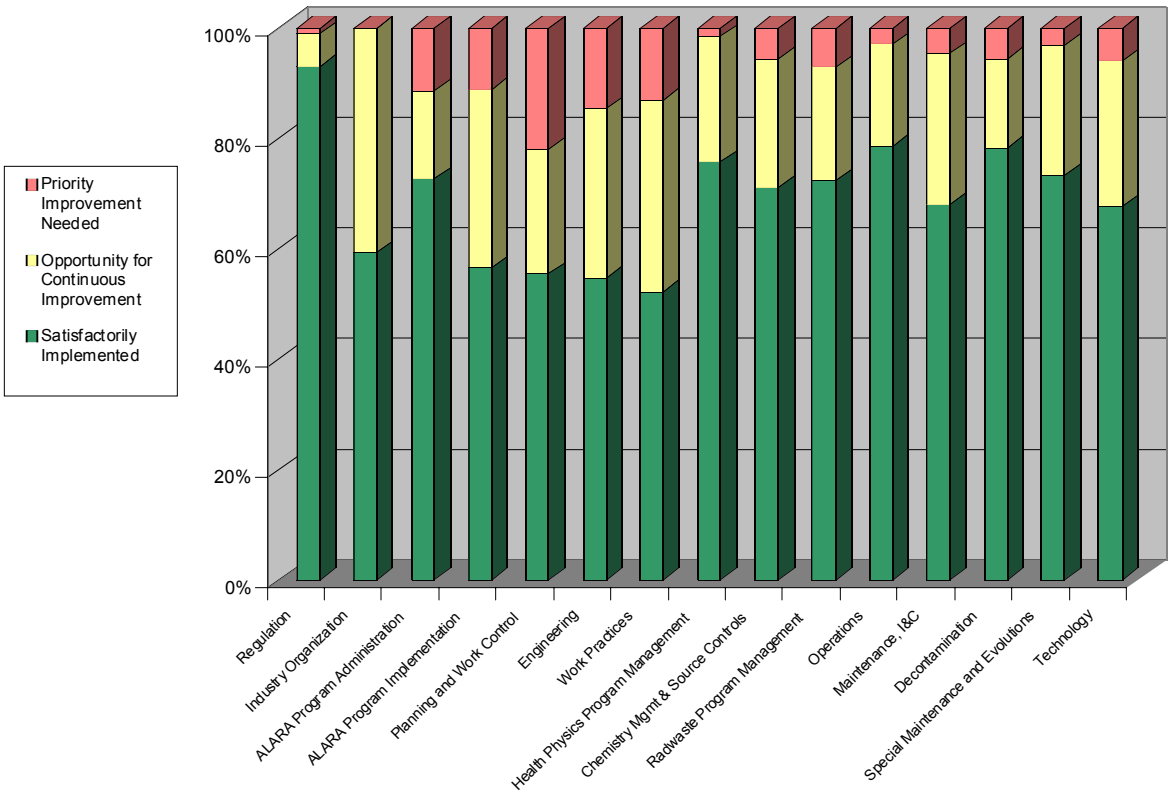
# Plant ALARA Assessments: Lessons Learned





*Technical Report*



# Plant ALARA Assessments: Lessons Learned

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Final Report, October 2002

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# REPORT SUMMARY

U.S. nuclear utilities have made significant progress over the last decade reducing personnel exposures to values that are As Low As Reasonably Achievable (ALARA). EPRI's ALARA assessment methodology is a spreadsheet tool that provides an objective assessment of the state of an individual plant's ALARA program. The tool has been used to evaluate ALARA programs at eight sites. This report summarizes program strengths and opportunities for program enhancements found at these sites. Other sites can incorporate the strengths into their programs. EPRI is using these generic opportunities for program enhancements to help identify future research needs.

### Background

EPRI's ALARA assessment tool contains more than 500 criteria that are used to evaluate various aspects of a plant's ALARA program. Industry experts use these criteria to evaluate and grade current ALARA programs at individual sites. Completed assessments at Browns Ferry, Callaway, Calvert Cliffs, D C Cook, Indian Point 2, Indian Point 3, Sequoyah, and Watts Bar serve as the basis for this "lessons learned" document.

### Objectives

- To analyze data compiled during the completed ALARA program assessments.
- To summarize strong points at individual sites.
- To identify program shortcomings of a generic nature that require industry resolution.

### Approach

The project team collected data from the assessments performed-to-date and reviewed them to [1] tabulate results by program category, [2] identify unique program management concepts, and [3] identify common industry issues. That information was sorted by program element and incorporated into this document as either a unique concept or program strength, or as an industry opportunity for improvement.

### Results

The assessment program has reviewed 3,996 criteria for the sites assessed to date. Of that total, 67% were satisfactory, 24% offered opportunity for improvement, and 9% were identified as priority improvements. This document identifies strengths or unique concepts related to nine program categories and discusses eight significant opportunities for industry-wide improvement. Some areas where improvements were desirable will form the basis for future EPRI research projects.

## EPRI Perspective

A description of EPRI's ALARA assessment tool and results from earlier plant assessments are presented in EPRI reports TR-112992 and 1000891. The ALARA improvement thinking process should not be confined to exposure. In reality, ALARA is a measure of both the process and the worker's efficiency and quality of work. Working faster and smarter, while producing the desired results the first time, will reduce personnel exposure. One topic identified as an area where improvements can be realized, scaffolding management, will be the subject of an EPRI-sponsored project next year.


## Keywords

ALARA
Exposure reduction
ALARA program assessments
ALARA program improvement

# ABSTRACT

Over the last decade, U.S. nuclear utilities have made considerable progress lowering personnel exposures to values that are As Low As Reasonably Achievable (ALARA). EPRI's ALARA assessment methodology is a spreadsheet tool that provides an objective appraisal of the state of an individual plant's ALARA program. The tool contains more than 500 criteria for evaluating various aspects of a plant's ALARA program. This project analyzes data compiled during previously completed ALARA program assessments at Browns Ferry, Callaway, Calvert Cliffs, D C Cook, Indian Point 2, Indian Point 3, Sequoyah, and Watts Bar. The study also summarizes strong points at individual sites and identifies generic program shortcomings that require industry resolution. Specifically, strengths or unique concepts related to nine program categories are identified and eight significant opportunities for industry-wide improvement are discussed. EPRI is using the opportunities for program enhancements found in this study to help identify future research needs.

# ACKNOWLEDGMENTS

EPRI would like to thank the staff members of the eight sites assessed-to-date as part of the EPRI ALARA Program Assessment project. Those sites and the primary site contacts were:

Browns Ferry; Danny Bohlender, Health Physicist

Callaway Station; Robert Farnam, Health Physics Operations

Calvert Cliffs; Patricia Jones, Plant Health Physicist

D.C. Cook; Robert Story, General Supervisor ALARA & RP Work Control

Indian Point Unit 2; Vic Nutter, Section Manager–Radiological Support

Indian Point Unit 3; Frank Mitchell, Health Physics General Supervisor

Sequoyah; J.Steven McCamy, Health Physics Principal–ALARA

Watts Bar; Doug Boone, Radiological Control Superintendent

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# 1
# INTRODUCTION AND BACKGROUND

## Background

Nuclear utilities have devoted significant resources to reduce personnel exposures at nuclear power plants to levels that are as low as reasonably achievable (ALARA). Challenges related to resource reductions, outage compression, and industry goals to further reduce the level of acceptable exposure, continues to face the industry. One of the tools available to help utility personnel meet these challenges is EPRI's ALARA Program Assessment Methodology. This spreadsheet-based tool defines the elements of a strong ALARA program and provides a consistent basis for the evaluation of the "health" of an individual plant's ALARA program. Using that tool and a team of industry experts, EPRI has sponsored ALARA assessments at eight sites, with a ninth participant scheduled for early 2003. As would be expected, these comprehensive station-wide program assessments have captured a wealth of industry experience, including both individual program strengths and generic problems that would benefit from a focused industry effort or research program.

## Objectives

The primary objectives of this project were to analyze the data compiled during the performance of the eight ALARA Program assessments, develop an industry lessons learned document, capture ideas for performance improvement, and to identify opportunities that appear to be generic issues requiring industry resolution.

## Organization of This Report

Section 1 of this report provides background information and objectives of the program. Section 2 provides a brief overview of the approach used. Examples of key ALARA program strengths are captured in Section 3. Section 4 discusses industry-wide opportunities for significant improvement with related recommendations. Section 5 presents the report's conclusions.

# 2
# APPROACH

The EPRI ALARA Program Assessment methodology focuses on station integration of the ALARA program and consists of over 500 criteria that evaluate 15 categories of the ALARA program:

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
9. Chemistry and Source Controls
10. Radwaste
11. Operations
12. Maintenance
13. Decontamination
14. Special Maintenance and Evolutions
15. Technology

Each of the applicable criteria is rated by the assessors based on quantitative and/or qualitative data obtained during data review and plant staff interviews. The ratings used are Satisfactory, Opportunity for Continuous Improvement, and Priority Improvement and are further defined below.

### Satisfactory

The performance meets current industry standards and/or provides the necessary guidance or controls to help ensure long-term program success.

### Opportunity for Continuous Improvement

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

### Priority Improvement

This rating results from a deficiency or an area that is not meeting standard industry good practices. Resources should be applied to improve these areas to achieve program health.

During the performance of EPRI ALARA assessments, an extensive database continues to be compiled. It currently includes a detailed summary of each plant's performance in the 15 assessed areas. This document was developed by first reviewing the eight plant's performance from a "global" perspective to identify items of interest to the industry. Data was then collated into

1. industry assessment results by program area;

2. a summary of the apparent strengths, including unique solutions that could be of value to other plants; and

3. generic unresolved industry challenges (i.e., issues that were identified at the majority of the assessed plants).

Finally, generic recommendations are provided for those areas that could result in industry-wide improvement.

# 3
# RESULTS

## Overview

The EPRI assessment methodology is very comprehensive and detailed, and a great deal of plant specific information is captured and reviewed during that process. Much of that data is considered proprietary to the extent that it may affect plant cost performance, and/or if taken out of context, could result in an inaccurate assessment of the station's program status. Therefore, the results presented in this section represent the aggregate of the eight sites' combined performance. For plant specific information, the individual plant ALARA leads should be contacted.

## Results Summary

Table 3-1 contains a brief summary of the results achieved by the eight sites, collated by rating.

**Table 3-1**
**Summary of Plant Performance by Rating**

| | Satisfactorily Implemented | Opportunity for Continuous Improvement | Priority Improvement Needed | Overall Total Criteria Evaluated |
|---|---|---|---|---|
| Totals | 2,666 | 973 | 357 | 3,996 |
| % | 67% | 24% | 9% | |

This information clearly illustrates the overall industry performance is very good, but continues to offer opportunities for improvement. In the majority of cases, several priority improvements may be linked via common causal factors or ownership and during the assessment process were grouped together for consideration for improvement. This significantly reduces the 357 (9%) values in the "Priority Improvement" category. Additionally, when reviewing this data it is important to recognize that improvement in many areas will result in an "avalanche" effect (e.g., improving a single "Priority Improvement" item may concurrently correct several "Continuous Improvement" issues).

Figure 3-1 presents a more detailed review of the eight sites' performance, breaking down the results by the fifteen (15) assessment categories.

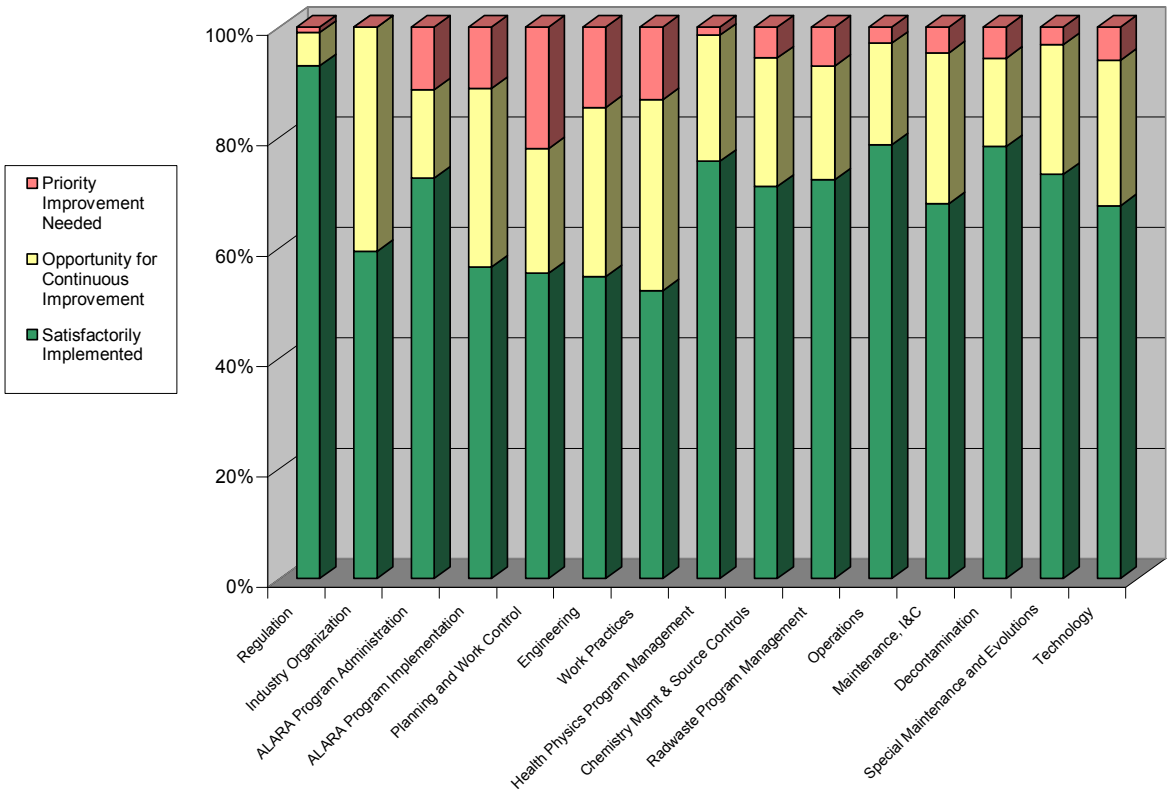


**Figure 3-1**
**Summary of Eight Site's Performance**

The data indicate that the four areas with the largest opportunity for improvement are:

1. ALARA Program Administration
2. Planning and Work Control
3. Engineering
4. Work Practices

## *ALARA Program Administration*

This program assessment category contains ~115 criteria. This is the most broad-reaching assessment area and includes Training, ALARA Group Planning and Estimating, ALARA Engineering Controls, Shielding and others.

### *Planning and Work Control*

At many stations, ALARA Planning is the sole responsibility of the ALARA organization. This category contains criteria that assess the ownership, involvement, and integration of ALARA into the Planning, Scheduling and Work Control processes.

### *Engineering*

Plant engineering changes can affect the station's exposure performance over the entire life of the plant through completion of decommissioning. Ownership by, and training and procedural guidance for, engineering staff is critical to the long-term success of an ALARA program. License extension compounds the importance of engineering support for ALARA related modifications and for ensuring all modifications are developed with ALARA integrated into
the design.

### *Work Practices*

This category includes criteria that measure the level of worker understanding, ownership and qualification to support the ALARA program. It also addresses management of repetitive tasks, job staffing and job site access and tooling.

# 4
# CONCEPTS AND PROGRAM STRENGTHS

Variations in plant structure, content, resources (staffing and monetary), senior management direction and support, and emergent issues all affect the importance of a single ALARA program element. This section of the report contains several proven ideas that have increased the overall program success at one or more of the stations where assessments have been performed. Although at first glance specific items may seem innocuous, these concepts have had a positive impact on the associated program. Conversely, at stations that have not been successful with implementing these or similar program improvements, the negative effect was equally apparent. Similar to any recommendation, these ideas should be evaluated prior to integration into a station's ALARA program. Each item is identified by the program category as listed in the ALARA assessment matrix.

## Scaffold Management

### *Description of Experience*

**Callaway Station's** management challenged their contractors and in-house craftsmen and foremen to improve the station's scaffolding program. The challenge, combined with the team effort to identify improvements and the station support, resulted in a five-fold reduction in scaffolding related exposure for the next outage. Several of the program improvements included:

- Extensive use of scaffolding suspended from overhead structures versus the traditional "ground-up" technique.
- Photo documentation of scaffolds and interferences to create an archived database for future planning, training and implementation.
- The use of wireless communication by trades and supervisors allowed the support crew to be staged in non-to-low radiation areas. The crafts erecting the scaffolding would use the hands-free wireless headsets to contact the support labor to request the next required scaffold component while completing the installation of the component in hand.

**DC Cook** is one of a handful of operating ice condenser plants. This presents a severe challenge to reach ALARA goals due primarily to space and access constraints. As a result, the station has had to identify unique, but workable solutions that address the scaffolding issue. The station has very successfully implemented the use of several JLG 30 EL Porta Lifts. These small one-to-two person lifts are powered by 110 VAC and can be used in very tight locations. Where access permits the use of the lifts, the exposure related to staging, erecting/dismantling, decontamination and storage of conventional scaffolding is completely eliminated. Additional benefits are realized in the areas of personnel safety and reducing the resource requirements associated with scaffolding.

## Planning & Scheduling

### *Description of Experience*

**Browns Ferry Nuclear Plant (BFN)** has enhanced the planning aspects of work management through the use of ALARA "Breakage" meetings. These meetings are used to review thoroughly the total picture of emergent and other unplanned work during both outage and operational periods. The significance of this effort is that any work, regardless of scope, is evaluated by a team to ensure that the impact on personnel exposure is minimized. This process also ensures that the "big picture" is analyzed and validated prior to allowing emergent work to proceed.

Identifying and capturing lessons learned after job completion is one of the more difficult challenges facing both the planning and ALARA organizations. **DC Cook** has minimized the impact of this challenge by conducting "T + 1" weekly meetings. The Work Control organization conducts the meeting in the week immediately following work completion to capture and review the lessons learned from the previous week. Future work plans are modified accordingly, or the item is added to a formalized corrective action tracking program to ensure open issues are resolved in a timely manner.

## ALARA Program Implementation

### *Description of Experience*

**BFN** has a very comprehensive, functional, and user-friendly shielding process. It was the best identified-to-date during the EPRI assessment process. Features included an excellent temporary shielding installation approval process, historical approvals requiring minimal review, and an easy to use tracking system.

Many stations use unique signs, postings, lights and streaming electronic banners to identify various aspects of their program. In some instances, those items can be over-used, causing confusion or complacency among the intended users. **Calvert Cliffs** adopted the use of a relatively unique method for identifying low-dose ALARA Waiting Areas. Specially designed and lettered traffic cones are placed in those areas. This method creates a very distinct separation from signage and requires no rope, hangers, or adhesive to stage.

## Communication/Awareness

### *Description of Experience*

Communication is one of the most critical aspects of an ALARA program. The importance of issues, station, organization and personal exposure goals and their status all require careful and clear communication to the target audience.

**LaSalle** station developed simple posters that clearly communicated the impact of "1 MR" on the station's ALARA program. One example of their efforts is illustrated in Figure 4-1 below.

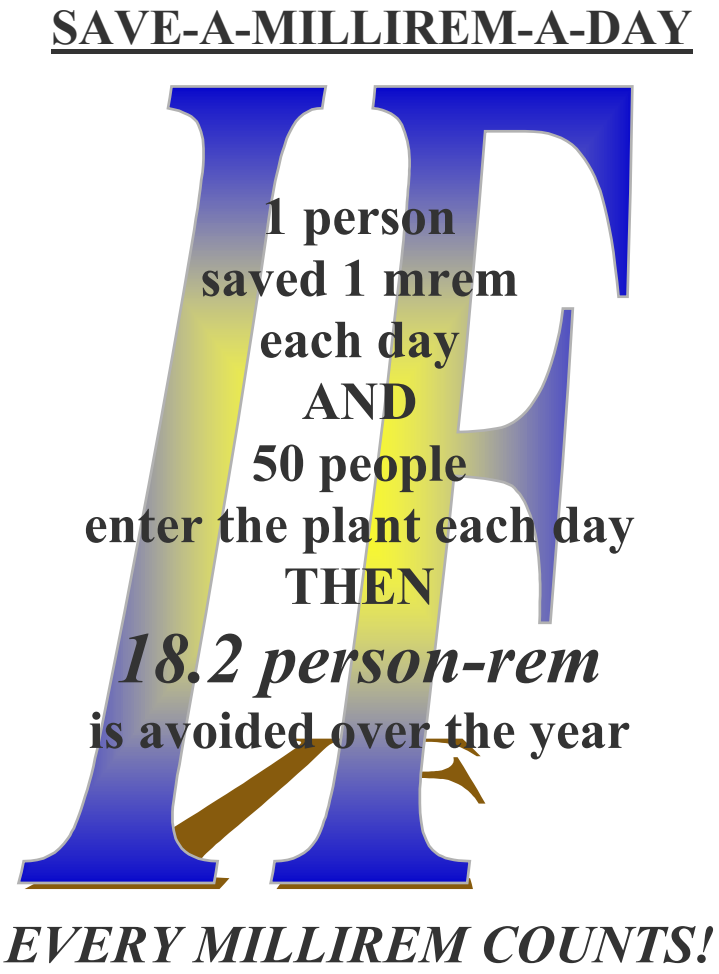


**Figure 4-1**
**LaSalle mRem a Day Poster**

**Similarly, Clinton Station** has painted an ALARA "Train" on the wall at the primary radiologically controlled area (RCA) access point. The mural represents various station organizations' integration and ownership of their ALARA program.

Determining how much and what level of detail is required to effectively communicate a program's status was fundamentally resolved by the **Indian Point Energy Center**. **Unit 2** created a concept that was later adopted by **Unit 3**. The status posters are easy to understand, but comprehensive Figure 4-2.

**DC Cook's** ALARA and Work Scheduling organizations worked together to incorporate individual task's dose budget on the daily work schedule. This approach clearly communicates expectations to the station's management team and facilitates upfront discussion related to issues affecting the exposure budget. It also allows provides a vehicle for communicating task exposure to the balance of plant staff.

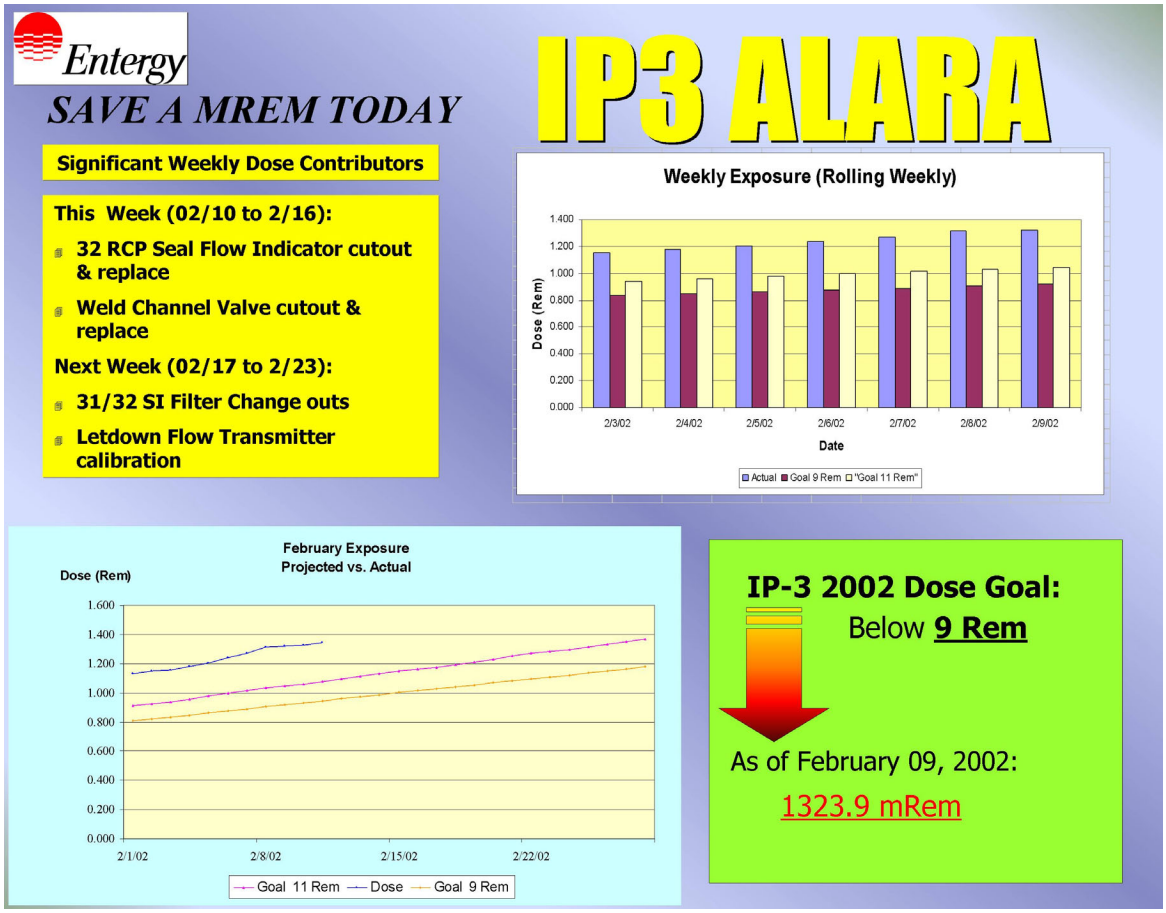


**Figure 4-2**
**Indian Point Energy Center Status Poster**

## Program Administration

### *Description of Experience*

Similar to the vast majority of nuclear plants, **Callaway's** staff is inundated with meetings. Accordingly, the effectiveness of some meetings is compromised, and conflicts related to meeting scheduling strain the available staff resources. However, in spite of this issue, the station has continued to operate an extremely successful and proactive ALARA Committee. The meetings, chaired by the site vice president, are well planned, advertised and attended, and have an excellent format, and meeting frequency. The team works to challenge plans, estimates and results, and to collectively identify improvements.

**DC Cook's** ALARA staff added an extra level of control to their program by forming an ALARA Subcommittee. That team includes first line supervision from all plant work departments. This creates an atmosphere that allows for a challenging and productive ALARA review process that results in lower doses for jobs that are expected to exceed 1 Rem., However in light of their recent improved dose performance, the plant is evaluating reducing that threshold to a lower value.

## Chemistry

### *Description of Experience*

**BFN**'s Chemistry organization recognized that they owned a significant portion of the ALARA program through chemistry related source controls. In an effort to educate the plant staff relative to their efforts in that area, they developed a Chemistry strategy document. The document was authored specifically for use by the non-Chemistry station staff. It is written in lay terms to the extent practical and is understandable to non-chemists. It includes descriptions for Hydrogen Water, Depleted Zinc Oxide, and Noble Metals Chemical Application chemistry processes and their known impact on the plant's operating condition.

## Engineering/ALARA

### *Description of Experience*

During refueling outages, BFN has routinely installed temporary lead shielding in the drywell on the vertical portions of the 28" suction and discharge piping of the recirculation system and the 12" recirculation risers. The shielding has traditionally been lead wool blankets with an outer cover of flexible Herculite. The bag configuration is flexible enough to allow the removal of the underlying mirror insulation from around the pipe for weld inspection with only minimal disturbance to the shielding material. The continued use of bags was considered more in line with ALARA goals than the use of rigid steel encased lead shielding material, which would require more disassembly for weld inspections. BFN proposed the installation of permanent lead bag shielding for these locations to avoid the recurring outage dose from installation and removal. A new version of lead wool blankets covered with a silicon impregnated fiberglass fabric with greater heat and radiation resistance made the application feasible. However vendor information indicated some embrittlement might occur after the blankets were exposed to 1 billion rads of radiation. TVA Engineering expressed early concerns on the possibility for this installation to increase the potential for fibrous material blockage of the ECCS suction strainers after a design basis loss of coolant accident where the bags would be exposed to 2.4 billion rads beta and 62 million rads gamma. To contain any fibrous material, the new blankets were enclosed with tight mesh stainless steel screen covering. The bags were thermal aged to the equivalent of 40 years at 200°F and then exposed to 62 million rads of gamma and neutron radiation. A jet impingement test simulating a 12" Small Break Accident (SBA) and a 28" Intermediate Break Accident (IBA) was conducted with steam at approximately 1050 psi and approximately 590°F.

The tests were successful and the design was approved. Partial installation was completed during the U3C10 outage. Installation and removal of the previous BFN temporary shielding package accrued 12 man-rem. As a permanent installation, BFN saved approximately 4 man-rem when the shielding was not removed after the U3C10 outage, and will save 12 man-rem during each future refueling outage when installation is complete. Additional savings will be realized if any mid-cycle outages should occur.

## Maintenance

### *Description of Experience*

Worker access to tools required for a task will affect that individual task's exposure results. A properly stocked and staffed tool room in the RCA can provide numerous benefits to a program including:

- Worker efficiency
- Task quality
- Exposure reduction

**DC Cook** has an exceptionally well-stocked RCA tool/decontamination room that is manned during normal work hours. This results in

1. exposure reduction by providing workers with the correct tooling in an easy-to-access location,
2. improves job-site cleanup by specifying where used tools are returned,
3. minimizes trips to and from the RCA and
4. minimizes the dose associated with workers waiting in the RCA for tools that need to be brought in from outside the RCA.

A side benefit is the reduction in radioactive material controls issues associated with tool release from the RCA.

## Engineering/Maintenance

### *Description of Experience*

- Comanche Peak implemented a modification to their Copes Vulcan valves. The actuator conversion kit acts like a "marriage block." The station has realized considerable time savings when performing valve actuator maintenance. Those benefits include:
- No actuator or stem rotation required during assembly (reduces the possibility of rotational galling).
- No loss of setpoints when removing the actuator.
- Reduced potential for component damage.
- Reduced maintenance and setup time (~ 4 hours reduced to ~ 1 hour).
- Allows the bonnet fasteners to be torqued without interference of the actuator.

# 5
# INDUSTRY OPPORTUNITIES

Challenges to an ALARA program are often site-specific and in some instances are quite readily resolved. However, during the assessment process, several issues emerged as consistent challenges at a number of the plants. These challenges, and potential solutions, are discussed in this section of the report. The discussion of each issue includes an **Opportunity** description, a **Recommended Site Improvement Lead** to take ownership of the improvement process for the identified challenge, and proven utility **Solutions** or proposed industry solutions. In reviewing the proposed solutions, it is important to recognize three factors:

1. All of the recommendations have been successfully implemented in at least one station.

2. The majority of the efficiency improvements and associated exposure reductions are repetitive on an annual or by task basis, and therefore provide cumulative benefits over the life of the plant.

3. *The tangible labor and dose savings that may be realized by a station become more significant for those plants with approved, or are in the application process for, license extension!*

## Scaffolding Management

*Recommended Site Improvement Leads:* Maintenance Manager and Contracted Services Site Representative

### *The Opportunity*

Scaffolding installation and removal is labor intensive and typically represents a large portion of a station's outage exposure (e.g. > 15%).

The relevant issues include:

- type of scaffolding used (tube-lock versus quick-erect)
- installer training
- planning and scheduling accuracy and detail
- execution of the plan
- labor requirements
- decontamination of the area accessed by the scaffolding

- decontamination of the scaffolding on removal
- scaffolding storage locations and labor and exposure to transport to and from that location

Accordingly, aggressive scaffolding coordination programs that are given a high priority for review and for implementation of dose reduction techniques can realize significant outage and annual exposure savings. In general the industry experience with scaffolding management has been to erect multiple "ground-up" scaffolds, without a formal stand-alone scaffolding plan, coordinator, or detailed scheduling review to minimize the impact of this process. The use of quick lock/erect scaffolding can benefit a station by reducing the time in radiation areas during erection and removal. Several BWR and PWR stations have very successfully implemented the use of this scaffolding, while others have determined that it is not be feasible for use at their site.

Similarly, establishing permanent storage racks/locations for scaffolding in containments and drywells continues to pose a challenge for some stations, while others have been using that technique for a decade. This process allows the storage of scaffolding from outage-to-outage, very close to the point of use, versus complete removal and storage in remote locations. Local storage will significantly improve the efficiency of a scaffolding program.

Finally, the use of alternates to scaffolding, such as permanent platforms, sky climbers and electric person-lifts, have all been successfully used at numerous sites to minimize the quantity and frequency of erecting and removing temporary scaffolding.

### *Solutions*

The industry should consider:

- Developing an industry guide that defines an efficient, safe, ALARA, scaffolding program management strategy. This could be accomplished by:
  - Creating a team of Health Physics, Maintenance Services, Planning & Scheduling, and Engineering industry experts, and possibly scaffold vendors.
  - Using the team's expertise to identify the industry's scaffolding management experience and related challenging issues.
  - Evaluating all available, and/or advanced scaffolding technologies and vendor services.
  - Defining the issues that require resolution.
  - Benchmarking the industry's best practices related to scaffolding management and the previously identified issues.
  - Using the team's collective analysis of the above items to develop an industry reference, the "EPRI Scaffolding Program Management" strategy document.

Individual utilities should consider the following:

- Establish a Formal Scaffolding Program as a focused and integrated element of the outage planning and scheduling process.
  - Have foremen start a review of outage scaffolding plans, including walkdown, six months prior to an outage.
  - Include the contracted/in-house scaffold crews in the planning process.
- Designate a scaffolding coordinator with the authority to require sign-offs from all organizations prior to committing to scaffolding erection and removal.
- Evaluate, or re-evaluate quick lock/erect scaffolding. Benchmark BWR and PWR stations that have successfully implemented that product's use.
  - Consider including union/crafts in the early discussion and analysis.
  - Utilize conventional side scaffolds for evaluation, training, and mockup (efficiency improvement) prior to dose intensive scaffold erection tasks.
- Suspend scaffolding from upper elevations inside biowalls versus ground up from bottom elevations.
- Install permanent access platforms or permanent platform supports (scaffold planks to be added during outages).
- Revise safety and scaffolding procedures to eliminate use of toe boards and hand rails in specific instances inside biowalls and high dose areas. Rely on fall protection and access restriction in areas below during work periods.
- Increase the frequency of working from ladders.
- Develop a photo library for future reference that is optimally linked to the station's surrogate tour system.
- Formalize post job dose assessments with the scaffold crews (prior to post-outage staff reduction) to capture lessons learned.
- Establish personnel records to ensure only experienced staff are used in higher radiation areas and inside biowalls/drywells. Train in non-radiation areas in the secondary plant or in remote buildings.
- Use dedicated channel hands-free communication devices for communication between laborers, carpenters and foremen.
- Challenge the local union halls/trades councils to improve training at their training center relative to suspended scaffolding.
- Establish an inventory, training on use, and a use plan for alternate methods such as sky climbers, electric person lifts and improved ladders.
- Use high duty cordless drills for conventional scaffolding knuckle installations.
- Benchmark Callaway station's excellent scaffolding program.

### *The Benefits*

- Improved scaffolding program efficiency.
- Establishing a program coordinator clearly communicates ownership of the scaffolding program.
- Inclusion of crafts in all phases of planning promotes ownership and alleviates staff reduction concerns related to implementing efficiency improvements.
- Personnel lift devices can result in a substantial exposure and labor cost savings when used in lieu of scaffolding.
- Callaway Station's significant level of craft involvement reduced scaffolding exposure by factor of five in one cycle from 25 Rem to ~5 Rem!
- Using hands-free communication between the erecting trades and their support laborers allows the construction crew to erect scaffolding while the support laborers are staged in lower dose areas. The erection team then communicates their needs to the laborers via hands-free headsets regarding the next required component(s) without requiring the laborers to wait in that higher doserate assembly area for those instructions.

## Major Service Vendors

*Recommended Site Improvement Lead:* Site Vice President

### *The Opportunity*

Major service vendors (e.g., contract maintenance, refueling, steam generator, Health Physics, radwaste processing, etc.) are frequently responsible for planning and executing the most exposure-intensive tasks performed at a site. While stations often have to operate with plant-specific issues that severely test their ALARA performance (e.g., Axial Offset Anomaly, operation with 44F steam generators, fuel failure issues), the challenge to meet more restrictive industry goals is typically not formally passed through to the contractors. The use of techniques such as formalized contract incentives, the use of contractor site ALARA coordinators, and the use of improved tooling can all provide positive and tangible support to the process efficiency and ultimately, ALARA program results.

### *Solutions*

Individual utilities should consider the following:

- Aggressively challenge major vendor services to respond with significantly reduced doses relative to site-specific handicaps (e.g. AOA, old steam generators, fuel issues, etc.).
- Require major vendors to provide station ALARA representatives (not just dose trackers).
- Require major vendors to develop, provide access to and to use, a database of lessons learned and experience from other sites.

- Ensure vendors have proceduralized ALARA policies that address site-specific requirements.
- Utility/contractor proposals and contracts should consider including the following provisions:
  - Ensure dose reduction incentives and penalties are specifically listed in requests for proposals.
  - Include hourly rate bonuses for trades working under that contract based on ALARA performance.
  - Include an ALARA impact review of vendor technology or method prior to awarding contracts.
  - For all proposals, require vendors to include a list of lessons learned since their specific "major" tasks were last performed.
  - Include a review of historical ALARA performance of that vendor.
  - Require vendors to provide top ten ways the vendor is going to achieve a dramatic improvement in their work efficiency.
- Challenge the vendor to evaluate and implement the use of advanced technologies.
- Work with the vendor to develop site-specific strategies.

### *The Benefits*

- The communication of clear expectations should result in improvements to the vendor processes.
- This can also result in a team approach for identifying and resolving historical and new challenges.
- Inclusion of trades in this process and recognition of their efforts, will result in their ownership of both the problems and their solutions.

## Modifications

*Recommended Site Improvement Leads:* System Engineering and Design Engineering Managers

### *The Opportunity*

Engineering designs and evaluations play a very critical, long-term role in the success of an ALARA program. Detailed design analyses and engineering evaluations performed with ALARA as a primary consideration, can result in improved equipment or process performance, accessibility, and reduced personnel exposure. The primary method for assessing engineering support of ALARA programs is found in plant maintenance and performance test results and in the plant's Engineering Design Manual ALARA criteria.

Further, the modification approval process should not focus solely on hard currency factors. The impact of personnel exposure relative to worker efficiency and averted liability can provide significant, but often non-quantifiable cost savings. Many stations are faced with unique systems or structural designs and operational challenges, but have not adjusted their cost-benefit analyses, or person-Rem values accordingly.

An ALARA impact review process should consider that exposure related savings can be distributed over an extended period of time (e.g., possibly life-of-plant). Unlike component evaluations, personnel exposure won't "wear out" requiring a future replacement. Modifications could continue to reduce exposure for that time period, not the limited amortization period typically used in performing cost/benefit analyses.

ALARA Engineering design checklists and ALARA training designed specifically for Engineers can provide extremely useful guidance. This often overlooked program enhancement can improve not only ALARA performance, but also the overall modification planning and execution process.

Finally, maintenance of plant equipment often requires work on, and/or in the vicinity of, highly irradiated plant components. The elimination of reworks through engineering evaluations, or component improvement through replacement or modification, can reduce the exposure burden of repair and operational monitoring efforts.

## Solutions

Individual utilities should consider the following:

- Aggressively challenge modification approval, planning and installation processes by:
  - Re-evaluate the cost and dose components of the modification justification analysis.
  - Consider life of plant and license extension to justify increasing the difficult to quantify value associated with exposure savings.
  - Define and use a consistent, comprehensive $/person-rem value.
  - Increase the priority for those modifications where substantial dose savings are realized.
  - Perform detailed long-range cost-benefit analysis for all modification justification reviews.

It is recognized that implementation of these suggestions may require a change to historical senior management thought processes!

- Conduct teambuilding sessions with ALARA, and Design and System engineers.
- Minimize the number of reworks and repetitive maintenance by thoroughly reviewing all tasks and implementing modifications, design changes, or component upgrades.
- Formalize a requirement for an assessment of the ALARA impact as part of the post installation performance review process.
- Develop an Engineering specific ALARA training module to be given on a routine basis (annually).
- Encourage Engineering staff members to attend Industry ALARA meetings.

### *The Benefits*

- The cumulative affect would be the implementation of modifications in accordance with the ALARA principle.
- Improved process efficiency resulting in ALARA related modifications.
- Improved understanding of, and respect for, the challenges faced by peer groups.
- A reduction in the labor burden related to modification installation, post installation testing, post installation operation, and maintenance.

## Planning and Scheduling

*Recommended Site Improvement Leads:* Work Control and Outage Managers & Site ALARA Lead

### *The Opportunity*

Planning and Work Control staff activities affect a station's ALARA program in several areas. Carefully evaluating tasks for their necessity, staffing levels, interface with other tasks, physical constraints and duration is critical for maintaining site and individual exposures ALARA.

- The primary elements of the Planning and Work Control module address:

  Planning

  – Formal planning review checklist
  – Dose compliance with ALARA
  – Review and evaluation for ALARA considerations
  – Contingency plan including "big picture" ALARA impact review

  Work Scheduling

  – Adjacent systems status–full, drained, work in progress
  – Common work areas–utilize same services, scaffolding
  – Job duration–estimate versus actual, task overlap
  – Review and evaluation–capture and disposition of lessons learned

### *Solutions*

Individual utilities should consider the following:

- Incorporate a formal ALARA planning review checklist into planning software.
- Include an ALARA/RP planning historical & lessons learned data page in the Planning and Scheduling software.

- Involve ALARA planning from the inception of the task, rather than at T-XX weeks into the project planning process.
- Use team meetings to develop a cohesive, organized relationship between the ALARA and Planning/Work Control organizations.
- Review the planning process to ensure consistency and to reduce the impact of the loss of experienced personnel (graybeard syndrome).
- Formalize the ALARA planning process through the use of ALARA checklists for pre and post job reviews Planning Reviews.
- Improve "wrench-time" estimates–use timers from audio/visual systems, and post-job interviews with HP technicians, workers and supervisors.
- Reduce thresholds for review and work controls.
- Improve resource loading estimates for Radiation Protection Technician coverage.

### *The Benefits*

- Improved dose estimating; minimizing the potential for the increased regulatory scrutiny that is associated with inaccurate dose estimates.
- Workers will have a better plan to work by and increase their ownership of and support for the ALARA and planning processes.
- Improved data and lessons learned archives to be used for future planning efforts.
- Reduce the level of effort required for both planning and task completion.
- Reduce RP resource requirements by better defining work scope and coverage requirements.

## Shielding; Permanent Installation, Supports & Storage

*Recommended Site Improvement Leads*: Engineering Manager and Radiation Protection Manager

### *The Opportunity*

As a result of conservatisms and high cost estimates many stations have not been successful at obtaining approval or funding for permanent shielding installations. This is significant when considering the life-of-plant and plant license extension. Alternatively, where permanent shielding was not an option due to operating or emergency environmental issues, several stations have installed permanent supports for temporary shielding. Finally, moving several tons of temporary shielding to and from the containment or drywell area each outage poses several risks related to personnel and plant equipment safety. The exposure associated with this effort also adversely impacts the overall incentive for installing shielding–exposure reduction.

### *Solutions*

Individual utilities should consider the following:

- Eliminate recurring sources of exposure through the installation of permanent shielding in locations that present a long-term, repetitive high dose challenge, or in frequently accessed areas.
  - This should be accomplished through the efforts of the ALARA Committee and senior plant management.
  - Browns Ferry (and other stations) have recently gained approval for using shielding casings that mitigate the potential for failure during accident scenarios.
- Install permanent supports for temporary shielding at frequently shielded locations.
- Design and install permanent shielding storage containers in the containment or drywell. This approach has been implemented at numerous stations. The storage program should include an inspection and inventory mechanism prior to closeout to ensure efficient shielding is available for installation at the next outage.

### *The Benefits*

Permanent shielding installed in frequently shielded locations resolves several issues:

- Reduce the structural engineering level of effort required for temporary load calculations.
- Improve personnel safety during shielding transport to work site, installation and removal.
- Surrounding equipment safety and materiel condition impacted by aggressive staging, installation and removal activities (system interaction).
- Facilitate area or component decontamination prior to and following shielding efforts.
- Lower personnel exposure for installation and removal.

## Historical Database and Benchmarking

*Recommended Site Improvement Leads*: Site Vice President and Experience Review Group Manager

### *The Opportunity*

Numerous independent databases are used by utilities for archiving information and resolving issues ranging from industry lessons learned to station-specific corrective action items. This approach reduces the ability for suggestions to be effectively utilized to ensure that programmatic improvements are implemented. Frequently, individual organizations develop stand-alone records that contain information pertinent only to their area of responsibility. Other data may be included in project files and filed in long-term storage facilities. Either of these options can make data access by other interested parties difficult, or impossible, which decreases

the usefulness of that data. Creating a single site historical database for storing lessons learned or for incorporating feedback in project management software programs located on plant networks, increases the ability to access that data. This also allows the user to incorporate lessons learned and historical data into estimating, planning and execution processes. Segregating the database by organization, task descriptors, or project numbers further enhances the value of this type of product.

### *Solutions*

The industry should consider:

- Developing a database similar to EPRI's Radwaste-based "RadBench" program to capture, track, trend and disseminate industry ALARA data and lessons learned in a manner consistent with industry practices.

Individual sites should consider:

- Creating a single, simple 'lessons learned' database for the identification, review, disposition, sharing, and tracking of lessons learned through resolution from all station organizations. The data could be organized, or include the ability to query by:
  - Station organization and sub-organization (e.g., RP, sub-ALARA)
  - RWP
  - Task number/date
  - System/Component
  - Keywords

### *The Benefits*

Incorporating that database into the station's LAN system would provide a readily accessible, valuable planning and execution tool. Additional benefits might include:

- A master lessons-learned tracking and prioritization list is developed.
- Lessons learned and corrective actions can be tracked through completion.
- Post-job task review issues can be tracked for resolution and implementation.
- Task reviews, lessons learned, and resolutions are documented.
- Provides a formal mechanism for worker feedback analysis, response and implementation of improvements.
- Industry, vendor and site specific lessons learned could be incorporated into procedures and pre-job training.

## Training

*Recommended Site Improvement Leads:* Radiological and Chemistry Control Manager (HP Training), Training Manager (Supervisor Training), Design Engineering Manager (Engineering Training)

### *The Opportunity*

Comprehensive ALARA training of radiation area workers and station management will provide a solid foundation for efficiency improvements and will also serve to clearly communicate individual ownership and program expectations. Several staff positions, such as First Line Supervision, Engineering and Health Physics can have a dramatic, long-term impact on a station's ALARA program. Providing them with accurate knowledge about their roles and responsibilities can result in significant exposure savings over the life of the plant.

Another issue is that many tasks are performed in high exposure areas or are infrequently performed. It is important to insure that these tasks are performed efficiently so that exposures remain ALARA. Refresher or "just-in-time" training and/or mockup training can provide valuable information regarding process improvements, selecting the most qualified worker, and incorporating lessons learned from historical industry experience.

### *Solutions*

Individual utilities should consider the following:

- Developing an ALARA training plan with brief (1-2 hour) modules specifically designed for:
  - Engineers
  - Supervisors
  - Planners and Schedulers
  - Health Physics Technicians
- Conduct refresher or "just-in-time" training for infrequently performed tasks.
- Integrate ALARA aspects into routine job-specific training.
- Procure or include mockup training for high exposure or repetitive tasks.
  - For contracted services, ensure that all mockup training is performed in accordance with site training standards.

### *The Benefits*

- Consistent, better quality results.
- Formal training can help to off-set the potential loss of experience associated with an aging workforce.

## Assessments, Benchmarking, and Action Plans

*Recommended Site Improvement Leads*: Radiation Protection Manager, Site Manager

### *The Opportunity*

Most stations have extensive lists of ideas for improving their ALARA program that originate from sources such as:

- Regulatory inspections
- INPO Evaluations
- EPRI program assessments
- In-house self-assessments
- Exposure Reduction Plans
- Dose Reduction High Impact Teams
- Incident response
- Others

Evaluation and improvement plans are good. However, in an effort to become the "best", many stations become overwhelmed with good intentions. This can lead to diverting limited resources down many avenues, leading to less-than-desirable results.

### *Solutions*

Individual utilities should consider the following:

- Identify all potential improvement suggestions and issues.
  - Use a peer team and at least one facilitator not connected with the ALARA or radiation protection programs to review and prioritize the list.
  - Use the same team to develop a single action list for the top 10 items.
  - After completion of those ten items, do a post-implementation effectiveness assessment about one year later to validate the team's results.
- Limit benchmarking activities to those few items that cannot be satisfactorily resolved in-house and to measure overall ALARA Program performance.

### *The Benefits*

- Improved results for the top ten items.
  - A side benefit may include a reduction in the number of lower priority items as the top ten items are completed.
- Develop and implement focused and proactive, rather than reactive, work plans.
- Staff resources are made available for daily program oversight and performance tracking.

# 6
# CONCLUSIONS

Collective exposures at U.S. nuclear power plants have consistently trended downwards over the last decade, but the challenging annual exposure goals recently implemented by the industry place renewed demands on operating nuclear plants to ensure that exposures continue to be maintained at levels that are "as low as reasonably achievable" ALARA. EPRI has supported a wide range of projects that have contributed to the industry's success, including development of an ALARA assessment tool. This spreadsheet-based tool, which contains some 500+ evaluation criteria, provides an objective assessment of the "health" of an individual plant's ALARA program. ALARA programs have been evaluated at eight sites using this tool, with the results providing insights into individual program strengths and weaknesses.

This report summarizes the results of these eight assessments. Typically, utility management at the sites with strong ALARA programs has provided the financial resources and encouraging environments required to improve performance. Specific examples of program strengths identified in the assessment process follow.

## Browns Ferry

There were a number of aspects and results associated with the station's ALARA program that represented strong implementation and commitment efforts including:

- Management attention and emphasis on dose reduction, including several comprehensive assessments and improvement plans.
- The Chemistry Department represents a model program for dose reduction in terms of employee involvement and management commitment.
- The station is well aware of industry issues with radiation source control, and has taken steps to ensure successful implementation of the following initiatives:
  - Hydrogen Water Chemistry
  - Noble Metals Chemical Application (NMCA)
  - Depleted Zinc Injection
  - Chemical decontamination efforts

## Callaway Station

There were a number of positive aspects of the station's ALARA program, including:

- Scaffolding program results lowest dose in plant history.
- Craft incentive for meeting dose goal implemented as an hourly premium.
- ALARA modifications have been installed for several important ALARA program initiatives including permanent shielding on pressurizer spray line, temporary shielding storage in containment and scaffolding storage in containment.
- Actively utilize Daily Dose Budgets and the use of CARS to trend over-budget situations.
- Candid and frank discussions and recognition of the need for sustained and continuous improvement in ALARA.

## Calvert Cliffs

Calvert Cliffs had an excellent ALARA program that was supported by several key plant initiatives.

### *Operations Department ALARA Improvement Program*

The Operations Department initiated a "2000 Operations Business Initiative–Dose Reduction" with the goal to aggressively implement dose reduction efforts. Approximately 20 improvement actions were identified with responsibilities and milestone dates defined. The effort was championed by the Operations staff with clear support and encouragement from Operations senior management.

### *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 the Steam Generator replacement project. Several specific ALARA improvement efforts were integrated into projects including long life In Core Instruments (ICI), quick lock ICIs, and their on-site fuel storage project.

## D.C. Cook

D.C. Cook had recently gone through an extended shutdown period, severely challenging the plant's resources. There were a number of very strong aspects of the station's ALARA program identified during the assessment process including:

- A very proactive, experienced, and knowledgeable ALARA staff.
- Their scaffolding program results show a marked improvement due to improved coordination of scaffolding use for multiple tasks.
- Inclusion of task Dose Estimates on Plan of the Day Schedules, communicating that status to the appropriate management team.
- Use of a Site ALARA Indicator windows system that clearly illustrates their current performance in an industry-familiar format.

## Indian Point Unit 2

### *Aggressive Major Source Term Reductions*

An active major source term reduction program resulted in significant reduction in overall dose contributors in the plant. Those efforts included:

- Full system decontamination resulting in dose reduction factors of as high as 10 in certain higher dose areas.
- Scabbling large areas of contaminated flooring in the containment and primary auxiliary building.
- Multiple decontaminations of regenerative heat exchanger.
- Waste collector tank sludge removal.
- Spent fuel pool cleanout project.
- Electropolishing of the replacement steam generators prior to installation.

## Indian Point Unit 3

The ALARA staff was very aggressive in its efforts to implement improvements that supported the ALARA program. Those efforts combined with station ownership of the ALARA program, have resulted in IP-3 being ranked as the best U.S. three year rolling-average exposure performer. Several program improvements included:

- Installation of a permanent shield wall around the regenerative heat exchanger.
- Installation of permanent lead shielding storage containers in the containment building.
- Installation of permanent scaffolding storage racks inside containment.
- Significant interaction (tailgate talks, posters, training) with the plant staff stressing program ownership.

## Sequoyah

The station's ALARA staff was very knowledgeable and committed to long-term improvement. Examples of those efforts include:

- A well thought out ALARA Dose Reduction Plan.
- Source control improvements such as:
  - Initiatives in operating and shutdown Reactor Coolant Chemistry
  - The use of advanced activity removal resins
  - Zinc injection
  - Electropolishing of the new steam generator channel heads.

## Watts Bar

The assessment revealed ALARA program strengths that were based on performance results and unique approaches.

- Expected top decile performance for 2001, perhaps attaining "best performer" status for that calendar year.
- A culture that promoted open and frank communications between station organizations. That environment clearly fostered improved performance and long-term success. *This was a significant strength at that station and should be considered an industry model.*
- An experienced and very knowledgeable ALARA staff that aggressively participates in station exposure control oversight improvement teams.

## Opportunities for Industry Improvement

The assessments, combined with other utility feedback, have also served to identify industry-wide opportunities for improving the ALARA process. Some common weaknesses have been identified in a majority of plants that have undergone the assessment process, although most of these shortcomings have been successfully resolved by at least one the plants whose ALARA program has been reviewed. The assessments suggest that the formal integration of the ALARA concept into plant engineering, planning, and implementation processes could be improved across the industry. Also, significant opportunities exist for projects that would identify solutions to six ALARA program areas that have the potential for significantly reducing collective exposure to plant personnel. These opportunities include:

1. Scaffolding Management–an industry-wide standard or guide
2. Modifications–ALARA design manual and checklists
3. Planning and Scheduling–template for planning and scheduling
4. Shielding; Permanent Installation, Supports & Storage–an industry-wide standard or guide

5. Historical Database and Benchmarking–Web based template for data capture, storage and retrieval

6. Training–specific modules for high-impact plant staff

While evaluating these and other program improvements, it is important to recognize that the ALARA improvement thinking process should not be confined to that of exposure. In reality ALARA is a measure of both the process and the worker's efficiency and quality. Working faster and smarter, while producing the desired results the first time, will reduce personnel exposure.

ALARA program improvements require:

- innovative ideas.
- teamwork.
- revamping some of the industry's historical cultural thinking.
- ALARA is owned and operated by all station organizations.
- formal integration of the ALARA concept into processes and procedures.

# A
# APPENDIX

## References Utilized for Criteria Development

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USNRC Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Doses 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

Chemistry measurement and analysis

Good practice

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

### *NEA/ISOE*

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Documents (various)

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

***PWR Primary Coolant Chemistry***

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

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### *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 Callaway Nuclear PWR, TR-107039 (11/96)

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

*Targets:*
Nuclear Power

## About EPRI

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