# COMMONALITY INITIATIVES IN US NUCLEAR POWER PLANTS TO IMPROVE RADIATION PROTECTION CULTURE & WORKER EFFICIENCY

**W. David Wood and David W. Miller**
**Donald C. Cook Nuclear Power Station**
**American Electric Power[1]**

**[1] W. David Wood, Director, Environmental & Radiation Protection, D.C. Cook Nuclear Power Station, One Cook Place, Bridgman, Michigan, USA (1 616 466-5991, WDWood@aep.com ) & David W. Miller, North American Technical Center Regional Coordinator, ISOE, University of Illinois, Champaign, Illinois, 61801 USA, (1 217 333-1098, fax 1 217 333- 2906, dwmphd@aol.com or dwmiller2@aep.com).**

## ABSTRACT

**Many US nuclear power plants have learned that common procedures, policies, instrumentation, tools and work practices achieve improvements to the radiation protection culture. Significant worker efficiency achievements are accomplished especially during refueling outages. This paper discusses commonality initiatives currently being implemented at many US plants to address management challenges presented by deregulation of the US electric industry, reduction in the pool of outage contractors and aging of the experienced radiation worker population. The new INPO 2005 dose goals of 650 person-mSv/year for PWRs & 1200 person-mSv/yr for BWRs will require new approaches to radiation protection management to achieve these challenging goals by 2005.**

## Introduction

This paper describes the 5-year plan developed to achieve the 2005 INPO dose goals for the D.C. Cook Nuclear Power Station. Due to page limits on the workshop papers, please see the handout slides for discussion of the commonality initiatives at US nuclear power plants. The D.C. Cook 5 Year Plan is provided below:

## 1. Executive Summary

This 5-year plan summarizes the existing programs for dose reduction. It also outlines exposure reduction activities to be implemented. Significant components among these activities are: installation of permanent shielding on the NRV/QRV walls, the removal of RTD lines, and the incorporation of PEX Resin into the CVCS beds. This document provides a vehicle to prioritize and direct these initiatives.

## 2. Introduction

DC Cook Nuclear Power Plant is committed to minimizing radiation exposure to meet PWR INPO first quartile performance and to be recognized as one of the superior radiation protection programs in the nuclear power industry.

The vision: DC Cook becomes a world class performer in nuclear power generation.
This vision will be realized through low collective dose to the workforce, low dose to the general public due to plant operations, low generation of radioactive waste, and a high degree of regulatory performance.

The 5-year dose reduction plan is the road map to superior ALARA performance. It will be periodically reviewed and revised as the station and industry demands change. On an annual basis, the ALARA Committee will review the results of the plan and recommend changes as warranted based on conditions and requirements present during that time period. This should occur prior to the start of the next calendar year.

## 3. Statement of Purpose

One of the fundamental principles of radiation protection is that radiation exposures be kept as low as reasonable achievable (ALARA). Furthermore, the Nuclear Regulatory Commission, the Institute of Nuclear Power Operations, American Nuclear Insurers, and others use cumulative radiation exposure as an indicator of nuclear plant performance. DC Cook is committed to maintaining collective radiation exposure among the lowest in the country.

The primary purpose of the DC Cook 5-year Dose Reduction Plan is to establish exposure reduction activities to be implemented which will help achieve dose reductions; projecting us into the first quartile of dose performers.

This will be accomplished through an aggressive approach to ALARA. Radiation sources will be reduced through filtration, flushing, system chemistry controls, decontamination, cobalt reduction, and eliminating certain high dose components. Where the source cannot be removed, temporary and permanent shielding will be used when dose effective. Reductions in collective outage dose will be realized through shorter and more efficient outages. A highly trained and motivated work force, utilizing the latest technology, will also make a significant contribution to lowering personnel radiation exposure during both outages and non-outage times.

This report also serves as a status report for on-going exposure reduction actions and as a summary of exposure reduction activities.

## 4. Plant Dose History and Projection (in person-rem)

The table below shows DC Cook's dose history and projections, and shows the gap we must bridge to reach median and upper quartile collective radiation dose values.

| Year | Cook Annual | Cook 3 year ave. | Cook delta to median | Industry Median | Cook delta To 1st Quartile | 1st Quartile 3 year ave. |
|---|---|---|---|---|---|---|
| 1999 | 171 | 141/unit | +43 | 98 | +63 | 78 |
| 2000 | 338 | 105/unit | +23 | 82 | +26 | 79 |
| 2001 | 27 | 89/unit | +2 | 87 | +13 | 76 |
| 2002 | 250 | 102/unit | +25 | 77 | +32 | 70 |
| 2003 | 240 | 86/unit | +13 | 73 | +24 | 64 |
| 2004 | 6 | 82/unit | +13 | 69 | +24 | 58 |
| 2005 | 114 | 60/unit | - 5 | 65 | -8 | 52 |
| 2006 | 108 | 38/unit | - 22 | 60 | -7 | 45 |

Shaded areas are forecasted numbers. See below for breakdown of Cook Annual dose projections.

2002 Dose (250 person-rem)

- U2C13 - 110 person-rem
- U1C18 - 90 person-rem
- CRDM inspection - 15 person-rem each unit (30 total)
- Non-outage dose - 20 person-rem (routine and DCP work)

2003 Dose (240 person-rem)

- U2C14 - 90 person-rem
- U1C19 - 88 person-rem
- Removal of RTD lines - 20 person-rem each unit (40 total)
- Installation of S/G platforms - 6 person-rem each unit (12 total)
- DCP work - 2 person-rem
- Non-outage dose - 8 person-rem

Outage dose reductions will be achieved through the use of PRC-01 resin, zinc injection, and outage efficiencies. Non-outage dose reductions will be achieved through optimization of preventive maintenance schedules (including radiological survey schedules), use of remote monitoring equipment, and continued improvements in worker efficiencies.

2004 Dose (6 person-rem)

- Non-outage dose - 6 person-rem
- No outages
- No design change dose

A reduction in the annual non-outage dose will be attained by means of a continued optimization of preventive maintenance schedules and remote monitoring.

2005 Dose (114 person-rem)

- U2C15 - 54 person-rem
- U1C20 - 54 person-rem
- Non-outage dose - 6 person-rem

A reduction in outage dose will be realized by the removal of RTD lines and continued benefit from the use of zinc injection and PRC-01 resin (reducing source term).

2006 Dose (108 person-rem)

U2C16 - 51 person-rem

- U1C21 - 51 person-rem
- Non-outage dose - 6 person-rem

Estimating approximately a 5 percent reduction attributed to the continued use of zinc injection and PRC-01 resin along with continued efficiencies in remote monitoring, preventive maintenance scheduling and radiation worker practices.

## 5. Administrative ALARA Program

### ALARA Procedures

The two governing ALARA procedures, PMP 6010.ALA.001, ALARA Program – Review of Plant Work Activities, and PMP 6010.ALA.002, ALARA Committees were recently revised to increase their effectiveness. Enhancements included clarification of responsibilities, lowering the dose thresholds for reviews and the creation of three data sheets that strengthen our review of Design Change Packages, ALARA In-Progress reviews, and ALARA Suggestions. It also clarified management's ownership of dose budgets and dose reduction, and included a section for source term reduction.

### Exposure Limits

Minimizing exposure at the individual level is an essential part of reducing the collective site radiation exposure. It is our policy to not just maintain personnel exposures below regulatory and administrative limits, but to keep individual exposure ALARA. In an effort to maintain individual occupational exposures as low as reasonably achievable, a site administrative limit has been established to maintain personnel radiation exposure to <2000 mrem during any year. This limit also helps to encourage departments to equalize dose among their work force.

### Training

Initial Radworker Training, and the annual Radworker requalification, stress ALARA awareness and the potential for changing or abnormal radiological conditions; including the actions required when these conditions occur. This training not only increases worker awareness of radiological conditions; it also reduces their dependence upon the radiation protection technicians in the field. Radiation Protection Department staff attend on and offsite training, seminars, and perform industry benchmarking to keep abreast of new developments in the industry and their impact on our site.

## ALARA Committees

DC Cook has 2 ALARA Committees, the ALARA Committee and the ALARA Sub-Committee. The ALARA Committee is chaired by the Plant Manager and is composed of departmental Directors, Managers, and Superintendents. The ALARA Sub-Committee is chaired by the RP Supervisor – ALARA and has representatives from the different departments.

Cook Plant procedure PMP-6010.ALA.001, ALARA Program – Review of Plant Work Activities, requires jobs estimated at ≥1 person-rem TEDE to receive an ALARA Review by the ALARA Sub-Committee for establishment of techniques and requirements to aid in maintaining exposure ALARA. The ALARA Committee reviews all jobs estimated to be ≥5 person-rem TEDE.

Departmental Dose Reduction Plans

Departments that expect to receive greater than 100 mrem in any year are required to prepare a Dose Reduction Plan outlining the actions they intend to implement during that year to reduce the dose received by personnel in their department. The requirements for these plans are in the ALARA Procedure PMP-6010.ALA.001.

## Shielding

To reduce personnel exposure, we install approximately 49,000 pounds of shielding (~25 shielding packages) during a typical refueling outage. The ALARA review/job planning process assesses the use of shielding for jobs during outage and nonoutage. Shielding materials include lead blankets, lead bricks, and water shields.

## Hot Spot Tracking

Hot Spots are defined in the Hot Spot procedure, 12-THP-6010.RPP.013, as an accessible component having a contact dose rate ≥ 100 mr/hr and five times the general area dose rate at 30 cm.

Each identified Hot Spot is entered and tracked in the Hot Spot Tracking Log. The Hot Spot is assigned a survey frequency to monitor for changes in location or activity. A Hot Spot Evaluation Worksheet is also completed for every Hot Spot. If the work sheet shows that removal or flushing is cost beneficial, then a Work Order request is generated for its removal.

## ALARA Cost Benefit Analysis

The current value associated to 1 person-rem of exposure is $18,154. This value is used to aid in justifying design changes, modifications, and other major expenditures. This figure was established in 1989 and was reevaluated again in 1995.

## Benchmarking

Radiation Protection personnel maintain contact with their counterparts at other nuclear utilities to exchange information and ideas. Efforts are made to attend regular meetings such as the Region III Radiation Protection Managers, PWR/RP ALARA Committee, Health Physics Society, EPRI, INPO, NEI, and others. Information exchanged is used to continually improve and maintain knowledge of industry changes and innovations related to exposure reduction. Evaluation of new products such as robotic technology, computer surveys and remote monitoring are essential for continuing improvement in radiation protection.

The corrective action program is used to track good practices from benchmarking which merit evaluation for implementation. Some of the items implemented from past benchmarking include:

- The new ALARA Suggestion cards.
- Formalized guide for ALARA reviews of procedures and design changes.
- Radiological Risk Significance categories (A, B, or C) for RWPs.
- Changes to the ALARA procedure to perform “in-process” ALARA reviews for high dose / high risk significance jobs or projects.
- RP Turnover Sheet to use for days to gives to nights (front side) then nights gives back to days (back side of paper). Sections include: Posting Changes, Condition Reports Written, work summary, look ahead, relief required, and expectations for nightshift/dayshift.
- Radiological Pre-job plans (i.e. cavity decon)
- Re-established area supervisors and leads with adequate staffing.

- DOP testing of HEPA ventilation units and HEPA vacuums.
- Changes to High Radiation and Locked High Radiation area signs (new signs have a visual and dynamic difference).
- Reinstatement of outage handbooks (U2C13).

## 6. Source Term Reduction (STR)

Source Term refers to activity in piping or other plant components which, through various processes, can be removed. The removal of this source term results in lower exposure rates to radiation workers and to reduced "Dose to the Public."

STR to be implemented prior to U2C13:

- Flushing of the RHR System – the RHR water will be flushed to the CVCS HUT using RCS pressure, prior to placing the RHR into service. This will reduce the increase in RCS activity normally seen during shutdown, because the RHR system will be at the same temperature and oxygen content as the RCS prior to being placed into service.
- Reduced activity in the reactor cavity - Filling the reactor cavity using the RHR's Hot Leg injection point instead of the Cold Leg injection point will reduce the activity in the reactor cavity because the fill will not flow through the reactor core.
- RCS Vacuum Fill and Vent – Reduces the RCS fill time by 6 hours and eliminates RCP sweeps which will reduce RCP seal wear and associated maintenance resulting in reduced dose.
- Fuel assembly modifications – The unit will be refueled using 80 fuel assemblies containing ZIRLO$^{TM}$ cladding, guide thimbles, instrument tubes, and mid-grids. ZIRLO$^{TM}$ is a zirconium-based alloy that enhances fuel reliability and achieves extended fuel burn-up. The thimble plugs will also be removed from all the fuel assemblies allowing for simpler refueling processes; reducing radiation exposure.

Source Term Reduction Team

We have assembled a Source Term Reduction Team with members from RP, ALARA, Operations, Maintenance, Environmental, Chemistry, and Engineering to evaluate and prioritize source term reduction processes. Processes include hot spot removal, flushing, cobalt reduction and shutdown chemistry.

Cobalt Reduction

Particulate cobalt entering the RCS is activated as it passes through the reactor. Cobalt isotopes are the major contributors of exposure at the Cook Plant. Reduction of radioactive cobalt precursors, such stellite, in the primary system will result in decreased dose. As a matter of perspective, one gram of $Co^{60}$ has a specific activity of >1000 curies.

The ALARA Group using the Data Sheet 3, ALARA Review form found in the ALARA procedure (PMP-6010.ALA.001), reviews plant modifications, including all Design Change Packages. Data Sheet 3 guides the reviewer to look for and eliminate stellite. Plant Engineering procedures and training also discuss reduction of cobalt bearing materials.

Some important contributions to cobalt reduction have already been accomplished. The steam generators in both units have been replaced with generators having lower cobalt content than the original design. Inconel fuel assembly grid spacers were replaced with zircaloy spacers in both units during refueling outages in 1990. A cobalt reduction program database that identifies cobalt-bearing valves in communication with the primary system was developed in 1992. Since the development of this database, valve replacements and valve replacement parts have been ordered cobalt free by the warehouse.

Chemistry Program Enhancements

Power Operations - Moving from a 'modified' RCS lithium program to a 'coordinated' program. The Chemistry Department is funding a system materials evaluation by Westinghouse that will allow higher coolant lithium concentrations at the beginning of each cycle. This change will allow lithium concentrations to be controlled at levels high enough to produce a constant pH throughout the cycle, minimizing early cycle corrosion product deposition on fuel surfaces and subsequent transport out of the reactor core.

Startup Chemistry - Continuing to follow a strategy to minimize time spent with acid reducing condition during RCS heatup. The aim of this strategy is to avoid creating a chemistry regimen that would de-stabilize core deposits and promote transport around the reactor coolant system.

Shutdown Chemistry - Revising reactor coolant de-lithiation practices to achieve acid conditions early in cooldown process. The coolant will be de-lithiated during the downpower at a rate that will result in an at-temperature pH of 6.5 at entry into Mode 3. Also, revising the RCS degas process to ensure that sufficient dissolved hydrogen is retained in the coolant to provide an adequate margin for maintaining corrosion products in a soluble form.

### Foreign Material Exclusion Program

The Plant Manager Procedure for FME contains guidance on cleanliness when working on valve internals with emphasis on thorough cleaning to ensure no loose cobalt/stellite is left inside the valve that could later get into the reactor. The FME program also controls debris/foreign materials from entering plant system, which prevents that material from damaging the fuel, or other components.

## 7. Worker Productivity Enhancements

### ALARA Work Planning

ALARA Job packages are used in pre-job planning and include lessons learned from past work. By reviewing past experiences, we can usually find ways to do the work more efficiently, reducing the overall personnel dose. The ALARA group breaks jobs into smaller activities to see where additional dose can be saved, if a mock-up would increase efficiency, or if other facilities have something helpful to share. ALARA dose goals and incentives are also used to motivate workers to work more efficiently.

### ALARA In-progress and Post Job Reviews

The ALARA group performs in-progress reviews, at 50% and 80% of the estimated dose, of all jobs with an estimated dose budget greater than 1 Person-rem. Post-work reviews are also performed after these jobs are complete. These reviews are placed into the ALARA Job package for review and incorporation of lessons learned prior to performing the work again.

### ALARA Suggestion Program

An individual or work group may submit suggestions to improve how a job is performed.
Since the rebirth of the Suggestion/Incentive program, in early 2000, an average of 10 suggestions have been received per month. The estimated dose savings from these suggestions is 5 person-Rem, or ~$90,000 ($18k/person-Rem).

Initiation of an ALARA parking spot has helped to increase interest in the ALARA Suggestion Program. The parking spot is used to reward personnel who submit suggestions resulting in large dose savings.

### Mock-ups

Mock-up activities are performed to help personnel become more efficient in their task and to identify areas needing improvement, especially new technologies or first time evolutions. By performing the task in a non-radiological environment, we can experiment with new ideas while becoming proficient with the job at hand. Examples of mock-ups which have aided in dose reduction include: RCP work, S/G activities, Reactor Vessel Support work/cleaning, filter change-outs, non-routine valve work, cutting and machining of RCS piping (SGRP), RCS pipe end decon (SGRP), Steam Generator girth cut (SGRP), moisture carry over testing, and many other new or unfamiliar tools, processes, and technologies.

### Exposure Trending

Comparison of dose received for prior evolutions allows for challenging dose goals to be established. When the ALARA dose goal are met, ALARA incentives awards are often given in recognition of good ALARA work practices.

**Contaminated Square Footage**

Many areas of the plant that were once posted as contaminated areas have been decontaminated and are maintained as clean areas. This enhances access while reducing contaminated clothing and DAW generation. The plant enforces a clean as you go policy for all workers. Contaminated area square footage is tracked by the RP Department and is an indicator of radiological performance.

## 8. Effective Exposure Reduction Practices

**Design Changes/System Enhancements**

Design Change Packages are reviewed by the ALARA group, using the Data Sheet 3, DCP ALARA Review form in the ALARA Program procedure (PMP-6010.ALA.001). The Data Sheet 3 is a check-off list with 117 questions prompting the reviewer to look for exposure savings design criteria. The questions are divided into 12 sections, including shielding, source term reduction, contamination control, and system layout.

**Remote monitoring**

Remote monitoring is used to reduce the exposure of personnel performing inspections or walk-downs, and for RP technicians providing job coverage. The individual is able to remain in a low dose area while work is being performed in an area of greater radiological significance. Remote monitoring is used for various refueling, RCP, and Steam Generator activities. Radiation Protection also uses robotics (e.g. under water subs, and the scavenger) to save personnel dose.

Remote technology is an important tool for reducing personnel dose. Use of remote monitoring and robotics has greatly increased throughout the nuclear industry. Several actions to evaluate and implement additional remote technologies are listed in this 5 year plan.

## 9. Exposure Reduction Techniques being investigated for implementation 2002 – 2006 (within the next five years)

| Project | Benefit | Owner | Due | Priority |
|---|---|---|---|---|
| Removal of U2 RTD lines RPA 5193 | Reduce exposure for future outages | B. Story | 2003 | 1 |
| Removal of U1 RTD lines RPA 5006 | Reduce exposure for future outages | B. Story | 2003 | 1a |
| Zinc Injection | Reduces radioactive material in the RCS | S. Griffin / D. Kozin | 2003 | 2 |
| PRC-01 Resin use in U-1 | Reduces RCS source term and contamination levels | S. Griffin / D. Kozin | 2001 | 3 |
| Installation of Jib cranes in U2 CTMT @ 22&23 | Reduces outage dose by decreasing time and exposure during mobilization and demob. | B. Story | 2003 | 4 |
| Installation of Jib cranes in U1 CTMT @ 12&13 | Reduces outage dose by decreasing time and exposure during mobilization and demob. | B. Story | 2003 | 4a |
| Improve turbine side access control | Increase RP interaction with rad workers | R. LaBurn | 2002 | 5 |
| Improvements to LHRA barrier @ Accumulators | Reduce exposure by eliminating RP constant coverage | R. LaBurn | 2002 | 6 |
| Install permanent S/G Platforms in U-2 CTMT RPA 5195 | Reduced exposure future outages | B. Story | 2005 | 7 |
| Install permanent S/G Platforms in U-1 CTMT RPA 5194 | Reduced exposure future outages | B. Story | 2005 | 7a |

| Project | Benefit | Owner | Due | Priority |
|---|---|---|---|---|
| Install permanent shielding @ NRV/QRVs | Reduce exposure future outages | L. Green | 2003 | 8 |
| Storage of lead in CTMT and Auxiliary buildings | Reduce exposure & time associated with transportation of shielding | L. Green | 2003 | 9 |
| CTMT penetrations for RP communications | Increase use of remote monitoring | R. LaBurn | 2005 | 10 |
| CPN-1 quick removal 4 bolt modification to Blind Flange | Save time and dose in lower CTMT | K. Rolins | 2003 | 11 |
| Improvements to 587' Drumming Room ventilation | Increase ventilation allowing processing of highly contaminated waste | R. Hedgepeth | 2004 | 12 |
| Permanent shielding in the Regen and Excess Letdown Hx. Rooms | Saves exposure from installation and removal in future outages | L. Green | 2004 | 13 |
| Flushing of Hot Spots during U2C13 | Reduce exposure in plant areas | S. Griffin | 2003 | 14 |
| Flushing of Hot Spots during U1C18 | Reduce exposure in plant areas | S. Griffin | 2003 | 15 |
| Pre-approved installation specifications for temporary shielding | Save engineering time and decrease time for installation – simplify the use of temporary shielding | L. Green | 2003 | 16 |
| Storage of scaffolding in containment during power operations | Reduced time and exposure for scaffold installation and removal | T.Tillstrom | 2003 | 17 |
| Cobalt Reduction Program for replacement of valves with high cobalt content (Evaluate the 1992 document) | Reduce the cobalt in the RCS | S. Griffin / Design Engineering | 2002 | 18 |
| Mock-up facility in the Training building | Increase worker efficiency, reducing dose | TBD | TBD | 19 |