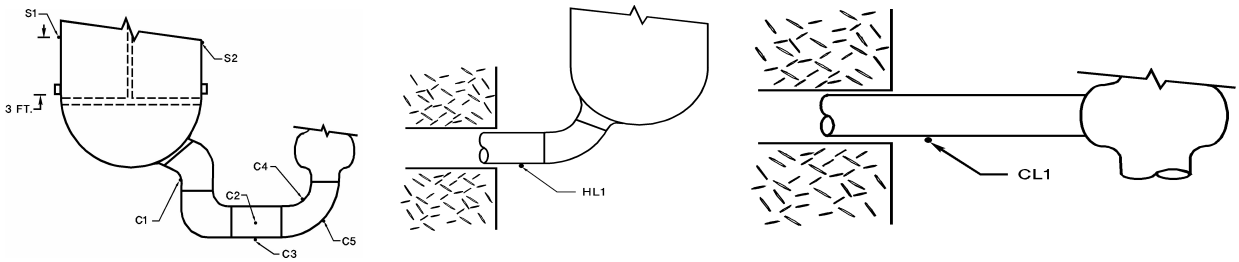

Figure 1 Steam generator loop piping monitoring points for Westinghouse plants

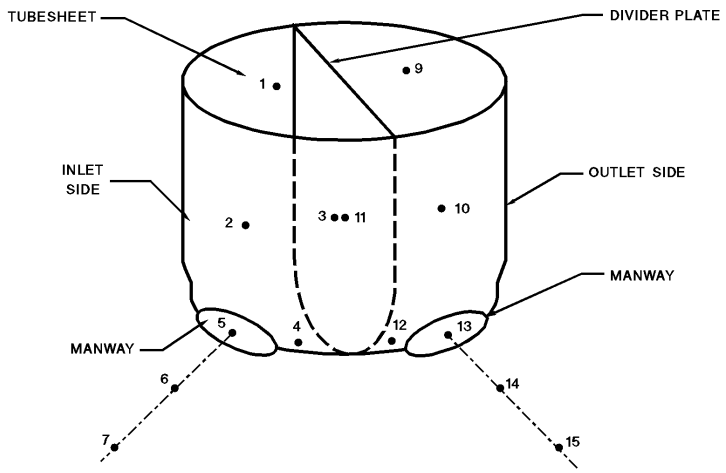

Figure 2 Monitoring points for Westinghouse steam generator channel heads

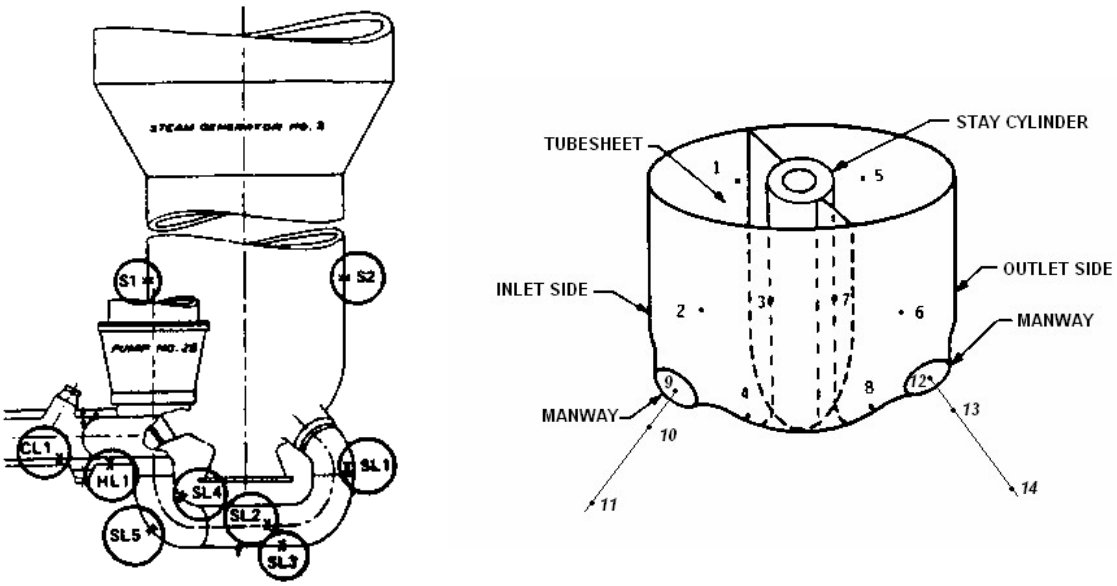

Figure 3 Monitoring points for Combustion Engineering loop piping and SG channel head

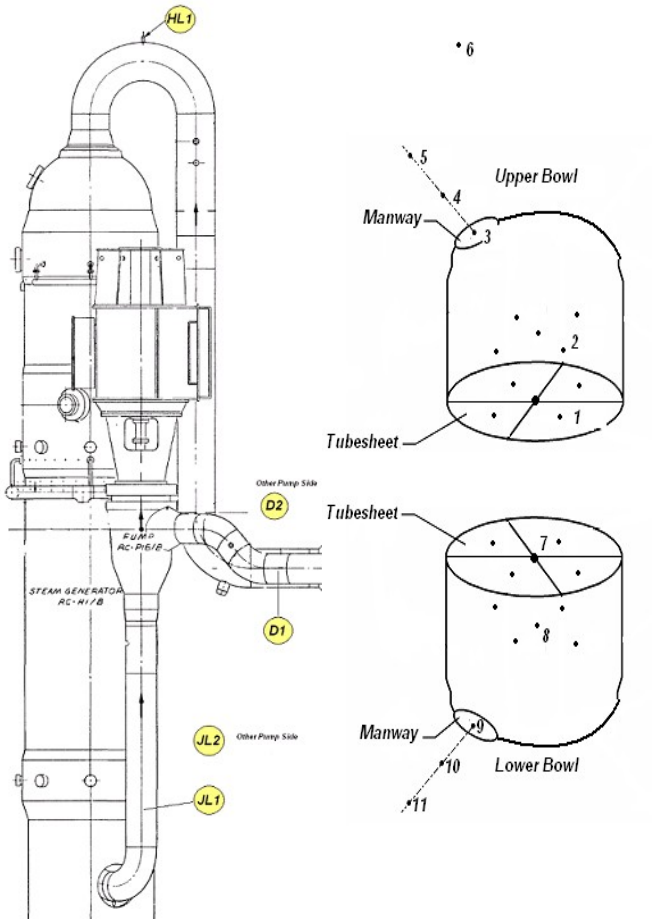

Figure 4 Monitoring points for B&W loop piping and SG channel heads

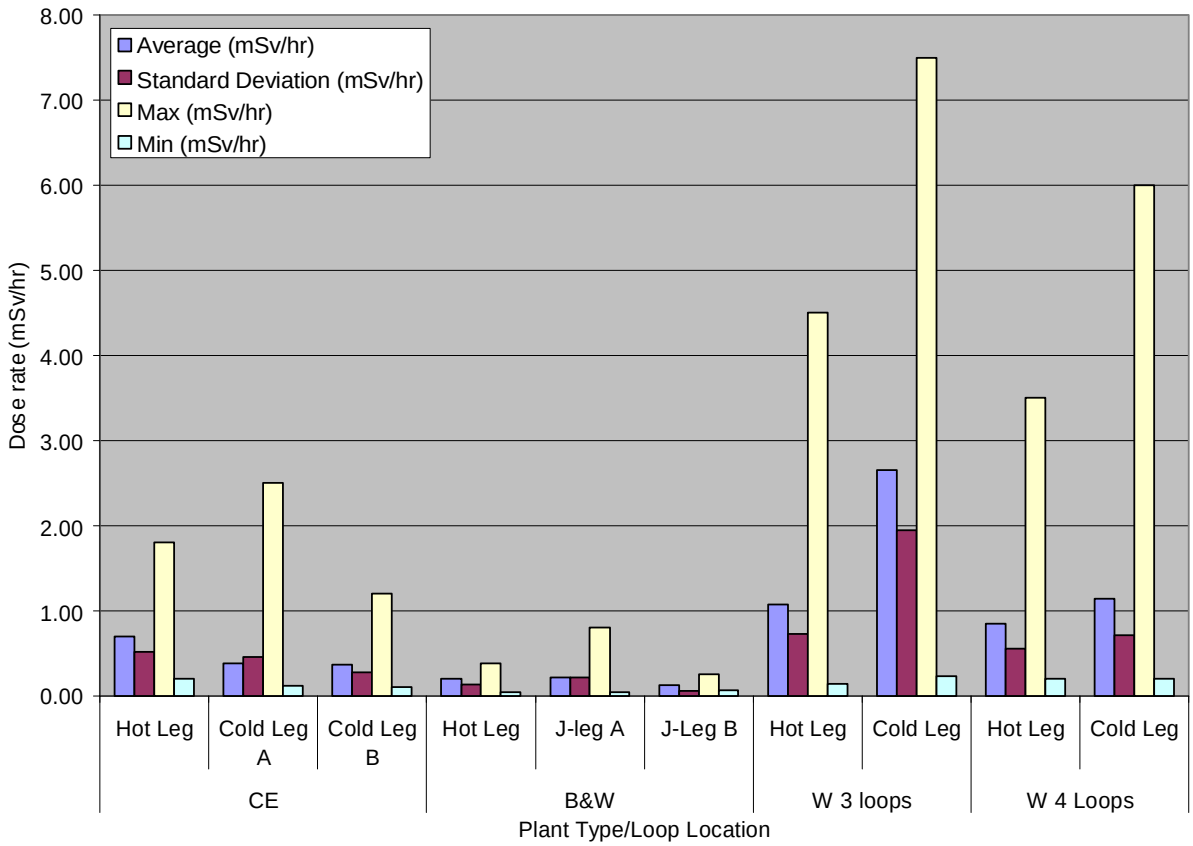

Figure 5 Summary statistics of hot leg and cold leg points for all plant designs

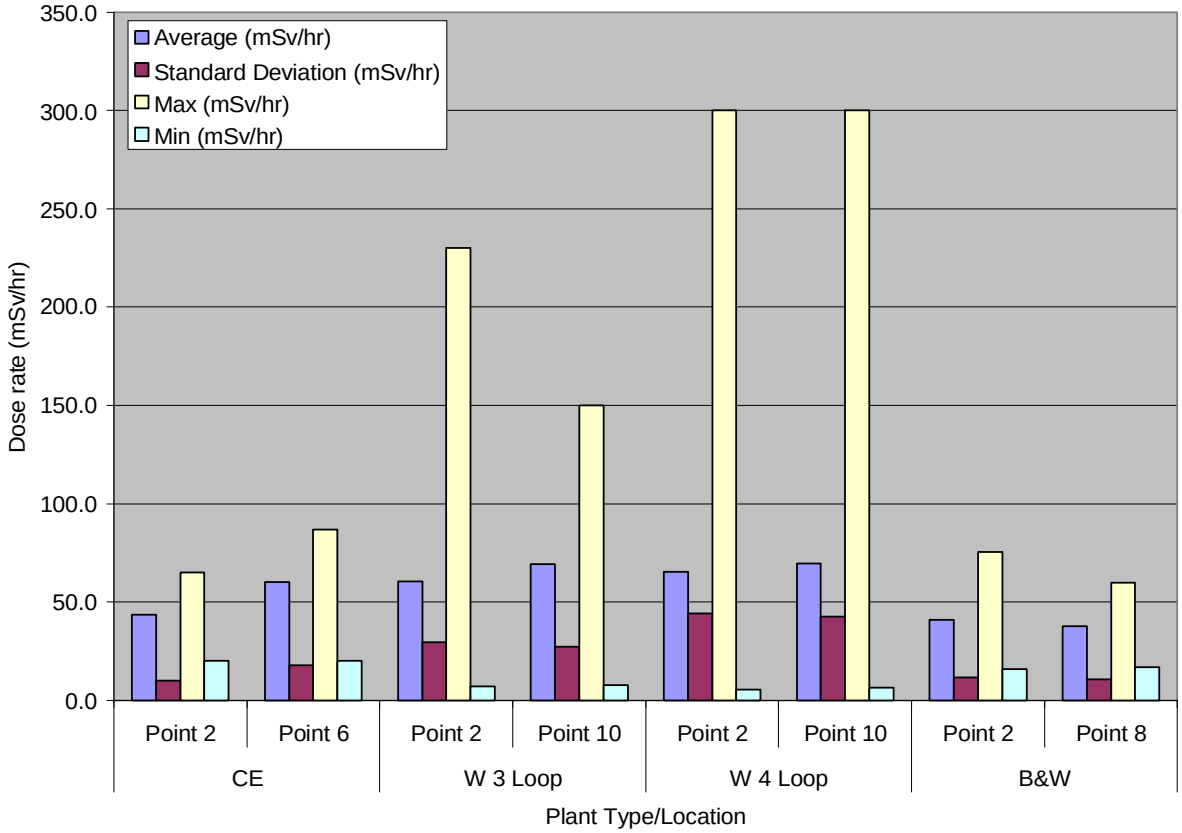

Figure 6 Summary statistics for steam generator channel heads for all plant designs

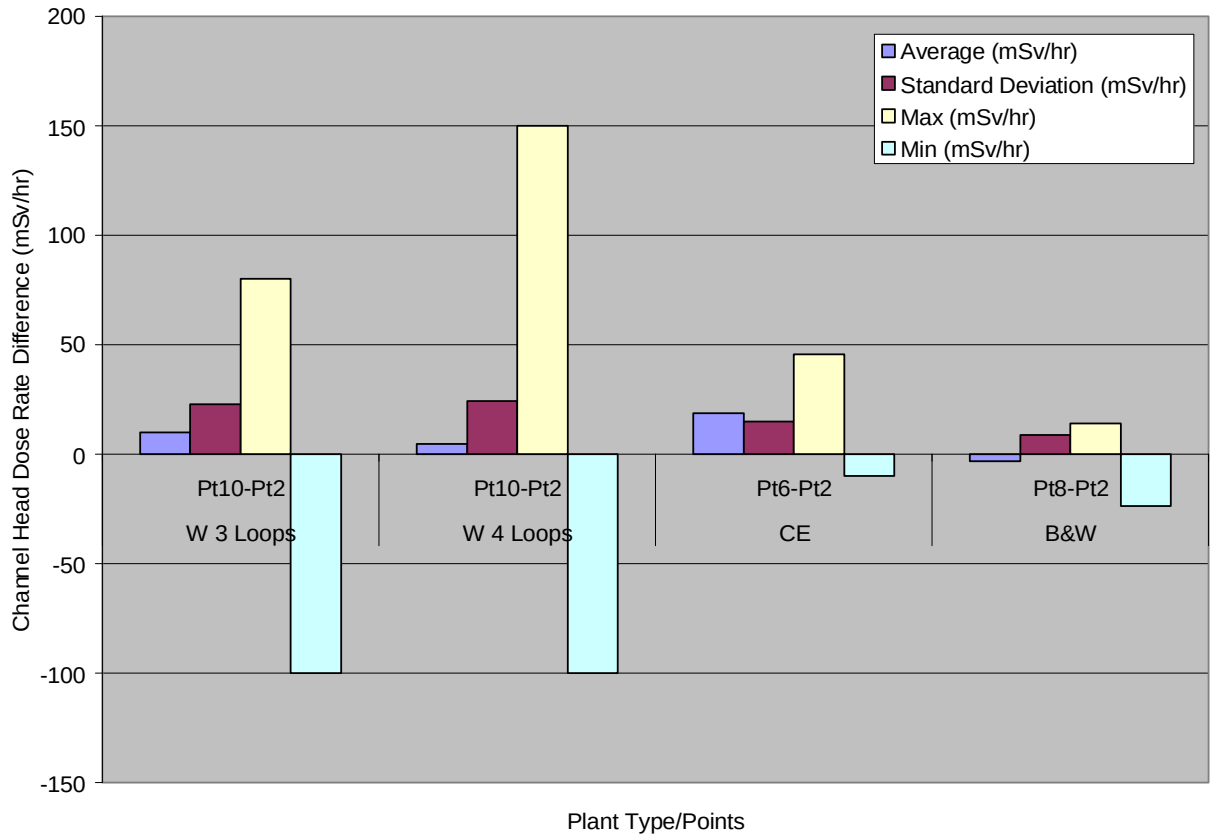

Figure 7 Summary statistics for dose rate difference of the cold leg and hot leg for channel heads