EPRI

Implementation of Optimized ALARA Assessment Methodology at BWRs and PWRs

Technical Report

Implementation of Optimized ALARA Assessment Methodology at BWRs and PWRs

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Final Report, November 2000

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REPORT SUMMARY

US nuclear utilities have made significant progress over the last decade in reducing personnel exposure levels to values that are As Low As Reasonably Achievable (ALARA). This document presents a methodology to assist utility ALARA program and Health Physics Managers in evaluating and enhancing their ALARA programs and gives the assessment results from using the tool at two PWR plants.

Background
ALARA programs help serve to minimize exposure of plant personnel and the general public to the effects of ionizing radiation. Regulations require that each nuclear plant perform a self-assessment of its ALARA program at least once a year, but considerable latitude is permitted as to how these assessments are to be performed. A tool was developed that permits ALARA programs to be evaluated in a more consistent manner than has been previously possible. The tool contains over 500 diverse evaluation criteria. This document describes the results of using the existing tool to evaluate the ALARA program at two PWR sites and the development of a similar tool for evaluating ALARA programs at BWR sites.

Objective
To use the existing PWR tool and methodology to perform an ALARA assessment at two PWR sites and compare the results; to develop a similar tool that would address issues unique to BWR ALARA programs.

Approach
EPRI technical consultants visited two PWR sites, and working with their utility counterparts, evaluated the ALARA programs. On-site work was followed by extensive off-site analysis of the information gathered during the plant visits. The results led to site-specific recommendations to improve the ALARA programs, together with information that could be used to highlight the strengths and weaknesses of the two programs. The investigators also built on the existing PWR ALARA assessment tool to develop a BWR tool. Subsequently, the team held a meeting with ALARA personnel at one BWR utility to ensure that the key issues were effectively addressed.

Results
At the first PWR, reviewers found 78% of the criteria assessed met or exceeded the assessment criteria. This strong performance reflects the award the plant received in 1998 as the "World Class ALARA Performer" by the International Atomic Agency. At the second PWR, 67% of the evaluation criteria met or exceeded the assessment criteria. At both sites, specific suggestions were offered by the investigator to improve some of the low rated program elements.

The peer review meeting held following development of the BWR assessment tool led to the identification of new criteria and improvements in others. After incorporating these revisions, the team concluded the BWR tool was complete and ready for field application at a lead BWR plant.

EPRI Perspective

Comments from utility personnel at the two PWR plants where assessments were performed acknowledged the assessments were very beneficial for the sites' radiological protection (RP) and ALARA programs. Most recommendations were deemed to be cost-effective and were implemented in short order or were incorporated into the plants' long-term improvement action plan. In a few instances, recommendations were rejected as being unimportant or not applicable. Subsequent to the assessments, both PWRs ALARA programs indicate an improving trend, although a number of elements have contributed to these successes. Details of the PWR tool development are given in EPRI report TR-112992. This approach also can be used to assess cost/benefit issues associated with the implementation of specific ALARA techniques, and a first step in this direction is an ongoing assessment of absolute filtration technology at Indian Point 3. The ALARA tool can be later modified and updated to incorporate new dose reduction technologies as they are implemented at operating plants and to incorporate changes to reflect new regulations that bear on ALARA. A similar approach can be developed to address ALARA issues at plants that have been shut down and will be decommissioned or plants that will be facing inspections to address life extension issues.

Keywords

ALARA Program Management
Health Physics Management
Exposure Reduction
Assessment

ABSTRACT

ALARA programs help minimize exposure of plant personnel and the general public to the effects of ionizing radiation. Regulations require that each nuclear plant perform a self-assessment of its ALARA program at least once a year. In a previous EPRI project (EPRI project TR-112992), a standardized protocol was developed for performing ALARA program self-assessments at PWRs and for evaluating new inputs to an existing ALARA program. The current project evaluated two PWR ALARA programs using this methodology. The methodology was also extended by incorporating BWR specific assessment criteria, which were reviewed by utility personnel at one BWR site.

EXECUTIVE SUMMARY

Project Background

Title 10, Part 20 of the Code of Federal Regulations (10CFR20) section 20.1101, Radiation Protection Programs subpart (C) states that "The licensee shall periodically (at least annually) review the radiation protection program content and implementation." Until recently, the majority of plants performed such self-assessments using in-house staff resources with varying degrees of radiological, ALARA, and/or assessment methodology expertise. The results associated with that type of review are highly dependent on the frequency, assessor qualifications, their objectivity and bias, available resources, and senior management support of assessment conclusions. Therefore, the benefit derived can be less than optimal.

More recently, utilities are opting for evaluations performed by external industry professionals. There is a direct and tangible benefit to having an objective, detailed analysis of the ALARA program. Careful consideration and implementation of the assessor's recommendations for improvement can often lead to both exposure reduction and a significant reduction in the level-of-effort required to attain that end.

According to 1996 NRC data, of the 68,182 people with measurable exposures at nuclear power plants, the average dose was 277 milliRem. In response to industry queries related to ALARA Program improvement, in 1999 the Electric Power Research Institute (EPRI) and a team of industry professionals developed and implemented the use of an ALARA Program assessment methodology. This comprehensive database now contains in excess of 550 criteria for review and analysis. Performance measures are used to identify those program elements that are satisfactory, those in need of long-term improvement, or those that require immediate attention to preclude undesirable performance. In the brief time that this powerful tool has been available, two PWR assessments have been performed, and a similar tool for BWR ALARA program assessments has been developed. These very comprehensive evaluations address all aspects of an ALARA program, from senior management standards and support, to the field application of training and procedures. It is anticipated that an assessment using the EPRI approach would be especially valuable for those plants that are currently in the bottom quartile of collective exposure or for those plants that are characterized by high collective exposure even though dose rates are comparable to plants with similar design features and operating history.

Assessment Results

For the first PWR assessed (PWR A), 78% of the total areas assessed met or exceeded the assessment criteria, ~15% provided opportunity for continuous, long-term improvement, and only 7% were found to be improvements requiring priority implementation. For the second

PWR assessment, 67% of the assessed criteria were satisfactorily implemented, 24% of the assessed criteria represented opportunities for continuous improvement and 9% of the assessed criteria represented areas that were recommended for priority improvement.

Site Benefit Update

Site feedback acknowledged that the assessments were very beneficial for the site's RP and ALARA programs and that improvements were made at a minimal cost to the station. The recommendations were either deemed to be cost-effective and were implemented in short order or were incorporated into plant long-term improvement action plans. In a very few instances, recommendations were rejected as being not important or no longer applicable.

PWR A's current ALARA program status clearly indicates an improving trend. The station is currently on track for a <10 person-Rem year. Following the assessment in 1999, the station completed their refueling outage with the lowest outage exposure in the plant's history.

PWR B's current status also indicates an improving trend. The station recently completed a refueling outage with the lowest exposure in the past 15 years. Although this was primarily due to an improved Integrated Work Management System, the implementation of assessment recommendations, combined with the heightened station awareness resulting from the assessment supported that effort. The station has also improved ALARA Program awareness, information dissemination, and their in-house assessment program. Finally, a new, formalized shutdown chemistry team has been assembled, targeting improvements in crud burst cleanup and source control at shutdown.

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PROGRAM BACKGROUND

1.1 Overview

The success of an individual site's ALARA program is highly dependent on a broad spectrum of issues, and therefore the program results are varied. In response to an initial request by a single unit PWR, EPRI developed an ALARA program assessment methodology. The goal was to develop a consistent approach for performing the assessments mandated by 10 CFR 20. This methodology also assists plants in identifying the best techniques for implementation, whether it is EPRI-developed field reduction technology, published industry good practices, information available from the Information System on Occupational Exposure (ISOE), or industry reports.

1.2 Categories and Criteria

Currently, the assessment methodology consists of approximately 550 criteria that have been divided into the following 16 primary categories (module):

1. Regulation
2. Industry Organization
3. ALARA Program Administration
4. ALARA Program Implementation
5. Planning and Work Control
6. Engineering
7. Work Practices
8. Health Physics Program Management
9. Chemistry Management and Source controls
10. Radwaste Management Program
11. Operations
12. Maintenance

13. Decontamination

14. Special Maintenance And Evolutions

15. Technology

16. Decommissioning

Each module contains a detailed set of criteria specific to a primary element of, or organization, affecting a plant's ALARA program. Each assessment module contains sub-topics with assessment criteria that are directly related to that aspect of, or organization's role in, the ALARA program. The modules and criteria are contained in a spreadsheet-based format that can be used to query data and compile assessments results. Each assessment category contains detailed assessment criteria. The following is an example of an individual category's hierarchy:

Category Title: Planning and Work Control

Sub-topic: Scheduling – common work areas

Criteria: Are controls and services utilized for several tasks (e.g. contamination control areas re-used for several jobs; temporary shielding, same scaffolding used for several tasks, etc.)?

Each of the assessment criteria is graded based on the assessor's conclusions. These grades are:

Satisfactory

The results clearly indicate that the station meets or exceeds the stated criteria.

Opportunity for Continuous Improvement

Identifies a deficiency or an area where it would be beneficial to expend resources to achieve program improvements. These are typically areas where improvement actions will result in a strengthening of specific areas of the program and should contribute to meeting overall program excellence.

Priority Improvement

A deficiency or an area that is not meeting standard industry good practices. Resources should be applied to improve these areas on a priority basis to achieve program health.

The grading data is automatically collated by the program to produce results in the form of tables and graphs that summarize the assessment conclusions by category. Finally, following off-site analysis by the assessors, a site-specific report is generated that identifies program performance, strengths, and enhancements that have the potential to be of benefit to the program.

1.3 Rationale for Independent ALARA Program Assessments

Historically, the majority of sites have performed assessments of ALARA programs using in-house resources. The use of industry professionals external to the site's organization is only recently gaining favor. When determining the value of an independent ALARA assessment using the EPRI tool, the following factors should be considered.

Consistency of Review

EPRI uses a core group of three individuals to perform the assessments. These individuals have approximately 68 collective years of reactor Health Physics field, engineering, and senior management experience with work in over 70 power plants. The use of these individuals with relevant expertise is expected to result in the most accurate, consistent benchmarking available.

Responsiveness to INPO Self Assessment Document

The INPO document titled "Principles for Effective Self-Assessment and Corrective Action Programs" (December 1999) states; "Independent self-assessments complement station management's self-assessments and provide a valuable additional source of information."

Site Management Support of Recommendations

Historically, plant's senior management has been more likely to take advice from, and act on, recommendations from independent "industry experts" than from in-house staff. The assessment should be viewed as a tool for improvement to gain senior management support.

Interpretation of Criteria

The bias when interpreting criteria based on site users experience level, position, or agenda is eliminated when using outside evaluators. The EPRI assessors developed the >550 criteria and clearly understand their intent.

Neutral Interpretation of Results and Recommendations

Minimizes impact of personal agendas. Eliminates site guidance on results interpretation. Minimize or eliminate conflicts between site assessor/assessor's organization and site organization responsible for implementation of recommendations.

Cost-effectiveness

The costs of an equivalent on-site assessment may be comparable to the costs of performing an independent assessment, especially if delayed/canceled primary functions of the utility assessor

are factored into the cost-benefit analysis at actual utility costs (loaded labor rates including benefits).

Avoiding Distractions

The use of independent assessors eliminates external distractions related to emergent site issues during the assessment period that can accompany the use of in-house staff.

2
ASSESSMENT RESULTS

Using the methodology and criteria developed as described previously, detailed, site-specific ALARA program assessments have been performed at two PWR stations. The assessments focused on in-plant application aspects of their programs. To maintain confidentiality, the sites at which the assessments were performed will be referred to as PWR A and PWR B.

2.1 PWR A

This single unit plant is a four loop PWR that has operated for >20 years.

2.1.1 PWR A Assessment Methodology

The first phase of the assessment focused on regulatory compliance, administration, and implementation of the ALARA program. Several of the primary categories and criteria interfaced with each other. This overlap allowed for assessment flexibility by permitting the assessor to define the evaluation strategy. During the initial phase of the assessment, the plant ALARA staff and several key RP staff members were interviewed. Specific tasks and routines were then observed for verification of compliance with procedural or program management expectations. Numerous procedures were reviewed to identify program requirements to evaluate their clarity and to confirm the appropriate level of detail.

Next, station organizations that are external to the ALARA group were assessed. The review focused on the impact and coordination of controls, practices, and procedures that affect the ALARA program.

Assessment performance statistics are presented in Table 2-1.

Table 2-1
PWR A - Assessment Statistics

Statistic	Quantity
On-site time	Two person weeks.
Number of site documents reviewed	46
Number of Criteria assessed	532
Number of plant contacts	18

Each of the assessment criteria was graded based on the assessor's conclusions. The data was automatically collated by the program, and then used to produce summary tables and graphs that present the general conclusions of the assessment. Finally, a site-specific report was generated that identified program performance, strengths, and enhancements that could be of benefit to the program.

2.1.2 PWR A Results

The overall conclusion is that the program currently provides very good ALARA guidance, and produces practices and results that are excellent. In 1998, PWR A experienced its lowest total annual exposure in their 22 years of operation. That year the International Atomic Energy Agency (IAEA) designated the station as the "World Class ALARA Performer". That prestigious international award is presented annually to only one of 140 commercial reactors operating in North America.

Table 2-2 summarizes the station's exposure data.

Table 2-2
PWR A - Summary Exposure Data

The Following Data is for Calendar Year	1998
Person-Rem Value ($ per Person-Rem)	10,000
Unit One	
Type of Plant (BWR or PWR)	PWR
Electrical Output (MW_e)	>1,000
# Primary Loops	4
Operational Exposure (Rem)	14.560
Number Operational Days	365
mRem per Operational Day	39.89
# RCA Entries per Operational Period	35,886
mRem per Operational RCA Entry	0.41
Refueling Outage Exposure (Rem)	0
Number Outage Days	0
mRem per Outage Day	0
#RCS Entries per Outage Period	0
mRem per Outage Entry	0
Forced Outage Exposure (Rem)	0
Number Outage Days	0
mRem per Outage Day	0
#RCS Entries per Outage Period	0
mRem per Outage Entry	0
Total Unit Exposure	14.560
mRem per Mw_e	0.01

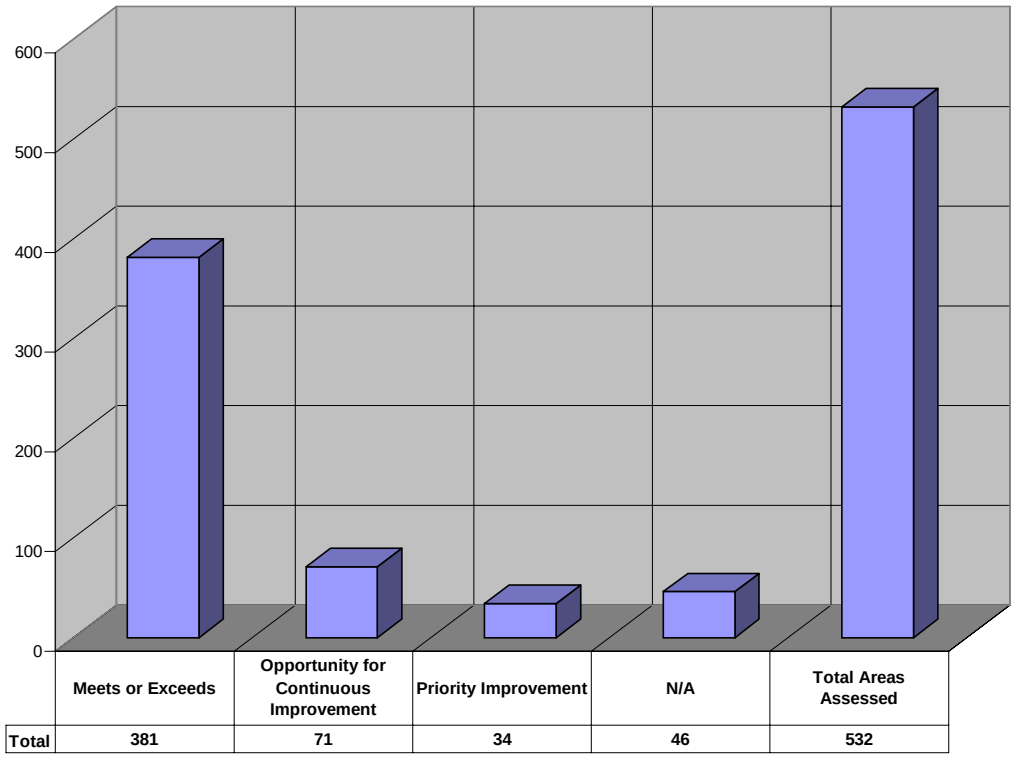
Table 2-2
PWR A - Summary Exposure Data (Continued)

The Following Data is for Calendar Year	1998
Annual Site Exposure (Rem)	14.560
# Total RCA Entries	35,886
mRem per Total RCA Entry	0.41
Annual Site Operational Exposure (Rem)	14.560
# Operational RCA Entries	35,886
mRem per Operational RCA Entry	0.41
Annual Site Refueling Outage Exposure (Rem)	0.000
# Outage RCA Entries	0
mRem per Outage RCA Entry	0
Annual Site Forced Outage Exposure (Rem)	0.000
# Outage RCA Entries	0
mRem per Outage RCA Entry	0

The exposure information in the previous table is presented in several categories. The intent is that this information be used for future benchmarking with other stations that are assessed using this program. A Plant Data module in the assessment program provides additional plant specific information to further assist in accurate data comparison.

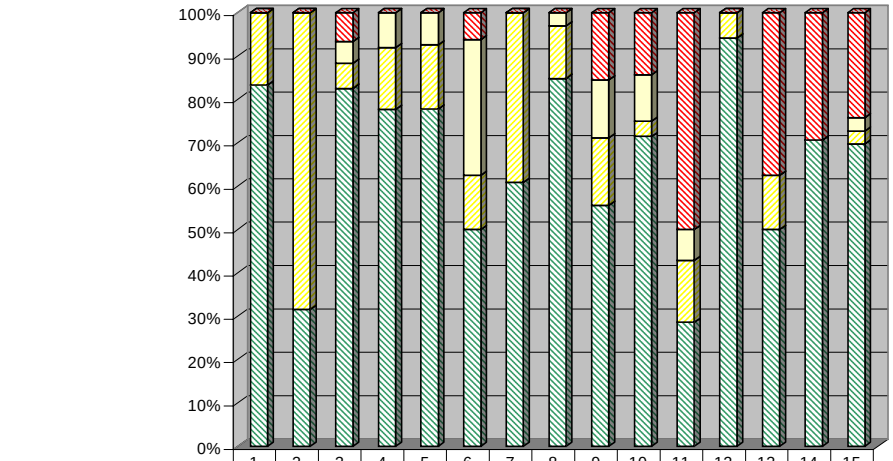
The following figures obtained from the assessment summary provide detailed results of the criteria performance.

Assessment Results



	Meets or Exceeds	Opportunity for Continuous Improvement	Priority Improvement	N/A	Total Areas Assessed
Total	381	71	34	46	532

Figure 2-1
PWR A Assessment Summary



Module Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
N/A	0	0	8	0	0	1	0	0	7	4	7	0	6	5	8
Priority Improvement	0	0	6	9	2	5	0	1	6	3	1	0	0	0	1
Opportunity for Continuous Improvement	2	13	7	16	4	2	9	4	7	1	2	1	2	0	1
Meets or Exceeds	10	6	99	87	21	8	14	28	25	20	4	16	8	12	23

Figure 2-2
PWR A Category Summary

Using the results in this figure, it can be seen that 73% of the total areas assessed met or exceeded the assessment criteria. When the non-applicable items are disregarded, that performance improves to 78% meeting or exceeding the criteria, with ~15% providing opportunity for continuous improvement. Only 7% were found to be priority improvements. These results support the conclusion that when using the 486 applicable program criteria the overall PWR A ALARA program performance is excellent.

Strengths

The assessment revealed a number of ALARA program strengths, based on performance results and unique approaches. These are briefly summarized here.

Industry Perception

This plant presented a unique opportunity for developing and beta testing the ALARA assessment tool and evaluation criteria. The Radiological Protection Program at the site has consistently been rated as a SALP I performer by the NRC and has been ranked as an industry benchmark by INPO. As a result of the station's very aggressive ALARA program, their performance in 1998 was outstanding, leading to national recognition of their achievements.

Plant Program Support

The plant staff was keenly aware of the importance of the program, and worked as a cohesive unit to identify, implement, and maintain the success of opportunities for improvement. Senior management support was visible through the use of written and verbal communications, and the incorporation of exposure expectations into management personal performance expectations. Daily interface between the ALARA, RP and plant organizations resulted in a high level of knowledge of exposure issues. Through the use of informational posters, program results charts, and an aggressive suggestion-reward program, an ALARA "presence" was very apparent throughout the plant.

Job Planning

Planning and scheduling incorporated formal ALARA measures that included "wrench-time" history and projections, tool lists, jobsite walk-down checklists (only when deemed appropriate in keeping with the ALARA principle), and the number and qualifications of workers. Digital cameras were used by RP, task supervision, and the planning staff to evaluate work locations, interferences, and for reviewing historical job site set-up (shielding, RP controls, and required services).

Recommendations

As a result of the station's generally excellent performance, the assessment identified a few categories with no significant recommendations for improvement. However, the analysis did identify program attributes that should be enhanced to increase the potential for continued

long-term success of the program. It is important to realize that this assessment was extremely detailed, and represented an "ideal" program. Examples of priority improvement recommendations for PWR A are given in Appendix A.

2.1.3 PWR A Assessment Conclusions

Based on the plant's exposure performance, it was readily determined that the station's ALARA program was very successful.

2.1.4 Current Program Status

The station's current ALARA program status clearly indicates an improvement trend. PWR A is currently on track for a <10 person-Rem year. Following the assessment, in 1999 the station completed their refueling outage with the lowest outage exposure in the plant's history.

2.2 PWR B

PWR B is a two unit Pressurized Water Reactor (PWR) site that has operated for >20 years. In 1999, the station's Radiation Protection (RP) staff requested ALARA program assistance from EPRI. The assessment was requested for several reasons:

- to have an independent comprehensive review performed of the ALARA program as implemented by station organizations.
- to compare the PWR B program performance with industry ALARA good practices.
- to identify new concepts for improving the PWR B ALARA program.

The ALARA Program assessment at PWR B was performed in December, 1999.

2.2.1 PWR B Assessment Methodology

Assessment performance statistics are presented in Table 2-3.

Table 2-3
PWR B - Assessment Statistics

Statistic	Quantity
On-site time	Three person weeks.
Number of site documents reviewed	103
Number of Criteria assessed	497
Number of plant contacts	32

2.2.2 PWR B Results

PWR B recent exposure history places it near the median for PWR dose performance. The results of this assessment indicate that PWR B has an acceptable ALARA program that meets the 10CFR20 requirements and generally follows industry good practices.

Table 2-4 summarizes the station's exposure data.

Table 2-4
PWR B - Summary Exposure Data

The Following Data is for Calendar Year	**1998**
Person-Rem Value ($ per Person-Rem)	25,000
Unit One	
Type of Plant (BWR or PWR)	PWR
Electrical Output (MW_e)	>500, <1,000
# Primary Loops	2
Operational Exposure (Rem)	17.340
Number Operational Days	300
mRem per Operational Day	57.80
# RCA Entries per Operational Period	not tracked by unit
mRem per Operational RCA Entry	not tracked by unit
Refueling Outage Exposure (Rem)	156.600
Number Outage Days	50
mRem per Outage Day	3,132.00
#RCS Entries per Outage Period	not tracked by unit
mRem per Outage Entry	not tracked by unit
Forced Outage Exposure (Rem)	3.200
Number Outage Days	not tracked by unit
mRem per Outage Day	not tracked by unit
#RCS Entries per Outage Period	not tracked by unit
mRem per Outage Entry	not tracked by unit
Total Unit Exposure	177.140
mRem per Mw_e	0.21

Table 2-4
PWR B - Summary Exposure Data (Continued)

The Following Data is for Calendar Year	1998
Unit Two	
Type of Plant (BWR or PWR)	PWR
Electrical Output (MW_e)	850
# Primary Loops	2
Operational Exposure (Rem)	17.340
Number Operational Days	310
mRem per Operational Day	55.94
# RCA Entries per Operational Period	not tracked by unit
mRem per Operational RCA Entry	not tracked by unit
Refueling Outage Exposure (Rem)	161.500
Number Outage Days	56
mRem per Outage Day	2,883.93
#RCS Entries per Outage Period	not tracked by unit
mRem per Outage Entry	not tracked by unit
Total Unit Exposure	178.840
mRem per Mw_e	0.21
Annual Site Exposure (Rem)	355.980
# Total RCA Entries	197,631
mRem per Total RCA Entry	1.80
Annual Site Operational Exposure (Rem)	34.680
# Operational RCA Entries	106,258
mRem per Operational RCA Entry	0.33
Annual Site Refueling Outage Exposure (Rem)	318.100
# Outage RCA Entries	91,373
mRem per Outage RCA Entry	3.48
Annual Site Forced Outage Exposure (Rem)	3.200
# Outage RCA Entries	not tracked
mRem per Outage RCA Entry	not tracked

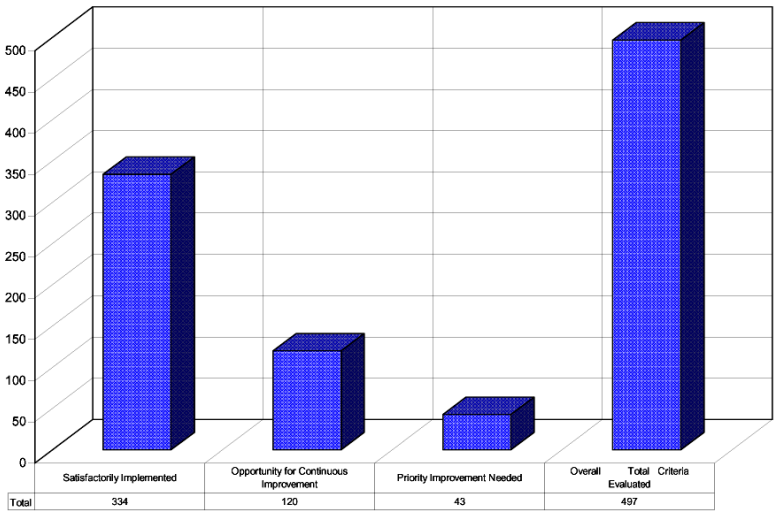
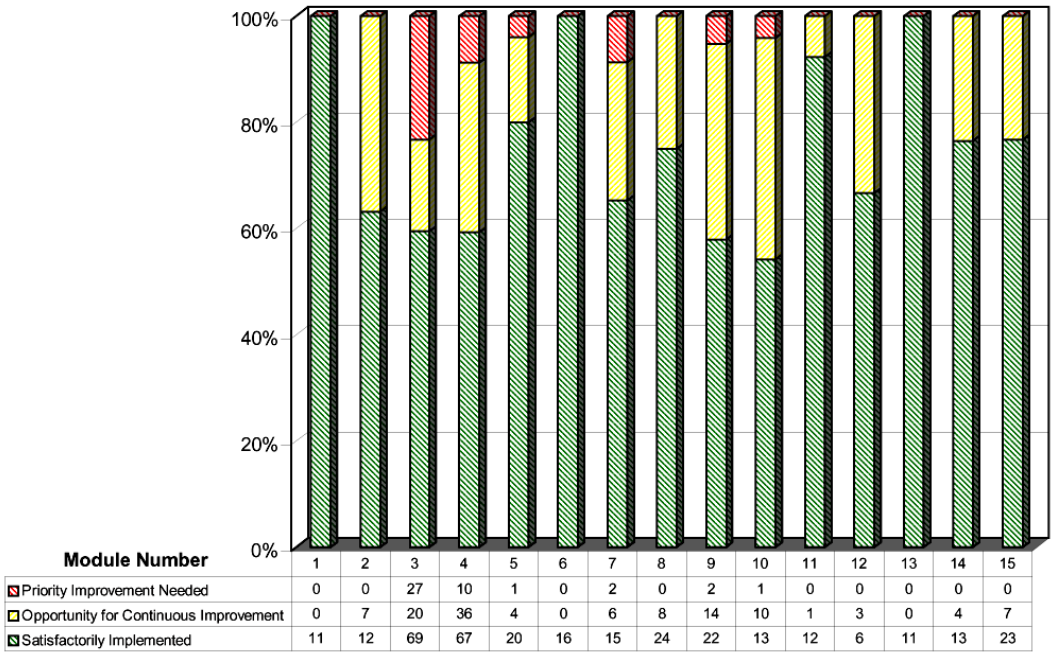


Figure 2-3
PWR B Assessment Summary



Module Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Priority Improvement Needed	0	0	27	10	1	0	2	0	2	1	0	0	0	0	0
Opportunity for Continuous Improvement	0	7	20	36	4	0	6	8	14	10	1	3	0	4	7
Satisfactorily Implemented	11	12	69	67	20	16	15	24	22	13	12	6	11	13	23

Figure 2-4
PWR B Category Summary

67% of the assessed criteria are satisfactorily implemented. 24% of the assessed criteria represent opportunities for continuous improvement. 9% of the assessed criteria represented areas that are recommended for priority improvement. The Assessment Summary Charts provide more detailed criteria performance results.

Strengths

The assessment revealed a number of ALARA program strengths, based on performance results and unique approaches. These are briefly summarized here.

Operations Department ALARA Improvement Program

The Operations Department has initiated the "2000 Operations Business Initiative – Dose Reduction" with the goal to aggressively implement dose reduction efforts during the year 2000 so that the total dose does not exceed 7.0 Rem during operations. Approximately 20 improvement actions have been identified with responsibilities and milestone dates defined. The effort is being championed by the Operations staff, with clear support and encouragement from Operations senior management.

ALARA Planning Methodology

The ALARA planning organization produces clear Radiation Work Permits with direct links to the Maintenance Orders. In addition, lessons learned are captured in an easily retrievable format enabling many years of data to be reviewed. ALARA planners are co-located within the integrated work management system. This encourages active discussion and development of high quality plans. The ALARA planners demonstrated significant plant experience and a desire to develop work plans that emphasize ALARA goals.

Technical/Engineering ALARA Focus

The Technical Support and Engineering staff was well versed in ALARA methodologies and actively participated in the preparation and implementation of ALARA initiatives as part of modification design and plant configuration. Examples include the incorporation of pre-designed shielding packages into the Temporary Shielding Procedure, as well as the detailed review, analysis, and planning evident in large, special projects. Several specific ALARA improvement efforts are underway including long life in-core instrumentation (ICI), quick lock ICI, and spent fuel storage, represent good practical initiatives.

Industry Event and Site Specific Document Retrieval

The Industry Experience Assessment Unit has developed a unique approach to Industry Event and Site Specific Document search and retrieval. The resulting database allows for instant access and full text search-ability to pertinent industry experience, regulations, site-specific documentation, etc. This tool represents a well-designed and maintained methodology that can be utilized for ensuring that ALARA program improvements are consistent with industry efforts and issues.

High Radiation Area and Low Dose Area Designations

Novel signs and plant awareness tools have been developed and implemented for notifying individuals that they are approaching High Radiation Areas (star sign) and for identifying Low Dose Areas (cone with green light). Both of these improvements aim to reduce exposure reduction and encourage overall good radiation worker practices.

There were a number of positive aspects of the station's ALARA program, including the initiative to identify and reduce routine exposure to plant Operators, a detailed job history database, and excellent engineering support to the shielding program.

Recommendations

The assessment identified certain categories that have no significant recommendations for improvement. However, this analysis did identify program attributes that should be enhanced to increase the potential for continued success of the program. The majority of the needed program improvements were in the areas of ALARA Program Administration and Implementation. Focusing attention on these two areas should result in a significant improvement of the ALARA program. Specific recommendations were listed only for Priority Improvement items. Those were combined where possible into coherent discrete recommendations in an attempt to avoid duplication. In some cases, additional recommendations were listed in the assessment field notes for consideration when addressing the Opportunity for Continuous Improvement items.

It is important to recognize that this assessment was very detailed, and represents an "ideal" program. Therefore, the identified recommendations represent concepts that will provide long-term benefit. Specific details were provided in the site's confidential report.

2.2.3 PWR B Assessment Conclusions

PWR B had taken an important step in benchmarking the ALARA Program and identifying opportunities for improvement. The assessment indicated that the ALARA Program was acceptable, and that with long-term, visible senior management support, there was an opportunity to make it one of the best in the industry.

Two major conclusions, if addressed expeditiously, would result in a significant improvement to several aspects of the ALARA Program. Other recommendations for priority improvements are given in Appendix B.

1. Ownership of the ALARA Program by the station:

   Insisting on ownership of the program at all levels. It was critical for the station's staff to recognize that ALARA was not just a Radiation Protection Department issue. The changes to the station's approach to Radiation Protection event prevention had elevated the station awareness of this issue. Similarly, ALARA should be everyone's concern. The ALARA focus can co-exist with other important plant issues, such as event prevention, cost considerations, etc. Senior Management support related to expectations, resource provisions,

and funding, etc., was critical to proposed program improvements and the long-term success of the ALARA program.

2. Developing an ALARA Focus:

   Developing a station-wide focus on ALARA by making it a station priority could be achieved using an ALARA Committee, signs, goals for individual jobs, departmental goals, a suggestion program, and other visible signs of support.

2.2.4 Current Program Status

The station's current ALARA program status clearly indicates an improving trend. PWR B recently completed a refueling outage with the lowest exposure in the past 15 years. Although this was primarily due to improved Integrated Work Management System, the implementation of assessment recommendations, combined with the heightened station awareness resulting from the assessment, supported that effort. The station has also improved tracking and implementation of ALARA Suggestions and experienced an increase in the number of suggestions this year. The ALARA organization has developed an ALARA Accomplishments file that is communicated to the site and improved site dose reporting. A new, formalized shutdown chemistry team has been assembled, targeting improvements regarding crudburst cleanup and source control at shutdown. Finally, the station is now performing quarterly Self Assessment's of the site ALARA program.

2.3 Industry Data Comparison

As is frequently the case, direct comparison of assessment results between stations only provides limited value. While the safety of workers and the public are critical goals for any ALARA program, numerous factors influence the derived assessment conclusions including. Several of those issue are:

- Plant type, system and structural configuration, and age.
- Resource allocation (funding and staff).
- Plant specific goals and direction from both internal and external organizations.
- Staff experience.

A more meaningful use of these results would be to identify areas where sharing successful methods might lead to improved program performance for the station with less-than-desirable results.

Table 2-5 contains a comparison of station exposure by various categories.

Table 2-5
Plant Exposure Comparison Data

Plant	PWR A	PWR B
The Following Data is for Calendar Year	1998	1998
Person-Rem Value ($ per Person-Rem)	10,000	25,000
Unit One	**Unit One**	**Unit One**
Type of Plant (BWR or PWR)	PWR	PWR
Electrical Output (MW_e)	1010	850
# Primary Loops	4	2
Operational Exposure (Rem)	14.560	17.340
Number Operational Days	365	300
mRem per Operational Day	39.89	57.80
# RCA Entries per Operational Period	35,886	not tracked by unit
mRem per Operational RCA Entry	0.41	not tracked by unit
Refueling Outage Exposure (Rem)	0	156.600
Number Outage Days	0	50
mRem per Outage Day	0	3,132.00
#RCS Entries per Outage Period	0	not tracked by unit
mRem per Outage Entry	0	not tracked by unit
Forced Outage Exposure (Rem)	0	3.200
Number Outage Days	0	not tracked by unit
mRem per Outage Day	0	not tracked by unit
#RCS Entries per Outage Period	0	not tracked by unit
mRem per Outage Entry	0	not tracked by unit
Total Unit Exposure	14.560	177.140
mRem per Mw_e	0.01	0.21
Unit Two	**Unit Two**	**Unit Two**
Type of Plant (BWR or PWR)	Not applicable	PWR
Electrical Output (MW_e)	—	850
# Primary Loops	—	2
Operational Exposure (Rem)	—	17.340
Number Operational Days	—	310
mRem per Operational Day	—	55.94
# RCA Entries per Operational Period	—	not tracked by unit
mRem per Operational RCA Entry	—	not tracked by unit
Refueling Outage Exposure (Rem)	—	161.500
Number Outage Days	—	56
mRem per Outage Day	—	2,883.93
#RCS Entries per Outage Period	—	not tracked by unit
mRem per Outage Entry	—	not tracked by unit
Total Unit Exposure	—	178.840
mRem per Mw_e	—	0.21
Annual Site Exposure (Rem)	14.560	355.980
# Total RCA Entries	35,886	197,631
mRem per Total RCA Entry	0.41	1.80

Table 2-5
Plant Exposure Comparison Data (Continued)

Plant	PWR A	PWR B
The Following Data is for Calendar Year	1998	1998
Annual Site Operational Exposure (Rem)	14.560	34.680
# Operational RCA Entries	35,886	106,258
mRem per Operational RCA Entry	0.41	0.33
Annual Site Refueling Outage Exposure (Rem)	0.000	318.100
# Outage RCA Entries	0	91,373
mRem per Outage RCA Entry	0	3.48
Annual Site Forced Outage Exposure (Rem)	0.000	3.200
# Outage RCA Entries	0	not tracked
mRem per Outage RCA Entry	0	not tracked

Figures 2-5 and 2-6 compare the two assessment's overall performance summary and the results achieved by category.

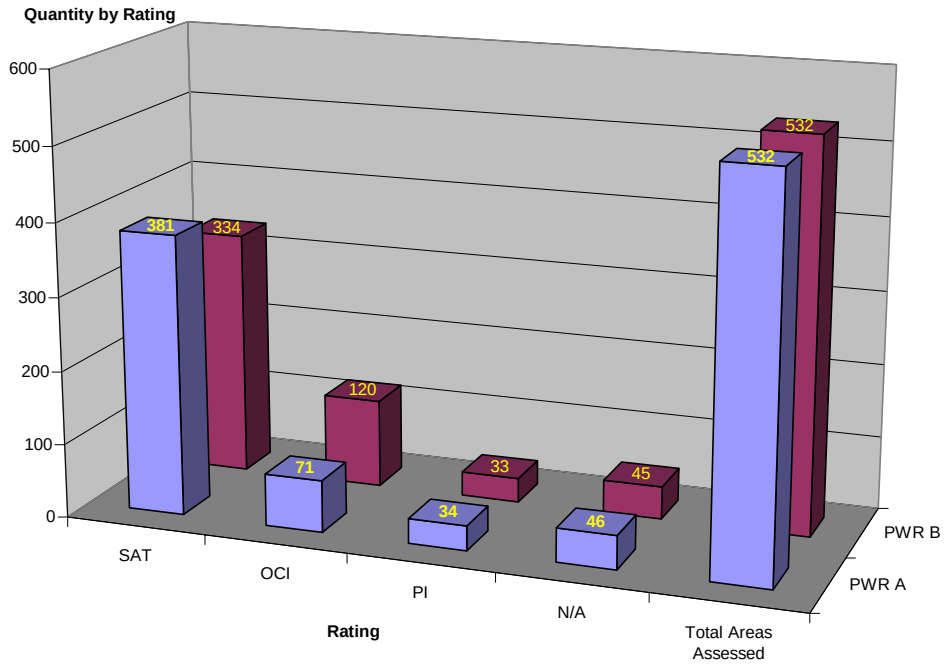


Figure 2-5
Assessment Summary Comparison

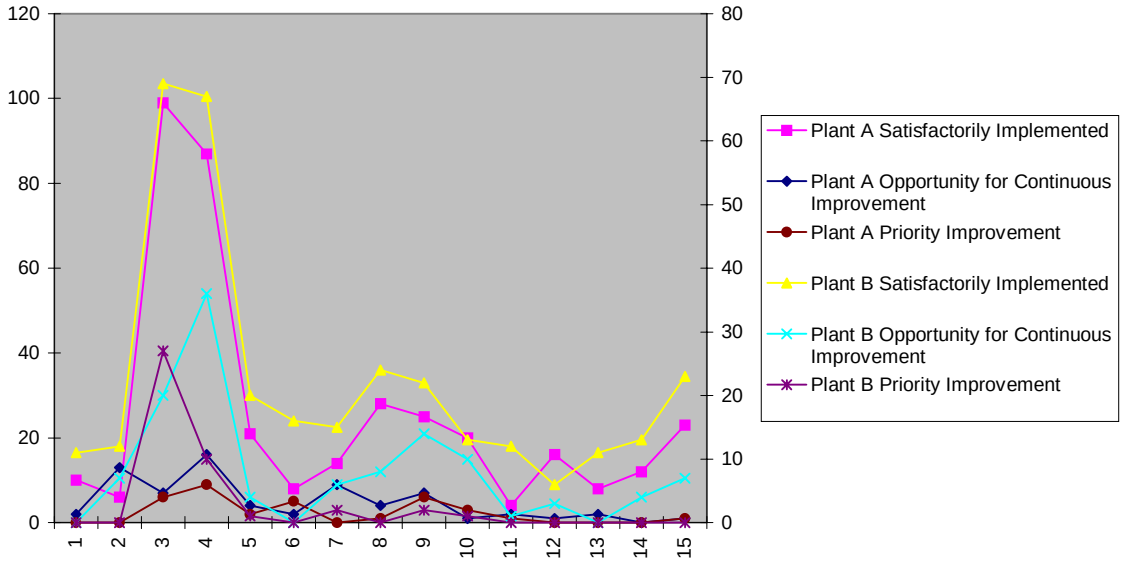


Figure 2-6
Assessment Category Comparison

3
BWR ASSESSMENT METHODOLGY DEVELOPMENT

3.1 Background

EPRI successfully completed the development and demonstration of a comprehensive ALARA program assessment methodology in 1999. To ensure the sponsoring utility's needs were met, that work focused on developing a PWR ALARA program methodology. As a result of this program's origin, concerns were expressed by ALARA personnel at BWRs about the product's applicability to evaluating BWR ALARA programs. Questions about issues such as higher BWR work area exposure rates and the significant size of BWR radiologically controlled areas (RCAs), prompted further research into BWR assessment criteria.

3.2 Objective

The primary goal of this phase of the project was to develop additional criteria, or modify existing ALARA program assessment criteria, to address the specific needs of BWR stations. This was accomplished by identifying BWR specific issues, reviewing industry literature, and capturing relevant personal experience from industry BWR ALARA professionals.

3.3 Methodology

The existing categories were reviewed to determine what, if any, criteria would be required to adequately address BWR programs. In parallel with that effort, based on interviews with BWR ALARA professionals, a list of specific topics was developed identifying potential differences in program management and plant applications. The list included several broad categories such as:

- Chemistry controls
- Spent fuel pool work
- Turbine and "secondary" system work
- Source term
- Utility staff size – number of monitored workers
- Transient outage work force

The next step was to review approximately 60 documents for BWR specific ALARA issues or applications.

Information that was reviewed included: industry papers, vendor literature, ISOE documentation, a BWR site ALARA program manual, Health Physics professional publications, and other miscellaneous documents.

To further support this effort, Exelon corporate staff agreed to sponsor a BWR peer review of the proposed PWR/BWR product. A one-day meeting was held at their Downers Grove, IL headquarters with a team of EPRI contractors and Exelon site and corporate ALARA staff.

3.4 Results

During the document review process, it became apparent that although BWR stations have larger radiologically controlled areas and more significant sources of exposure, the processes for managing exposure via an ALARA and RP program are nearly identical to those used at PWR stations. In spite of the similarities, several additional assessment criteria were added, or existing criteria modified, because of the greater "impact" these issues have on BWR exposure.

BWR Criteria

The document review noted above resulted in the development of several new "BWR unique" criteria. Those criteria were incorporated into the existing assessment categories as either stand-alone items, or as enhancements to existing PWR criteria. Several examples follow.

Category: Chemistry and Source Controls

Primary Chemistry Controls

1. Have the corrosion product sources - % hotwell, moisture separators, feedwater heaters – been evaluated and controls implemented based on that assessment?

2. Has zinc injection been evaluated as a dose control method, including the following issues?
    - Depleted zinc versus naturally occurring zinc?
    - Impact on effluent activity and dose?
    - Spent processing media activity, dose rates, and disposition options?
    - Zinc consumption rate versus benefit?

Absolute Rated Filtration

3. Is reactor makeup water purity evaluated and controlled to minimize chemical impurities relative to their impact on RCS activity?

Category: Engineering

Engineering Design Changes

4. Has the station evaluated or implemented design changes to forward pumped heater drain systems? Has the replacement of carbon steel extraction steam piping with CrMo alloys to reduce corrosion product transport been evaluated?

Category: Specific Maintenance and Evolutions

Spent Fuel Pool Work

5. Does the Spent Fuel Pool (SFP) cleanup contractor selection process include information about historical ALARA successes?

6. Are vendor procedures reviewed for inclusion of site ALARA requirements?

7. Have alternate disposal options for irradiated hardware been evaluated, including shipment of Stellite™ materials to source manufacturer for commercial irradiators?

8. Is remote monitoring utilized?

9. Are stored high activity wastes (> class C) packaged to preclude need for re-packaging/handling for future disposition?

10. Does the station rinse tools, components, and casks with demineralized water prior to immersion in SFP?

Category: ALARA Program Implementation

Shielding

11. Has the installation of permanent shielding been evaluated in areas which temporary shielding is typically/frequently installed?

12. Does the temporary versus permanent shielding assessment include evaluation of personnel safety issues related to area accessibility, lifts, and support?

Category: Radwaste

Liquid Radwaste Generation

13. Have system isolation and drain points been evaluated for minimization of liquid waste generation, redundant tagging, and area dose rates?

Peer Review Meeting Results

At the peer review meeting, the contractor and Exelon team reviewed all 561 of the assessment criteria developed during both phases of this project. Each primary category was reviewed to ensure it addressed known BWR specific issues. In addition, each category's criteria were reviewed for applicability to BWRs, for technical content, and for clarity. As a result of the detailed review, several existing criteria were improved, and additional criteria (including those noted above) were developed. These criteria were incorporated into the final version of EPRI BWR ALARA Program Assessment tool.

After incorporating these revisions, the team concluded that the assessment product was comprehensive, complete, and ready for field application at a host BWR station.

NOTE: It is important to recognize that similar to any assessment methodology, the product is a "living" document and as such, will be modified in the future to capture process improvements, to correct deficiencies in the criteria, and to reflect industry needs as appropriate.

3.5 BWR Site ALARA Program Assessment

The next step in this project is a detailed ALARA program assessment at a host BWR site. EPRI is currently negotiating with several BWR site ALARA assessment candidates to evaluate the final product. The intent of the assessment is to verify to the extent practical that the current criteria are both sound and comprehensive. As was the case for PWR assessments, two person-weeks will be spent at the host site, and following off-site data analysis, a site-specific report will be produced. The report will address the results and recommendations of that assessment and include industry-benchmarking results using a format reflecting plant type, size and operational periods. Finally, those results will be compiled in a database for future reference and industry benchmarking.

Following confirmation of the methodology and content for BWRs, this EPRI service will be available to all utilities interested in improving, or maintaining the long term success of, their ALARA program.

4
EPRI ALARA USERS GROUP

4.1 Background

A Users Group has been formed to monitor the success of, and provide guidance to EPRI's Radiation Exposure Management target. The group held two meetings in 2000. The first meeting in March was held in conjunction with the BWROG ALARA meeting in Scottsdale. That meeting provided insight to the members regarding the ALARA tool and proposed enhancements. A second meeting was conducted in July in Denver, CO. That meeting was held in series with the PWR and BWR joint ALARA meeting.

4.2 Status

At the Denver meeting it was determined that the Users Group provided an ideal platform for ALARA program enhancements. The proposed and accepted concept follows.

The Owner's Group meetings would collectively identify a target exposure reduction opportunity or issue. Through the Users Group, EPRI would work with utility and industry experts to identify solutions for the targeted issue. Meetings would be used as a forum for directing efforts and reporting progress. This would clearly meet the intent of EPRI's resources, while providing a service to numerous utilities based on their collective input. It is expected that the next meeting will provide a first test for this process, with an issue to be identified and a course of action developed for research and resolution.

A
APPENDIX A

PWR A - Condensed List of Priority Improvement Recommendations

REC-1	Reevaluate the specific roles of individuals in the corporate RP organization. At a minimum, one individual should be assigned the primary responsibility for periodically reviewing and maintaining utility procedures and incoming industry experience documents that relate to the ALARA program. That “filtered” knowledge could be forwarded to the site for implementation.
REC-2	Update and reactivate the ALARA Design Manual.
REC-3	Revise the “Work Control Process” procedure to formally address ALARA input to that process and where applicable, require ALARA approval as part of the scheduling process.
REC-4	Identify and implement a method for “charging” lead department for implementation of task specific ALARA improvements. The station is currently evaluating options.
REC-5	Develop and implement the routine use of a supervisor’s ALARA awareness module.
REC-6	Include elevational/area planning in the work planning process. Consideration should be given to maintaining water levels in adjacent systems/components, alternatives to “front-end” schedule loading, and contingencies for problems.
REC-7	Provide all Engineers performing RCA modifications with ALARA and source reduction training. Encourage members of the Engineering organization to attend RP/ALARA industry meetings.
REC-8	Develop a simple checklist and/or conduct training for RWP criteria related to the benefit derived versus the affect on personnel exposure.
REC-9	Aggressively pursue sub-micron, absolute rated filtration for all primary filter applications and develop procedural guidance for effecting changes to micron rating based on plant mode and/or for special evolutions.
REC-10	Perform a detailed analysis of media changeout criteria to optimize the balance between cost, personnel exposure, transport, and disposal considerations.

B
APPENDIX B

PWR B - Condensed List of Priority Improvement Recommendations

REC-1	Plant management should periodically reinforce the importance of a continuously improving the ALARA program through methods such as memos, newsletters, and staff meetings, as well as requiring active ALARA Committee participation by all site organizations.
REC-2	The station needs to identify and fund ALARA improvement initiatives each year. Develop a mechanism for prioritizing, assigning ownership, and funding ALARA improvements. Take credit for the fact that these are ALARA – related improvements.
REC-3	An active ALARA Committee should be formed to aggressively pursue ALARA program improvements and long-term success. The ALARA Committee should address the following items at a minimum: – ALARA policy guidance – results analysis and tracking (goals versus performance) – improvement action planning – overall ALARA planning, implementation and results review – ownership of improvement actions – annual and special report reviews and approvals
REC-4	Implement actions that focus the site staff on making continuous ALARA program improvements by identifying mRem savings in order to beat (not just meet) global and individual goals. This requires a cultural change that can be initiated with the development of goals at the supervisory and individual level. It can be further supported by publicizing the individual contributions required for improvement.
REC-5	*Recommendation removed from Priority Improvement List based on draft report feedback and review.*
REC-6	As planned in 2000, implement a formal ALARA self assessment methodology that: – targets critical performance reviews – seeks continual improvement – ensures effective feedback and implementation – includes an effectiveness review element to ensure identified deficiencies are appropriately addressed.

REC-7	Require major vendors to have an individual responsible and accountable for dose reduction initiatives for their respective contract staff (e.g. Bartlett). Explore the use of an incentive/penalty program in major vendor contracts for ensuring that the station ALARA focus is clearly evident as an important aspect of successful job/task completion. Develop a tracking mechanism to measure and publicize performance.
REC-8	Develop a 'living' document listing successful ALARA improvements to ensure that future program-wide improvements are made where practical and to publicize the importance of a continuous improvement culture. Additionally, this document can be used to demonstrate that the station is maintaining a healthy and aggressive ALARA program.
REC-9	Develop a supervisory ALARA training category for house and contract supervisors that addresses the following minimum items: – Supervisor's responsibilities and program ownership – ALARA review requirements and background – Exposure reduction techniques – Worker feedback– solicitation, documentation and resolution
REC-10	Develop a mechanism for planning at the task-level, focusing on establishing limits and estimates based on wrench-time and actual on-the-job dose rates (could be included as part of the Integrated Work Management system). This level of detail also creates an opportunity for identifying additional ALARA improvements and clearly defined performance monitoring for individual task goals.
REC-11	The dose reduction potential of digital camera use (or a surrogate tour system use) should be emphasized and a method for cataloging and retrieving this information should be developed. Incorporating that database into the station's LAN system would provide a readily accessible, valuable planning and execution tool.
REC-12	Formally consider eliminating recurring sources of exposure through permanent shielding and/or decontamination (e.g. Regenerative Heat Exchanger, Rx head shields, etc.). This can be accomplished through the ALARA Committee and the Integrated Work Management process. This will become more significant with the pending plant life-extension approval.
REC-13	Ensure that lessons learned and ALARA improvements are captured and implemented for 'medium/low' risk and frequently performed activities. Additionally, evaluate high-risk task controls for their ALARA exposure "cost" benefit impact.
REC-14	Ensure that future guidance booklets and publications prominently display and discuss ALARA dose reduction goals and ALARA good work practices. Detailed information could include dose reduction techniques and related photos (e.g. low dose waiting area lights, no loitering in the radiologically controlled area (RCA), planning is key to ALARA success, know your dose, bring ALARA suggestions to supervisor, you are responsible for ALARA performance, etc.).
REC-15	Include the use of quick lock/erect scaffolding in task planning. Develop a formalized process for coordinating its use in the RCA.

REC-16	Develop and implement elevational area work plans, maximizing the MX-19 man-lift (or similar devices) usage.
REC-17	Develop and utilize a shutdown/crudburst checklist with benefit-bases for decision-making parameters identified and documented.
REC-18	Detailed drawings (or CAD productions) of each shipping package configuration should be compiled. In addition, a technical basis document should be developed that addresses a methodology for accurate pre-determination of curie content and expected dose rates.

C
APPENDIX C

References Utilized for Criteria Development

Regulatory

Code of Federal Regulation, Title 10, Part 20 (10CFR20), "Standards for Protection Against Radiation".

USNRC Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Exposures at Nuclear Power Stations Will be As Low As Reasonably Achievable", June 1978.

USNRC Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable", September 1975.

USNRC Regulatory Guide 8.19, "Occupational Radiation Dose Assessment in Light Water Reactor Plants – Design Stage Man-Rem Estimates", June 1979.

USNRC Regulatory Guide 1.33, "Quality Assurance Program Requirements", Appendix A.

Code of Federal Regulation, Title 10, Part 50, Appendix I (10CFR50 Appendix I), "Numerical Guides for the Design Objectives and Limiting Conditions for Operation to Met the Criteria, As Low As Is Reasonably Achievable for Radioactive Material in Light Water Cooled Nuclear Power Reactor Effluents."

USNRC Regulatory Guide 1.8, "Qualification and Training of Personnel for Nuclear Power Plants".

INPO

INPO 97-002, Performance Objectives and Criteria for Operating Nuclear Electric Generating Stations.

INPO 91-014, "Guidelines For Radiological Protection at Nuclear Power Plants".

RP personnel knowledge and skills

Chemistry control

Appendix C

Chemistry measurement and analysis

Good practice

INPO 97-002, Performance Objectives and Criteria for Operating Nuclear Electric Generating Stations.

NEA/ISOE

Reports (various)

Documents (various)

Meeting presentations (various)

ANI Documents

ANI Section 8.2.1.12

ANI/MAELU Information Notice 80-1A, “Nuclear Liability Insurance Records Retention”.

ANI/MAELU Section 8.3, Revision 3, “Engineering Inspection Criteria for Nuclear Liability Insurance - Radiation Protection - ALARA”.

ANI Section 8.2.1.12

NEI Documents

NEI Industry wide Benchmarking Program - “Radiation Protection Rapid Benchmarking Report”, November 1998.

ANSI Standards

N18.1-1971, Selection and Training of Nuclear Power Plant Personnel.

EPRI Technology

EPRI Paper titled "Becoming a World Class ALARA Performer with EPRI Technology", H. Ocken and

C. J. Wood, 1997

Radiation Field Control Technology Manual - 1997 Revision, TR-107991 (10/97)

Proceedings: Radiation Exposure Control Seminar, 1999, TR-114003 (12/99)

Cobalt Source Term Reduction

Cobalt Reduction Guidelines - Revision 1, TR-103296 (12/93)

NOREM Applications Guidelines; Procedures for Arc Welding NOREM Hardfacing Alloys, TR-107231 (12/96)

Performance of NOREM Hardfacing in Plant Valves: In Situ Application and Leak Rate Testing of Feedwater Check Valves, TR-107987 (9/97)

An Economic Analysis of Cobalt Valve Replacement Strategies, TR-107169 (12/96)

An Economic Analysis of BWR Control Blade Management Strategies, TR-105812 (12/95)

Performance of NOREM Hardfacing Alloys, TR-112993 (12/99)

PWR Primary Coolant Chemistry

PWR Primary Water Chemistry Guidelines, Revision 3, TR-105714 (11/95)

Evaluation of Zinc Addition to the Primary Coolant of PWRs, TR-106358-V1 (11/96)

Re-Evaluation of the Benefits of Implementing Enriched Boric Acid, TR-109992 (3/98)

Evaluation of PWR Radiation Fields; 1991-1996, TR-107566 (2/97)

Dose Rate and Coolant Chemistry Data at PWRs Operating with Alternative Primary Coolant Chemistry, 1000153 (7/00)

Zinc Addition at the Palisades PWR to Reduce Shutdown Dose Rates, 1000190 (7/00)

BWR Primary Coolant Chemistry

BWR Water Chemistry Guidelines - 1996 Revision, TR-103515-R1 (12/96)

Hydrogen Water Chemistry Effects on BWR Radiation Buildup Volume 5: Executive Summary, TR-104605-V5 (11/95)

BWR Vessel and Internals Project: In-Plant Demonstration of Noble Metal Chemical Addition Treatment at Duane Arnold Energy Center, TR-108702 (9/97)

Experience with Depleted Zinc Oxide Injection in BWRs: 1999 Progress Report, TR-108741 (6/99)

BWR Activity Control – Plant Demonstration Results, TR-112981 (12/99)

Preconditioning Surfaces of Replacement Components

Electropolishing Process for PWR Steam Generators, NP-6619 (4/91)

Assessment of Chromium Coating Technology, TR-112982 (12/99)

Decontamination

LOMI Decontamination Reagents and Related Preoxidation Processes, NP-5522M (12/87)

Field Test of ELOMIX Radioactive Waste Treatment Process for Decontamination Solutions, TR-101797 (1/93)

Chemical Decontamination with Preoxidation Steps: BWR Systems at Plant Hatch, TR-107165 (12/96)

Full-System Decontamination of the Indian Point 2 PWR, TR-107039 (11/96)

Decontamination for Decommissioning: EPRI DFD Process, TR-106386 (5/96)

EPRI LOMI-2 Decontamination Process, TR-108740 (5/98)

Qualification of the NP/LOMI Decontamination Process for BWRs Under HWC, TR-111667 (11/98)

Decontamination Handbook, TR-112352 (7/99)

NP/LOMI Decontamination of the Laguna Varde-2 BWR, TR-114742 (3/00)

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