ALARA DATABASE VALUE IN FUTURE OUTAGE WORK PLANNING AND DOSE MANAGEMENT

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ABSTRACT

ALARA database encompassing job-specific duration and man-rem plant specific information over three refueling outages represents an invaluable tool for the outage work planner and ALARA engineer. This paper describes dose-management trends emerging based on analysis of three refueling outages at Clinton Power Station. Conclusions reached based on hard data available from a relational database dose-tracking system is a valuable tool for planning of future outage work. The system's ability to identify key problem areas during a refueling outage is improving as more outage comparative data becomes available.

Trends over a three outage period are identified in this paper in the categories of number and type of radiation work permits implemented, duration of jobs, projected vs. actual dose rates in work areas, and accuracy of outage person-rem projection. The value of the database in projecting 1 and 5 year station person-rem estimates is discussed.

INTRODUCTION

Clinton Power Station is a General Electric Boiling Water Reactor, BWR-6, Mark III Containment. Clinton Power Station commenced commercial operation in 1987. The station achieved 320 days of continuous operation in 1992-93. Highlights of the ALARA aspects of the radiation protection program are summarized below:

- Dose to the public is minimized due to an aggressive program to avoid failed fuel and maintain zero liquid discharges to the environment. Clinton Power Station is the only BWR-6 which has not experienced fuel failures. CPS has achieved zero liquid discharge in 1993 and year-to-date in 1994.

- Personnel contaminations have been maintained at a low level from 1988-92. Each year the station experienced approximately 33 skin contaminations and 63 clothing contaminations for the first four years of operation. In 1993, a 30% increase in personnel contaminations was experienced largely due to the implementation of new 1OCFR20 requirements.

- High emphasis has been given to plant and system cleanliness. Refueling contractors are indoctrinated on the importance plant management places on plant cleanliness and foreign material exclusion from the reactor vessel and primary system. This emphasis has resulted in the Mark III containment entries continuing to be a street clothes entry zone during non-outage periods. We understand that other BWR-6s require protective clothing to be worn for containment entries.

- An in-house developed personnel radiation exposure management system (PREM) was accomplished from 1988-90 to achieve real-time dose tracking capability, support outage work planning and improve accuracy of dose estimation for repetitive work activities. This paper provides a comparison of dose estimation and actual results for refueling outages 2, 3, and 4 at CPS using the relational database methodology. Senior management at Clinton Power Station recognized early that the cobalt-60 source term was higher than many BWRs. Hence, strong support was given to the development of a computerized dose-tracking system after the first refueling outage to assist in improvements in work planning and dose management necessary to reduce dose whenever possible.

Five-Year Station Dose Projection

A five-year dose projection was developed by the ALARA staff in 1989 based on industry experience from five sister BWR-6s and estimation of recirculation piping dose build-up. Figure 1 shows the five-year dose projection made for the period 1990-95. Actual man-rem experience tracked very closely to actual annual man-rem for years 1990-93. 1994 annual man-rem was projected to be 120 man-rem in 1989 based on no refueling outages scheduled. Monthly, non-outage man-rem has been below 5 man-rem so far in 1994, hence, this projection appears to be good.

Work Planning and Dose-Management System Description

The in-house developed relational database system has provided automated radiation work permit (RWP) generation, access control for personnel entry to the radiologically controlled area (RCA) and real time tracking of work duration and dose accumulation. The system architecture was specifically designed to capture important radiation protection data in the field to achieve a nearly paperless dose management system. Each permanent radiological control point is provided a PREM terminal for access to RWPs and input of dose and job duration data.

During each outage, over one million separate ingress and egress transactions from the RCA and seven radiological control point zones within the RCA were recorded on the computer. As shown in Figure 2, the system is like a home intercom system. It tracks work duration and dose accumulation a literally 20-30 work locations during the peak of outage maintenance activities. Over 90,000 ALARA and dosimetry tracking reports were executed by the system during each outage. Areas of concentrated work activities could be monitored on a real time basis by radiation protection management. Areas of greatest attention at CPS were the drywell, refueling floor, and auxiliary building.

Outage Dose Trend Analysis

One of important reasons for developing a detailed dose history database on repetitive BWR work activities was for improvement in planning for future refueling outages. Detailed dose and duration data needed to be collected for three to five outages to achieve the types of trends information that could be used for the following reasons:

- outage staffing levels for both maintenance crews and support groups (i.e., radiation protection technicians, etc.)
- planning outage work by zone in the plant and schedule
- selection of outage work scope with accurate projection of impact on outage dose goals

- decision on amount of temporary shielding to be installed in specific plant area where work is concentrated

- daily monitoring of dose accumulation to provide greater management attention to work which is proceeding above projections either in dose or duration

- assurance of a good match between work scheduled and available staffing especially during peak outage work periods

- improvement in accuracy of annual man-rem goals and five-year man-rem projections based on identified operation and maintenance schedule.

This paper represents radiation protection's first attempt to use the relational database from three refueling outages to identify and verify trends in dose accumulation and job duration for improvements in the estimation of dose for work selected or deferred in future refueling outages. For purposes of the presentation at this conference, trends are presented based on their impact on the overall outage dose and outage schedule estimates. Of course, many other associations can be made. But, for brevity, impact on overall outage dose is the primary basis for the comparison.

It should be emphasized that it was important to collect data at the job step level with each maintenance work package covered by the RWP for this analysis to have the greatest accuracy.

Also, note that Refueling Outage-2 and 4 are similar in work scope since in-service inspections (ISI) in the bioshields where performed in even year outages. Hence, Refueling Outage-3 contained less high-dose work scope. PREM was not available for Refueling Outage-1. Finally, the comparison should be viewed has "reading the tea leaves" in terms of validity of trends identified until two more refueling outages are added to the database.

Trend Analysis Results

A total of 40 trend graphs have been developed in the analysis of Refueling Outages 2, 3, and 4. Slightly less than half of these graphs are described in this paper to highlight general conclusions reached from the relational database analysis. Discussion of the selected graphs is provided below:

Figure 3: RWPs - The number of RWPs generated to support refueling work dramatically reduced from 952 in RF-2 to 306 in RF-4. The number of RWPs issued represents the degree of radiological control exercised to manage work in the RCA. As plant personnel and contractors have more experience in successive outages, the number of RWPs issued can be reduced accordingly.

Figure 4: RWPs/Day - Comparison of RWPs issued per day allows for normalization of the variables of interest. The effect of outage length can be properly evaluated (e.g., RF-2 was for I 1 5 days, RF-3 was for 90 days, and RF-4 was for 7 5 days).

Figure 5: RWP/Day Chart - Comparison of RWPs issued per day based on estimated dose categories (less than 1 man-rem, greater than 1 man-rem and blanket RWPs) shows the Radiation Protection Manager that the number of RWPs greater than 1 man-rem remained remarkably the same over the three outage period. Reduction in RWPs issued occurred in the less than I man-rem category as more work was grouped under single RWPS.

Figure 6: Man-Rem - Man-rem charts are often the main comparison made by station management. Clinton Power Station experience shows that ISI work in the bioshield improved between RF-2 and RF-4

based on implementing lessons learned from the first ISI work. RF-3 outage man-rem will not have a meaningful comparison until RF-5 data is available.

Figure 7: Man-Rem % - Man-rem % shows that 75-85% of outage dose was received on RWPs estimated to have more than 1 man-rem for the work planned. This validates the ALARA planning rule of thumb for CPS that the bulk of outage dose is in greater than 1 man-rem RWPs. This focuses radiation protection management attention on reduction opportunities within this category of RWPs.

Figure 8: Man-Rem/RWP - As number of RWPs is reduced, the dose accumulated per RWP increases. This confirms the assumptions made regarding Figure 3.

Figure 9: Man-Rem/Day - This comparison shows that as outage duration is shortened, dose accumulated per day increases. The man-hours in the RCA increase in shorter outage and the figure properly reflects this conclusion.

Figure 10: Mrem/RWP-Hour - Mrem/RWP-Hour increases similar to increase observed in daily dose. More workers are engaged in work activities in the RCA.

Figure 11: Man-Hours - Man-hours for RF-3 and RF-4 are essentially the same.

Figure 12: Man-Hours/Day show that RF-2 and RF-3 are essentially the same. These two figures illustrate the importance of normalizing the data sets before comparisons are made in outages of varying lengths.

Figure 13: Man-Rem Delta - Man-rem delta figure shows the difficulty that can be encountered in under estimation of man-hours for work or dose rate estimates (RF-4).

Figure 14: Example of 1994 cumulative site exposure tracking graph which is distributed to plant personnel to inform them of actual site dose vs. annual goal.

Figure 15: Man-Hours/RWP - Man-hours/RWP illustrations the increase in man hours assigned to each RWP from RF-2 to RF-4.

Figure 16: Man-Rem Estimates - Man-rem estimates are of concern if they are less than actual man-rem experience (non-conservative).

Figure 17: Man-Hour Estimate - Man-hour estimates were found to be highest in RF-2. Man-hour estimates improved in subsequent outages. Demonstrates value of database use in future outages planning.

Figure 18: Dose Rate Estimates - Dose Rate Estimates are of particular concern when they are underestimated which has been a minor problem in all three outages. Estimates have been good for all three outages.

Figure 19. Man-Hours Delta - Man-hours delta was overestimated most in RF-2. However, RF-4 underestimated manf-hours which will need to be avoided in future outages.

Figure 20: Dose Rate Delta - Dose Rate Delta shows similarities between RF-2 and RF-4 where actuals were half of estimates.

CONCLUSION

Relational database comparison of similar work outages can be a valuable ALARA tool for outage planners and ALARA engineers in refining man-rem and duration estimates for future outages. Also, outage workers are provided realistic man-rem and duration goals to achieve based on previous outage crews performance. More importantly, it offers the Radiation Protection Manager key, plant-specific insights into daily dose accumulation management on a real-time basis. Proper management attention can be focused on problem areas to explore opportunities for dose reduction.

Author Biography

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DISCUSSION

Baum: I may have misunderstood, but I thought you said something increased by 30% due to new part 20. Could you repeat that, and explain how the part 20 change caused that?

Miller: I'd be very happy to. We have put people in "Pillsbury doughman" suits for 20 years in the United States. This significantly degrades their manual dexterity, and their visual acuity is blurred because of the respirators. We also put double plastic gloves on an individual who may only have to put a screw in a junction box in a very slight couple of DAC/hour airborne area but a 200-300 mR area of our drywell. So we have decided, in really understanding ICRP 26, that requires a TEDE ALARA evaluation for all jobs that may have an impact in terms of a respirator causing up to 20% of a slowing up of productivity of the actual work occurred. We take into account the total effective dose and make the decision on whether the individual wears a respirator or not. We had a 2-year effort of going through what we call a "cultural change" in America, because we have been telling everyone that internal dose is bad, you're going to take it home with you, it's not what we want you to do, and to respect all radiation -- even the smallest amount. In this case, we had to educate the process that a small amount of airborne, if it creates a higher total effective dose equivalent, is not in keeping with ICRP 26 recommendations. We actually had the use of respirators drop all across the United States to a factor of about 80-90% reduction after implementation of part 20 in January 1994. We implemented early in 1993, and we actually dropped our respirator use much earlier. We had sold our senior management on this, and when we saw that our doses were going up higher than our goal in our last outage this fall, our fourth refueling outage, they thought it might be just because people were wearing fewer respirators and that they were more comfortable being in low airborne areas and that they were staying in this low-dose, <1 man-rem RWPs. We simply punched up the button and a number came up, and we compared it to the two outages that were under the old part 20, where 6,000-7,000 respirators were worn. We interviewed several individuals, and, to a man, they all said they were still very uncomfortable going into low airborne areas. They would go in there and get out as quickly as they could. We used the intercom system to quickly check that, and sure enough, the same types of entries to airborne areas were much longer duration in the pre-part 20 period than in the post new part 20 area. That's what we were able to quickly prove, and we are going to continue to look at that because it is an important parameter. We do not require people to not wear a respirator. We think there is going to be a 2 to 3 year period, where if they are really uncomfortable and have concerns about airborne, then they will still be able to wear that respirator.

Lazo: The man-hours that you displayed, did you have any problems with unions in terms of collecting that data in terms of its being sensitive? It is really valuable information, but some people have some questions about that.

Miller: This is something we have learned and have been benefitting from, particularly by looking at other plants. We've had this in place for four years, and, in fact, it was just the opposite. When we installed it, we went out and talked to all of our 800 outage workers, and we talked to our own plant people. First of all, they liked it because their name was on the computer when they first came in the front door. It's like having your name on the mailbox. They feel a part of the team. We push team effort, as we all do, and even more so now that the company is organized by teams instead of by supervisor levels. Second, they like not having the clock nuisance business that they used to perform on manual doses, where one had to mark down 1723 I went in, and 1952 I went out, and subtract in one's head. That was now done by computer and they liked that. Third, instead of having

2,000 watches running around this plant, we liked the accuracy of the one computer watch. Fourth, we were better able to plan work, not only by schedule, but also plan your work and your outage, and subsequent third and fourth outages, by zoning the plant, so you don't stack the guy who is going to drop wrenches on top of two or three other work groups in the drywell. We were able to have a drywell coordinator who does nothing more than coordinate or police the activity in the drywell, and we would have all the linking of all the work in that very hot box done 4-5 months before the outage actually occurs because it's easy when 85% of your work is repetitive. We've now done that pump four times, and you know the duration. Finally, we have used the best part of ALARA motivation or incentive -- peer pressure. On going in to that particular crew, we post the 1992 performance duration dose. Here's the 1990s performance, and here's Sweden's performance, and France, and Germany, and Japan. Now guys, welcome. Do your job. And that's how we have been able to motivate in the true concept of optimization. You give your people the confidence and trust that they will perform well, and you provide them with the information. Until recently, it's been difficult to get that kind of dose information, even though 85% of our jobs are repetitive. We don't always do things well at Clinton or at many plants yet, and the biggest problem is that we still have a lot of construction trade people coming in as brand new carpenters off that guy's house right down the road who have never seen a nuclear plant. They are still getting 85% of our dose. We have a lot of effort in the mock-up and the training so there is more briefing of those individuals because your risk is as weak as the least experienced radiation worker in your RCA.

Viktorsson: I appreciated your emphasis on work management actions. But I have two other more specific questions. The first on the fuel failure. You said that you had the senior management commitment to shut down the plant if you exceeded some level of impurities in the reactor water. Could you tell us a little bit more about this -- what the levels are?

Miller: Yes, it was a year ago January that a sister plant in our region experienced very high off-gas levels in failed fuel. We recommended to the senior management to send people up there. They brought a report back and, in a nutshell, we showed that you have four times the problems we are having with cobalt if you start getting into alpha, transuranic monitoring, and the additional cost of decommissioning. So we have a level of 50,000 mCi/cc on the off-gas that we will actually make the decision to shut down within a week or less. We put together a task force who are still working and are monitoring any of our other plants, both in Spain and in Switzerland, and the ones domestically, so that we can grasp any of the lessons learned -- and there are a lot of them in radiation protection -- so that we are the most able to handle that challenge. The management commitment is at the senior vice president level. Unfortunately, my boss just resigned to go up north to handle six other BWRs at another utility, so we will be working on continuing to get the support of the next vice president in some critical areas as far as radiation protection sees it.

Viktorsson: Was this level derived based on sort of a cost-benefit analysis?

Miller: Yes, and that's why I'm bringing in the decommissioning costs. We had not seen before any real analysis of what you are dealing with and happened when this was occurring all the rule-making was going on in terms of decommissioning. So a part of the cost-benefit was not just the normal in additional dose and person-rem that we might see in that year that we have off-gas. Those numbers are readily available because we have three sister plants that have very high increase. We have found that our cobalt, because we have this flaky cobalt, actually goes up 3-5 times because uranium, if it starts circulating and a boiler kicks the cobalt off the fuel. We've seen spikes in some of our sister plants, so yes, we did all that in terms of showing the man-rem and in finally the decommissioning costs in terms of how much most of us have of 100,000,000 to 150,000,000 in our long-term reserve for decommissioning. How much more in terms of cost we might have to put in there if we start seeing transuranics in piping in radwaste system sporation pool, etc.

Viktorsson: The second question related to in-service inspection. Could you tell us the percentage of the total collective dose that relates to annual in-service inspections. I mean, ultrasonics, radiography, and things like that? And do you have any special automatic equipment for this.

Miller: Yes, the in-service inspection dose is normally around 80-85 man-rem in that RF2 and RF4. What we have done, is that the first time entered our bioshield to do that work, we hydrolyzed extensively, and that dropped the nozzles on the N2s and N4s on the boilers down from 30 to 50 R/hr after that second outage down to 300 mR/h as the highest nozzle. So hydrolyzing from the bridge was very effective. Still, we brought in 35 ISI people, but still the work was very high person-rem. Second, we had a lubricant problem which we have now resolved in terms of actually putting the equipment on in that first outage, and third, we had significant problems in building scaffolding and the time that it took. We did not have permanent work platforms. We needed them in that area and we had put that in for our following outage. Those three improvements, along with a whole list that has come out of the team debrief from our last outage, are hoping to reduce that dose and there is also a technical approach that some boilers are using which is induce stress relief, and that can allow you to go up to 10-year cycles, instead of even-year cycles.