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Revision 0

PROJECT W-320

AS LOW AS REASONABLY ACHIEVABLE PLAN

W. M. Harty

June 1995

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AS LOW AS REASONABLY ACHIEVABLE PLAN

1.0 INTRODUCTION

1.1 PURPOSE

It is the goal of Westinghouse Hanford Company (WHC) to limit radiation and toxicological (hazardous material) exposure to "as low as reasonably achievable" (ALARA). The ALARA concept represents a programmatic approach for maintaining occupational exposure as far below the regulatory limits as can be achieved using available technology at a reasonable cost.

The U.S. Department of Energy (DOE) subscribes to the philosophy of ALARA and requires that DOE facilities subscribe to it as well. Thus, WHC is committed to developing and implementing a forceful ALARA program with the intent to use ALARA principles in relevant areas of construction and startup activities.

An effective ALARA program for the Sluicing Project (W-320) will reduce radiation and toxicological exposure using a systematic approach that includes the following:

- Providing guidelines
- Identifying responsibilities
- Specifying documentation
- Requiring review of proposed methods and job and process control plans as well as completed tasks (lessons learned reviews).

1.2 SCOPE/APPLICABILITY

This ALARA Plan will affect construction and startup personnel and activities of the Project W-320 Sluicing Project.

1.3 BASIS

The primary basis for this Program is the ALARA philosophy which recognizes that even though current occupational exposure limits provide a very low risk of injury to personnel, it is prudent to avoid unnecessary exposure. The technical basis for the ALARA philosophy is primarily discussed in four government documents.

1. DOE Order 5480.11, *Radiation Protection for Occupational Workers* (DOE 1988a), is the most important DOE Order for radiation protection. It requires that specific radiological design criteria and controls be incorporated into the facility designs through the application of optimization principles; internal and external

exposure reduction goals; and provisions for maintenance, decontamination, and decommissioning. The primary means for achieving ALARA goals will be physical engineered controls, with administrative controls and procedures considered as supplemental means.

2. DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1990), gives specific criteria for maintaining doses to the general public ALARA, such as limits on the release of airborne and waterborne radioactivity to the environment.
3. DOE Order 6430.1A, *General Design Criteria* (DOE 1989), is the principal order for engineering design. This Order requires that the designs of nuclear facilities protect the public and facility personnel from radioactive hazards and maintain the effects from these hazards ALARA. The ALARA concerns shall be emphasized during all design phases of nuclear facilities, and the primary protection method used shall be engineered controls (e.g., confinement, ventilation, remote handling, equipment layout, and shielding).
4. PNL-6577, *Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are As Low as Reasonably Achievable (ALARA)* (PNL 1988), states that ALARA should be incorporated into the earliest stages of the design of a building and that a radiological engineer or ALARA specialist should be on the design team from the beginning. The design should be reviewed at predetermined stages of development and any team reviewing the design should include representatives from the appropriate engineering disciplines. The Manual also states that the design engineers, as well as other groups, should be trained in the principles of ALARA.

The cost-benefit methodology presented in this Program was developed using the technique of Achievability Index - Apparent Reduction Potential developed in U.S. Nuclear Regulatory Commission *Regulatory Guide 1.110*, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Reactors" (NRC 1976). This method of analysis provides an in-depth overview of all aspects of a program to determine inadequacies in structure, approach, management, communications, and other areas. Another valuable guide for cost-benefit analysis is the technique developed in International Commission on Radiological Protection Publication 37, *Cost-Benefit Analysis in the Optimization of Radiation Protection* (ICRP 1983).

Many references contain guidance on ALARA. Those particularly recommended and referenced by the federal government include: PNL-6577, *Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are As Low as Reasonably Achievable (ALARA)* (PNL 1988) and DOE Order 5820.2A, *Radioactive Waste Management* (DOE 1988b). Other appropriate references include National Committee on Radiation Protection and Measurement reports, International Commission on Radiological Protection reports, American National Standards Institute standards, and other specific industry guidance for good practices (see Section 6.0). However, no single document can concisely present every possible situation in detail and take account of new regulations and technology.

1.4 SLUICING PROJECT ALARA APPROACH

Consistent with the WHC and Hanford Site ALARA plans and programs, the Sluicing Project has implemented, and continues to implement, design and administrative practices to maintain the ALARA principles. The following list provides some of the major practices and activities that are being performed or planned.

- Tank ventilation equipment (e.g., mist eliminator) has provisions to add shielding if radiation exposure becomes significant.
- ALARA issues are discussed and reviewed as part of the design review process.
- Radiation protection and hazardous material handling training will be conducted.
- Remote installation of jumpers will be rehearsed in a clean area to ensure that support equipment and methods are adequate.
- Pits will be decontaminated before construction activities begin.
- Containment tents ("greenhouses") will be used to limit and control the spreading of contamination.
- Portable shielding will be installed around "hot spots" to protect personnel, as necessary.
- Hazardous material control procedures will be used.
- Personnel residence times will be minimized through pre-job briefings and planning meetings.
- Radiation and hazardous material areas will have controlled access.
- Personnel contamination prevention techniques, such as protective clothing and respiratory protection, will be used.
- Mockup testing will be performed for appropriate tasks.
- Radiation exposure records will be monitored and maintained.

1.5 DEFINITIONS AND ACRONYMS

- ALARA. The philosophy that any exposure to radiation or toxic/hazardous materials is associated with some level of risk, no matter how small, and that all exposure should be reduced to "as low as (is) reasonably achievable" on the basis of the state of technology and the economics of reducing exposure relative to the benefits realized.

- ALARA Plan. A plan that describes the management commitment to reduce exposures to ALARA, the approach to the implementation of the ALARA philosophy, and the key features of where and how ALARA will be implemented.
- Cost-benefit analysis. A methodology used to determine if the benefit received from reducing exposure justifies the cost. During the analysis, dollar amounts are assigned to the technology, materials, social, regulatory, personnel, and operational requirements needed to accomplish a task. The results are usually expressed in dollars/person-rem.

2.0 PROGRAM ELEMENTS

2.1 TRAINING

Training that includes the philosophy, implementation, and evaluation of ALARA shall be given to all personnel performing work or directing the work of others whose responsibilities require access to radiological controlled areas or dealing with radioactive materials. Training is expected to motivate and inform personnel regarding the importance of the ALARA exposure principles.

Training in the following subject areas will be provided for selected project personnel as appropriate:

- Radiation worker training
- Hazardous material handling training
- Mockup on-the-job training
- Pre-job safety training.

2.2 PROGRAM IMPLEMENTATION

The following sections provide guidelines to implement ALARA, and address planning, procedures, temporary shielding, rehearsals and briefings, work performance, pre-job reviews, exposure analysis, contamination control, and mockups.

2.2.1 Review of Design Media

Design media documentation (piping and instrumentation diagrams, electrical single lines, layout and equipment location drawings, procurement specifications, construction packages, calculations, etc.) is reviewed by the WHC Project W-320 startup and construction personnel. This documentation, as appropriate, shall be reviewed to ensure that ALARA practices and precautions are factored into the design media documentation. The Project W-320 startup and construction personnel shall use ALARA design-oriented checklists (Form A-6000-291) when reviewing the 90% documentation packages and any other design verification or validation packages. An example of an auxiliary checklist is provided as Appendix A. All checklists shall be controlled via the Project W-320 configuration management plan.

2.2.2 Minimizing Exposure During Construction and Startup

The following paragraphs contain procedural elements for implementing ALARA during construction and startup activities. These elements will be used by operations, maintenance, and repair personnel to cope with radiation and toxic material exposure. To improve the effectiveness of current and future work in radiation areas, all subjects in this section should be considered in planning and performing each Project W-320 task. For low-radiation work (for example, in an area of 5 mrem/h), adequate consideration might be a brief review of the topics discussed in this section. For high-radiation work (for example, in areas of 100 mrem/h), each item in this section should receive

intensive consideration. For such high-hazard work, written procedures should be prepared that include and reference radiological/industrial controls. Figure 2-1 shows ALARA-related steps involved in the preparation and implementation of process control packages (PCP).

The elements in Sections 2.2.2.1 through 2.2.2.6 should be used for planning a job in a radiation or toxic material area. Further details regarding these elements can be found in Appendix B.

2.2.2.1 Preliminary Planning (Section B1.0). The objective of planning is to ensure that all factors that may influence the adequate and efficient performance of a task are recognized and that appropriate skills, training, and resources are available. Careful planning and preparation for work activities may reduce the hazardous materials exposure received because work will be performed more efficiently and less time will be spent in a hazardous area.

An ALARA Management Worksheet (see Appendix C) can be used by the work package preparer or the work plan author to record and document input from the various operations and support organizations concerning the ALARA protective measures and practices considered, selected, and/or required for a particular job.

2.2.2.2 Preparation of Work Procedures (Section B2.0). Procedures should provide for the control of radioactive materials, for safe operations, and for clearly identifying areas of potential hazards. Radiation Work Permits (RWP's) are used for all radiation work. These RWP's are developed by health physics staff and approved by management. Specific job-related exposure reduction efforts are to be incorporated into work procedures. A checklist to review procedures, tests, and documents is provided in Appendix C. The work plans and/or procedures should include the following information.

- Plan access to and exit from work areas.
- Provide for service lines.
- Provide communication.
- Reduce or remove sources of radiation/toxic materials, if possible.
- Plan for installation of temporary shielding.
- Decontamination.
- Work in lowest radiation/toxic material levels.
- Perform as much work as practicable outside hazardous areas.
- State requirements for standard tools.
- Consider special remote or extension tools.
- Include inspection requirements.
- Minimize discomfort of workers.
- Estimate person-rem/toxic exposure levels.

Figure 2-1. As Low as Reasonably Achievable Process Flowsheet.

2.2.2.3 Inspection Requirements for Exposure Controls (Section B3.0). As the work progresses and conditions change, the exposure rates should be continuously monitored to ensure that radiation levels and other hazards do not change unexpectedly. Work plans/procedures will provide for required radiological/toxic material control inspections.

2.2.2.4 Temporary Shielding (Section B4.0). Consideration should be given to the use of temporary shielding during preparation of procedures for work in radiation areas. The following should assist in determining what to shield and how to shield it.

- Balance exposure expected in placing shielding with benefits to be realized (i.e., shielding may reduce exposure, but increase job performance duration).
- Shield travel routes.
- Consider shielding individual components, rather than work location.
- Evaluate worker positions.
- Evaluate structural support of temporary shielding.
- Evaluate directional shielding.
- Assess shielding material.
- Use mockups to determine if shielding design, including support structures, is feasible.

2.2.2.5 Rehearsing and Briefing Workers (Section B5.0). Personnel briefings, and rehearsals as appropriate, will be held before work is performed in radiation control areas. These briefings will be a supplement to radiation work permit (RWP) information and will ensure that those involved in the work understand where and how the work is to be done and what hazardous materials protection requirements are involved. The following activities shall be performed, as appropriate, prior to the initiation of work in radiation control areas.

- Rehearse difficult procedures on mockups.
- Test specially designed support equipment on mockups.
- Use photographs or videos to brief workers.

2.2.2.6 Performing Work (Section B6.0). Work procedures are to be adequately documented and updated as necessary. Radiation exposure controls will minimize personnel radiation exposure. The routine and accident personnel dosimetry programs will ensure that whole body radiation exposures are accurately determined and recorded. Internal radiation exposure controls will minimize internal exposures. The internal dosimetry program will ensure that internal radiation exposures are accurately determined and recorded. Radiological protection instrumentation used to obtain measurements of radioactivity or personnel dosimetry will be calibrated, used, and maintained so that results are accurately determined. The respiratory program will

ensure optimum protection against internal radiation exposures to workers. Proper air monitoring systems selection, location, calibration, and maintenance will ensure reliable estimates of air activity for radiological control purposes. The radiological monitoring and contamination control program will include the following measures to ensure worker protection from radiological exposures.

- Post the radiation levels.
- Keep excess personnel out of radiation area.
- Supervisors and workers keep track of radiation exposure.
- When possible, workers may assist in radiation and swipe surveys via the delegation of limited radiological control monitoring responsibilities.
- Evaluate use of fewer workers.
- Reevaluate reducing radiation exposure.

2.2.3 Pre-Job Reviews

The *Waste Tank Administration Procedures*, WHC-IP-0842, Section 15.6, "Waste Tank ALARA Program" (Ellis 1994) contain important guidance regarding the use of appropriate checklists and the levels of review appropriate for a job. This guidance is based on preliminary radiation survey information and predicted task durations.

The flowsheet included as Figure 2-1 provides a good representation of the activities to be performed during the ALARA implementation process.

Pre-job reviews may include convening of the ALARA Team, completion of the RWP Request Form (macro number GEF026), the ALARA Checklist (WEF042), the ALARA Management Worksheet (WEF043), and/or the Prejob ALARA Review Record (WEF193), as appropriate. See Appendix C for these checklists.

2.2.4 Exposure Reduction Analysis Methods

The cost-benefit analysis and related analytical methods for the determination of a potential action's effect on exposure reduction are powerful tools to achieve an effective ALARA program. A subjective ALARA approach makes it more difficult to provide a means to justify the expenditure of resources in order to reduce personnel exposure.

The apparent reduction potential is described in *Regulatory Guide 1.110*. This method provides a numerical approach to enable the ranking of potential radiation exposure reduction choices to get the best return on investment. *Cost-Benefit Analysis - ALARA* (WHC-SD-SQA-CSD-20003) (Brown 1992) presents the method accepted for use for Hanford Site operations to meet the intent of PNL-6577 (PNL 1988). The PNL document uses a variable cost associated with a person-rem. Appendix D provides additional information on the cost-benefit analysis method.

One method that may be used to identify actions that have the highest potential for radiation exposure reduction is the performance of maintenance/operations access studies (if project management decides a formal analysis is warranted). Appendix E outlines the process of investigating the normal and off-normal construction and startup sequences anticipated throughout the life of the project to determine what actions are expected when personnel will be exposed to significant levels of radiation. The results of such investigations not only help identify potential radiation reduction sources, but also have positive results from systematically examining the details of construction/startup operations and maintenance actions and the identification of special tools and support equipment. The Maintenance Access Worksheet (Figure 2-2) provides a format for collecting the type of information required to understand the overall personnel exposure levels. (This information can then be used for the completion of the RWP Request Form section on exposure estimates.) Appendix E provide guidance and background for completing the worksheet.

2.2.5 Contamination Control Measures

Pre-task preparation involves the employment of appropriate contamination control measures. Project W-320 will control and prevent the spread of contamination by performing or providing the following activities:

- Perimeter control (e.g., fences, locked gates, etc.)
- Facilities to provide anti-contamination change capability and step-off pads
- Routine radiation surveys of job sites
- Temporary and/or permanent storage provisions for contaminated equipment
- Decontamination provisions (e.g., washdown bays, spray rings at risers, etc.) used to reduce tank pit and equipment radiation levels
- Permanent or temporary enclosures (greenhouses)
- Heating, ventilating, and air conditioning airflow (from less to more contaminated zones).

2.2.6 Mockup Demonstration Requirements

Access to a mockup test facility will provide the opportunity to gather experience that will be used to significantly decrease radiation exposure to workers. Typical training of personnel involves the increase of proficiency in operational and maintenance procedures to reduce their time in radiation areas. Additionally, mockup facilities can be used for training in anticipated off-normal occurrence workarounds, the use of special support equipment, and investigation of possible protective clothing/temporary shielding interferences without exposing workers to high-radiation levels.

Figure 2-2. Construction/Startup Operations Access Study.

Instructions:

Column 1 contains the code for the area of the facility (room, location designation, etc.).
 Column 2 is a short, descriptive name of the task being performed.
 Column 3 is the type of activity being performed (operations/maintenance/inspection).
 Column 4 indicates if the activity is remote or hands-on.
 Column 5 predicts the frequency of performance of the task, if more than once.
 Column 6 estimates the duration of the task for the primary worker(s), if any, i.e., those in close contact with the equipment involved.
 Column 7 estimates the duration of the task for the secondary worker(s), if any, i.e., those in an area not in close contact with the equipment involved.
 Column 8 predicts the radiation or toxicological exposure rate for the primary worker.
 Column 9 predicts the radiation or toxicological exposure rate for the secondary worker, if any.
 Column 10 is the result of the cumulative exposure from the task.
 Column 11 can be used to explain how the staff-hour duration values were calculated, or any other pertinent information.

Acronyms/Abbreviations

DBox1 - Diversion Box 1 DR - Dose rate N/A - Not applicable or negligible O/M/I - Operations/Maintenance/Inspection task categories PM - Preventive maintenance	Port.Encl. - Portable enclosure r&r - Remove and replace R/H - Remote/hands-on SC - Sample cubicle TBD - To be determined/developed
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Examples

Area	Task	Type		Frequency (per task)	Duration (Staff-hrs)		Exposure level		Cum. Expos.	Comments
		O/M/I	R/H		Primary	Support	Primary	Support		
SC	Sampling (tanks & sumps)	O	R	2	16	--	1 mrem/h	--	16 mrem	8 h, 2 people
DBox1	Valve jumper replacement	M	R	1	4	2	100 mrem/h	10 mrem	420 mrem	4 h, 1 person (primary); 2 h, 1 person (secondary)

Cumulative Total (mrem) 436 mrem

2.3 PROGRAM EVALUATION

This section discusses documentation that should be developed so similar future tasks and projects may take advantage of "lessons-learned" and factor them into their tasks/project. Post-job reviews are an important element in an ALARA program.

2.3.1 Post-Job ALARA Review

Upon completion of a task, those performing the work will meet and discuss the problems encountered, techniques for improving the future performance of similar tasks, and techniques for further reducing exposures.

The following shall be considered, as a minimum, during a post-job review (see Appendix C):

- Problems encountered and solutions developed/employed
- Correct number and type of persons for job (was estimate correct; reason for differences, if any)
- Actual total dose and/or nonradiological exposure.

2.3.2 Comparison of Estimated versus Actual Exposure

A comparison of estimated and actual radiological and nonradiological (industrial hazards) exposures will provide the single most objective evidence of an effective ALARA program. If the comparison shows that the actual collective exposures were similar to predictions, it would indicate that pre-job planning had been performed adequately to understand the details of the job and that surveys were performed properly.

2.3.3 Lessons Learned

A summary of "lessons learned" of project tasks performed will be issued to keep track of important ALARA issues raised during reviews and the subsequent resolution of the issue. This summary will provide a single source of input to ongoing ALARA reviews to assist the task planners in reducing hazardous (radiological and industrial) material exposure. The results of quarterly radiation control reports, and costs of previous radiation reduction measures, will be available to the reviewers of current tasks.

3.0 RESPONSIBILITIES

The facility organization and administration should ensure effective implementation and control of radiological protection activities within the facility. The following key personnel are involved in the ALARA effort on Project W-320.

3.1 STARTUP/CONSTRUCTION MANAGER(S)

The Startup/Construction manager(s) for the Sluicing Project is responsible for the implementation of the ALARA Program and will appoint the ALARA point of contact. This responsibility includes the following tasks.

- Demonstrate project support and commitment to ALARA.
- Instruct the project supervision to ensure that their personnel are trained in applying ALARA principles in the performance of their tasks by reviewing jobs in progress.
- Establish ALARA goals and objectives.
- Serve on the ALARA Team as its chairperson.
- Ensure the maintenance of ALARA review records.
- Review training programs related to Sluicing Project implementation of ALARA methodology.
- Recommend the use of mockup facilities when their use could significantly reduce doses.

3.2 STARTUP ENGINEER

The Startup engineer's responsibilities are as follows.

- Provide technical information necessary to review ALARA issues.
- Perform technical reviews of the design, procedures, and startup steps for compliance with ALARA policy and recommend design features affecting the maintenance of exposures ALARA.
- Review project work packages, recommending modifications as necessary to incorporate ALARA considerations and lessons learned from experience.
- Serve on the ALARA Team.

3.3 HEALTH PHYSICS/RADIOLOGICAL CONTROL DEPARTMENT SUPERVISOR

The HP/Radcon Department's responsibilities are as follows.

- Perform exposure tracking, trending, and evaluation for the duration of the W-320 Project.
- Ensure that personnel radiation exposure records are maintained.
- Provide a representative to serve on the ALARA Team.
- Use project radiological exposure data for comparison with goals and for trend analysis.
- Provide a point of contact to prepare RWPs and review PCPs, work plans, and/or procedures.
- Participate in pre-job reviews by identifying radiation exposure levels and locations within the job scope with attention to the following areas:
 - Radiation and contamination levels
 - Shine-through penetrations into work area
 - Adequate permanent shielding or the need for temporary shielding
 - Adequate access to utilities such as electrical outlets and air line connection locations and proper radiation monitoring equipment
 - Spill control and ability to be decontaminated
 - Adequate containment of contamination
 - Identification of personnel protective equipment.
- Monitor the radiological conditions during task operations.
- During the pre-job safety meeting, discuss the radiological hazards for all personnel involved in project field work.

3.4 SAFETY (INCLUDING INDUSTRIAL HAZARDS)

System Safety responsibilities are as follows.

- Review the toxic/hazardous material conditions that occur at the work site, with attention to the following:
 - Accessibility to toxic/hazardous materials (contained within piping)

- Estimated toxin exposure levels
 - Floor drains and sumps (their effluent paths)
 - The use of personnel protective equipment and response, in case of accidents
 - Breathing air line connection locations
 - Toxin/biohazard warning signs
 - Requirements for air monitoring, before work starts and where conditions change (welding, cutting, breaking lines).
- The Industrial Safety representative will review the PCPs and identify industrial safety and hazardous material hazards associated with the work task to ensure the objectives of the *Tank Farm Health and Safety Plan* (WHC-SD-WM-HSP-002) (Mickle 1995) are met. The hazards will be reviewed with the work team during the pre-job safety meeting. Actions to mitigate these hazards and responses to accidents will be discussed.
 - Monitor the toxicological conditions during task operations.

3.5 ICF KAISER HANFORD COMPANY (ICF KH) GENERAL SUPERVISOR

The ICF KH general supervisor's responsibilities are as follows.

- Act as the interface between the WHC project management team and the field worker crews.
- Serve on the ALARA Team.

3.6 FIELD PERSON-IN-CHARGE (PIC) OF APPLICABLE TASK

The field PIC's responsibilities are as follows.

- Act as the representative of the field worker crew for the current task.
- Provide task descriptions, logistics, and duration information to the field worker crew to minimize personnel exposures.
- Serve on the ALARA Team when the applicable task is under review.

3.7 ALARA REVIEW TEAM

As warranted by the magnitude of the hazard risk for a particular job, an ALARA Review Team shall be established to periodically perform significant ALARA evaluations, initiate work methodology changes to reduce exposure, and document exposure reduction results. The Team will provide a method for

review, evaluation, and input to ALARA problems from all groups involved in the construction and startup effort. The Team also will provide an avenue for ALARA recommendations from field workers to WHC management and other project personnel.

3.7.1 Membership

In keeping with the ALARA philosophy and WHC's commitment to maintaining exposures ALARA, Sluicing Project management has formed a team as the focal point of its ALARA Program.

The ALARA Review Team consists of the Startup manager (as chairperson), an HP representative, the Startup engineer, the Safety engineer (for industrial safety), and the ICF KH general supervisor, with participation from each of the PICs for the tasks currently under review.

The above-listed people are the decision-making body of the ALARA Review Team and have the ability to make commitments for the project.

Team members are encouraged to bring interested personnel and experts on specialized subject matter to Team meetings in order to get broader participation and an understanding of the project's ALARA efforts.

3.7.2 Meetings

The Project W-320 ALARA Review Team will meet at least once per quarter (or before and after each major project task).

3.7.3 Functions

The ALARA Review Team functions are to review areas of potential exposure within the facility to determine what could be done to reduce exposure and to review/research exposure-saving suggestions for viability. These are accomplished by the following.

- Evaluate ALARA post-job reports from previous tasks and suggestions on exposure reduction methods.
- Decide if exposure reduction analysis is warranted and, if so, assign a person responsible for its completion (see Appendix C).
- Initiate requests for correction of ALARA problems.
- Before the start of a major project field task, review ALARA goals and ALARA issues identified by the Team or in pre-job review checklists completed by the work groups.
- Follow up with the originator of any currently submitted ALARA suggestion.

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4.0 DOCUMENTATION

The Sluicing Project will document the ALARA activities and issues and maintain records to provide verification of the actions taken to provide a work environment in which radiological and toxicological hazards exposure to the worker is maintained ALARA. Records related to occupational exposure will be maintained in a manner that permits easy retrievability, allows trend analysis, and aids in the protection of an individual and control of hazardous material exposure.

4.1 IMPLEMENTATION

The types of documentation maintained by the project to document the ALARA implementation policy include the following:

- General management review:
 - ALARA Checklist (WEF042)
 - ALARA Management Worksheet (WEF043)
- ALARA Review Team meeting minutes including the following:
 - RWP Request Form (GEF026), including job exposure estimate
 - Prejob ALARA Review Record (WEF193)
 - Action item list and assignment of responsibilities.

4.2 EVALUATION

The types of documentation maintained by the project to evaluate ALARA effectiveness include the following:

- ALARA Review Team meeting minutes including the following:
 - Post-job ALARA Review (WEF192)
 - Action item resolution
- Post-job comparisons
 - Job exposure estimate versus actual
 - Radiation control reports
 - Lessons learned summary (evaluation of exposure reduction techniques employed during job and recommendation for future use).

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APPENDIX A

EXAMPLE OF AS LOW AS REASONABLY ACHIEVABLE DESIGN REVIEW CHECKLIST

APPENDIX A

EXAMPLE OF AS LOW AS REASONABLY ACHIEVABLE DESIGN REVIEW CHECKLIST

SITework/INTER-FARM PIPING SYSTEM

Design Package 1

ALARA Design Review Checklist

If the answer is "Yes," mark the column. If a particular item is not applicable to the drawings under review, "N/A" shall be placed in the "Yes" column. If the answer is "No," action is required so check the appropriate organization and identify the action required. An "Explanation" can be used to discuss why the design is adequate to receive a "Yes" if there could be some confusion.

Item of consideration		Action by		Action required or explanation
	Yes	WHC	ICF KH	
1. Site surveys for soil contaminated by radionuclides or toxic substances have been used in the selection of piping routes.				
2. Routings for the raw water and electrical lines do not cross the contaminated areas, if there is an alternative route.				
3. Adequate space is provided for the contaminated soil removed or provisions have been made to immediately remove the contaminated soil. Adequate contamination control provisions are provided (e.g., berms, pits, or covers).				
4. Dose rate and airborne radioactivity monitors are required in the area and they are provided.				
5. Radiation sources are separated from (shielded from) frequently accessed areas. (When reviewing this consider traffic patterns, radiation zoning, movement of waste and supplies, change room locations, personnel health protection equipment, decontamination facilities, and fixed radiation monitoring equipment.)				

Item of consideration	Yes	Action by		Action required or explanation
		WHC	ICF KH	
6. Radioactive components are separated from non-radioactive components.				
7. Provisions are made for access control.				
8. Adequate lighting is provided to support activities in the radiation areas.				
9. Ample means of communication are provided in the area to maintain contact with workers in the radiation area.				
10. The wearing of protective clothing, respirators, etc., has been considered in the selection of equipment or installation equipment. (Consider human factors related to bulky clothes and temperatures within the suits.)				
11. It is specified that piping and nozzles are to be sloped so they do not collect contaminated fluids.				
12. Crud traps are eliminated or kept to a minimum, and accumulations of source material can be remotely removed. (When reviewing this, consider special provisions for draining, flushing, and decontamination.)				
13. Adequate shielding is provided over the piping.				

ICF KH = ICF Kaiser Hanford Company
WHC = Westinghouse Hanford Company

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APPENDIX B

GUIDANCE FOR MINIMIZING HAZARDOUS MATERIAL EXPOSURE

CONTENTS

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APPENDIX B

GUIDANCE FOR MINIMIZING HAZARDOUS MATERIAL EXPOSURE

B1.0 PRELIMINARY PLANNING

Before preparation of the detailed work plans or procedures for a specific job, the following actions will have been taken to minimize exposure to radiation and other hazards.

1. Plan. Many of the possible methods for reducing exposure to radiation and other hazards require considerable planning and indoctrination (training) before the work starts. Planning is essential to these preparations. For example, planning is necessary to design, construct, and test a containment enclosure outside the radiation area.
2. Delete unnecessary work. Because any work conducted in a hazardous area puts workers at risk, only that work which is necessary is performed. Additionally, exposure time is reduced by having the right materials and equipment present and performing the job in the correct sequence.
3. Obtain expected radiation and or toxic exposure levels. Radiation and industrial hygiene surveys will be taken periodically. Reports of these surveys provide the general exposure information needed for most work. In addition, detailed pre-job surveys will be performed to identify high- and low- exposure areas. Work area sketches will be used to record locations of the levels measured.
4. Maintain records. Project W-320 will maintain accurate records to assist future tank waste retrieval projects and to provide data for waste disposal records.

B2.0 PREPARATION OF WORK PROCEDURES

Detailed written process control packages (PCP) and/or work plans will be used for major jobs in high-radiation high-risk areas and for work that might result in the spread of airborne radioactivity or surface contamination. These detailed PCPs/work plans include information for minimizing exposure to radiation and/or other hazards and/or limiting the spread of contamination.

Information provided in the PCPs includes the following.

1. Plan access to and exit from work area. Access to and exit from the work areas will include a convenient and large enough location for donning and removing personnel protective equipment, for briefing personnel before entry, and for locating access/egress points (i.e. step-off pads and decontamination corridors). The access and exit

to radiological work areas will avoid having personnel waiting in areas where significant radiation levels exist. For example, the step-off pad will be located so that people leaving a contaminated area will not have to wait inside a radiation area while the people ahead are surveyed.

2. Provide for service lines. Before installing service lines (air, welding, and ventilation), the methods specified in the PCP will be followed to minimize radiation exposure associated with service line installation, maintenance, and removal and to control their interference with personnel access. The number of lines into and inside the hazardous area will be minimized to prevent accumulation of unnecessary equipment. Lines that can readily be decontaminated will be used, or protective covers will be used to prevent the lines from being contaminated.
3. Provide communication. Radio communication will be used between workers inside a hazardous work area and supervisory/support/safety personnel outside the hazardous/contaminated area. This arrangement will reduce the time required to make decisions on matters unforeseen in written work procedures or to request inspections or radiological control personnel, if practical. Use of a communication system also allows supervising personnel to maintain effective control of a job even though continuous visual observation is impractical because of high-radiation levels.

Remote viewing television systems, as deemed necessary, will be used to obtain better control of work and, therefore, reduce radiation exposure of supervisors and workers.

4. Remove sources of radiation. Significant reductions in radiation exposure for specific work will be obtained by eliminating some sources of radiation. The following are examples.
 - a. Component hot spots, which significantly contribute to the general area radiation levels, will be reduced by decontamination. Hot spots normally have individual radiation levels that are much greater than the general area.
 - b. The sequence of work tasks will be arranged to minimize personnel exposure. For example, a job near a crud trap might be delayed until after the scheduled removal or flushing of the crud trap.
5. Provide temporary shielding. The PCPs will frequently specify the installation of temporary shielding to ensure adequate placement of the shielding material and to control the exposures of personnel installing it. Temporary shielding is discussed in Section B4.0.
6. Perform decontamination. Tank farm pits will be decontaminated to reduce the spread of contamination generated by removing contaminated equipment. Disadvantages of decontamination will be balanced against the benefits of reduced radiation levels and reduced contamination. The disadvantages include (1) the radiation

exposure accumulated in performing the decontamination, and (2) the resulting additional waste that must be processed.

7. Work in lowest radiation levels. In considering details of how to do a specific job, knowledge of radiation levels in various locations can help reduce radiation exposures. For example, by changing the location in a run of pipe where a cut is made, the worker might be able to move from an area of higher to lower radiation levels.
8. Perform as much work as practicable outside radiation areas. Prefabrication will be used to minimize the work done in a radiation area. For example, difficult welds will be made in repair facilities and the less difficult welds made in the contaminated environment, providing this does not increase the total number of welds. Another example is prefabrication of temporary shielding to reduce installation time.
9. State requirements for standard tools. Standard tools known to be needed for the job will be available and will be located near the job site so that radiation exposure of working personnel waiting for tools can be minimized.
10. Consider special tools. For unique jobs, special equipment, extension tools, or jigs will allow major reductions in radiation exposure through simplification, reduction in time, or reduction of mistakes. These tools will be designed, built, and tested on full-scale models before they are used in radiation areas if usage experience does not exist. In designing special tools, consideration should be given to the ease of decontamination. Calibration of special tools will be specified in the PCP.
11. Estimate exposure. After planning the preceding details of a PCP and before performing the work, organizations will estimate the radiological/toxic material exposure to be accumulated by each craft or specified work team for each job where significant exposure is experienced. This estimate will be based on levels measured at the work location, the estimated time it will take within contaminated areas to complete each phase of the job, and applicable experience gained by the individual organization or other organizations performing similar previous work. Organizations will retain exposure data from previous jobs as necessary to support future estimates.

Examination of exposure estimates might cause reconsideration of details of the work procedure. For example, more temporary shielding might be installed, additional personnel might be trained for portions of the job, or special tools might be developed to reduce working time. During and after the work, the actual exposure received should be compared with the estimates.

B3.0 INSPECTION REQUIREMENTS FOR EXPOSURE CONTROLS

Steps required for radiological and toxicological hazards control inspections will be included in the PCPs. Typical situations include verifying work zone radiation levels before onset of work, inspecting work areas, and determining radiation level changes when a system is being removed and during removal of items from a system or an area.

B4.0 TEMPORARY SHIELDING

Temporary shielding will be considered when personnel are preparing procedures for radioactive work. The following suggestions should assist project personnel to determine what to shield and how to shield it.

1. Weighing advantages. Radiation exposure received in installing temporary shielding will be balanced against exposure to be saved by the installation. This process will result in reducing the total person-rem exposure for a job. In some cases, it may be necessary to increase the total exposure for a job by using relatively unskilled personnel to install large amounts of temporary shielding. However, these relatively unskilled personnel should be directed by experienced personnel. As a result, highly skilled personnel (such as welders) might be able to significantly increase the amount of work performed within their radiation exposure limitations. A potential disadvantage of temporary shielding is that it might get in the way, and therefore increase the time required to perform a job. If temporary shielding is properly designed and installed, it will reduce either total person-rem or the person-rem for certain skilled personnel.
2. Shielding travel routes. If the route of travel to and from a specific work area is rapidly traversed, special shielding is normally not worth considering. Only in unusual conditions, such as for small, highly radioactive components near the travel route, is temporary shielding beneficial.
3. Shielding near work areas. The effectiveness of temporary shielding installed on individual components with abnormally high-radiation levels is often underestimated in terms of the overall reduction in general area radiation levels. Applying temporary shielding to components measuring more than about twice the average radiation levels around the anticipated work areas can result in a substantial reduction of radiation exposure.
4. Shielding work areas. In most of the physical work on components, the worker receives radiation exposures greater than the average area radiation levels because the worker is in contact with radioactive pipes and components. For the shielding to be most effective, the actual positions occupied by the workers should be considered.

5. Design of temporary shielding. The following can assist in designing temporary shielding.
 - a. An approximation for the effectiveness of lead shielding against gamma radiation from Cobalt-60 (about 1.2 meV energy) is that 2 in. of lead should reduce the radiation levels by a factor of at least 10; 1 in. of lead will reduce the level by a factor of more than 3. Because lead is heavy, weighing approximately 60 lb/ft² for a 1-in. thickness, the lead should be supported to avoid excessive strain on a run of piping and to prevent the lead from being dislodged during the work period. The actual effectiveness of installed temporary shielding should be determined by measuring radiation levels before and after shield installation.
 - b. Radiation levels decrease with the square of the distance from a small source. For example, consider a small valve that produces a radiation level of 1 rem/h 1 ft away. At twice this distance (2 ft), the radiation level will be down a factor of 4 (250 mrem/h). At four times this distance (4 ft), the contribution to radiation levels from this valve will be down a factor of 16 (63 mrem/h). (NOTE: Because this is a small valve, the contact measurement on the surface of the valve would be >50 rem/h.)
 - c. Radiation levels decrease linearly with the square of the distance from a line source. For example, consider a long, straight 2-in. pipe that produced radiation levels of 1 rem/h 1 ft away. At 2 ft, the radiation level from this pipe would be 500 mrem/h; at 4 ft, 250 mrem/h.
 - d. Radiation levels decrease very slowly with distance away from large sources. For example, the radiation level several feet away from the side of a tank that measured 1 rem/h on the outside surface would be about 900 mrem/h.
 - e. Less weight of shielding is usually required if shielding is applied close to the source rather than away from the source. The same thickness of shielding will probably be needed in both cases; however, close to the source a smaller area (therefore, weight) of shielding should be effective.
6. Directional surveys. Directional surveys should be performed to assist in designing temporary shielding where the location and strength of radiation sources are not readily apparent from routine surveys.
7. Temporary shielding materials.
 - a. Although other materials that are environmentally safer should first be considered, the most commonly used temporary shielding is lead sheet. Thin sheets can be readily bent to cover complex contours of components, can be cut easily with hand

shears, and are light enough that personnel can carry pieces of several square-feet area into spaces where entry is difficult.

- b. Bags of lead wool, bags of lead putty, or bags of segmented lead chain can be advantageous where complicated geometry would require extensive cutting and fitting of lead sheets, such as around tank farm pit nozzles. Bag material must be heavy-duty to preclude tearing during handling. Double bags should be used; the outer bag should be a smooth material to better lend itself to decontamination.
 - c. When shielding to reduce radiation levels caused by high levels of contamination, be sure to place a layer of low-density materials (such as plywood) between the contamination and the lead shielding material. Use of high density material (such as lead) in direct contact with high radiation contamination may actually increase radiation levels.
8. Use of mockups. In simple cases, the temporary shielding details in the work procedure or plan might need to state only the number of sheets of lead, or other shielding material, to install and their location. In more complicated cases, such as shielding the bottom of a component where installation access and support of shielding material is difficult, the design might have to be developed on a mockup of the component. Use of a mockup can reduce the radiation exposure received during shielding installation through (1) eliminating cutting and designing shielding in a radiation area, and (2) allowing installation practice in advance.

B5.0 REHEARSING AND BRIEFING WORKERS

Experience has clearly shown that effective training, rehearsing, and briefing of workers can substantially reduce the person-rem required to perform a job; reduction of exposures by factors of 2 or 3 are not uncommon results of such programs.

1. Rehearse. Rehearsals can contribute to major reductions in personnel radiation exposure. For maximum effectiveness, rehearsals should be conducted with personnel dressed as they would be when doing the actual work because work in normal clothing is much simpler to perform than the same work while dressed in full anti-contamination clothing and a mask.
2. Use mockups. Mockups will be used for training, rehearsing, and final briefing as well as for proof-testing details of PCPs. Types of mockups vary from full-scale sections in steel for welding qualification to reduced-scale cardboard models. Where high-radiation levels are present or complex work is to be performed in a low-radiation area, the mockup should duplicate as closely as practicable work area conditions and space limitations.

3. Use photographs. Photographs are often useful for preparing work procedures to verify the actual job details. Such photographs can be useful in the training, rehearsal, and briefing of workers to reduce the time wasted in becoming oriented at the job location. Photographs can be particularly useful for work that is performed by personnel in cramped or unusual positions and for work in special types of containment enclosures. In such cases, a photograph of a previous worker at the same job can reduce the time in a radiation area spent explaining details to the new worker.
4. Brief workers. Before working in a radiation area, a worker will be briefed. Large, posted charts with up-to-date radiation levels and stay-times entered on an arrangement sketch have proven most useful in this briefing. Similar briefings will be used to verify the following factors.
 - a. The worker has received adequate radiological control training.
 - b. The worker has the necessary tools and spare tools available to minimize delays.
 - c. The worker knows the assignment and where and how to do it.
 - d. The worker knows the areas of high-radiation levels to avoid and the areas of low-radiation levels in which to remain when practicable.
 - e. The worker knows (1) the range of his/her dosimeter and how to read it, (2) the allowable dose, and (3) stay-time for the work.

In addition to mockups and photographs, briefings can be supplemented through use of blackboard sketches and plans.

B6.0 PERFORMING WORK

The following means of reducing radiation exposure should be considered during performance of work in radiation areas.

1. Post the radiation levels. Signs clearly showing which areas have highest, and which lowest, radiation levels should be posted in work areas. Barriers around the highest radiation areas can be useful in addition to posting. A suitable barrier can be made with magenta and yellow lines and signs.
2. Keep excess personnel out of radiation areas. Supervising personnel and radiological control technicians should periodically ensure that personnel are not waiting unnecessarily in radiation areas. These surveillances should also ensure that workers leave the radiation area whenever a work stoppage occurs. Radiological control personnel should also ensure that they themselves are not receiving

unnecessary radiation exposure. Radiological control personnel often have been assigned to remain in radiation areas controlling radiological aspects of jobs for extended periods of time; radiological control personnel should be able to check the job periodically and at crucial points rather than remaining continuously in the radiation area.

3. Minimize beta radiation exposures. During most maintenance work, personnel receive little beta radiation exposure because the beta radiation is attenuated, for example, by pipe walls and contamination containment areas. However, when performing work on component surfaces that have been exposed directly to high-level wastes, this exposure from beta radiation can be more controlling than gamma radiation exposure. NOTE: Radiation survey instruments will not accurately measure betas unless specially calibrated for the specific energies of beta radiation.

Radiological and hazardous material control precautions include (1) performing beta radiation surveys and (2) protecting portions of an individual's body with anti-contamination clothing.

4. Supervising personnel and workers keep track of radiation exposure. Workers and supervising personnel should be aware of their radiation exposure status if for no other reason than to avoid finding out suddenly that all qualified workers are not allowed further exposure.
5. Evaluate use of fewer workers. To maintain personnel exposures at low levels, large numbers of skilled individuals are sometimes used for a specific high-radiation job that could otherwise be performed by one individual. In some cases, permitting a few individuals to receive exposures in excess of weekly control levels can result in lower total exposure for the job because inefficiencies associated with substituting other individuals in the middle of the job would be eliminated. In addition, the use of fewer individuals would permit more extensive training of the smaller number of individuals actually performing the work, can reduce rework because of experience gained doing repetitious operations, and can result in further reduction in exposure.

Personnel provided special training for particular work should be reserved for that particular work. In addition, personnel should not be trained for several special jobs when it is likely that they would be limited to a few jobs because of exposure considerations.

The use of cross-trade training can produce significant reductions in the total number of workers exposed and the exposure received.

6. Reevaluate reducing hazardous material exposures. Planning for the job cannot be perfect. Changes will be dictated by difficulties in the job and changes can be made to improve performance during the job. Therefore, the plans and execution should be reviewed again for applicability during the performance of a job.

7. Use a pre-work check-off record. Use checklists to reduce the possibility of missing procedural steps during the job.

APPENDIX C

CHECKLISTS

LIST OF FIGURES

C-1	As Low as Reasonably Achievable Management Worksheet	C-5
C-2	Radiation Work Permit Request Form	C-6
C-3	Pre-Job as Low as Reasonably Achievable Job Planning Checklist . . .	C-7
C-4	Post-Job as Low as Reasonably Achievable Review Checklist	C-8

LIST OF TABLES

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Table C-1. As Low as Reasonably Achievable Review of Procedures, Tests, or Documents.* (2 sheets)

Item reviewed	YES	NO
Correlation between document and hardware		
1. The document contains a statement regarding the basis of the hardware configuration, including assumptions made.		
Adequacy of the document		
1. The document provides the best methodology to do the task while maintaining ALARA.		
2. The document is clear, concise, and free from any ambiguity that could lead to incorrect decisions.		
3. Details are appropriate to meet the ALARA criteria.		
4. The hardware addressed in the document has been evaluated for human factors and behavioral stereotype problems. If not corrected, any such problems are clearly identified.		
5. The document specifies its affect on the safety of other personnel or on equipment in adjacent areas.		
6. Errors in previous, similar processes were studied, and this document corrects such errors.		
Accuracy of the document		
1. The safety and ALARA limitations in this document are adequate for the task to be performed.		
Adequacy and accuracy of the supporting documentation		
1. All interfacing documents are listed in this document.		
Non-ALARA provisions		
1. This document avoids putting any component or system in a condition that could be non-ALARA.		
2. If the document does put any component or system in a condition that could be non-ALARA, it contains information from the operator on how this condition will be handled.		
3. The above information or instructions are included in the proper DOE or WHC basis document.		

Table C-1. As Low as Reasonably Achievable Review of
Procedures, Tests, or Documents.* (2 sheets)

Item reviewed	YES	NO
Requirements for communications and instrumentation		
1. An adequate communication system has been provided.		
2. Radiological or toxic hazards will be avoided even with a loss of communications.		
3. An adequate instrumentation/monitoring system has been installed to gather the necessary data or to warn personnel of impending hazards.		
4. Radiological or toxic hazards will be avoided even with a loss of the instrumentation/monitoring system.		
Environmental considerations (natural or induced)		
1. The induced environments (radioactive, explosive, or toxic atmospheres, etc.) have been addressed.		
2. Induced hazards can be avoided even if more than one procedure is performed by personnel within a given space (e.g., control room tag-outs).		
3. The possibility of releases to the environment (outside) has been addressed.		
4. The document contains information from the operator on how hazardous conditions will be handled.		

*NOTE: If a particular item or area is not applicable to the procedure/test/document being reviewed, mark it "N/A."

Instructions: After completion of this checklist, it shall be reviewed. All items indicated "No" shall be evaluated and the purpose or reason for not complying with the indicated method or required action shall be documented. Otherwise, appropriate changes shall be implemented to comply with the method or action. A copy of this checklist and supporting documentation shall be forwarded to the ALARA point of contact when completed. Attach to this checklist any additional considerations or information applicable to this review.

ALARA = As low as reasonably achievable
DOE = U.S. Department of Energy
WHC = Westinghouse Hanford Company

Figure C-1. As Low as Reasonably Achievable Management Worksheet.

ALARA MANAGEMENT WORKSHEET (AMW)										
RWP Number		Date		Page 1 of						
PART I PRE-JOB INFORMATION										
Work Package No. or Equivalent		Area/Facility/Location								
Job Title/Description:				<div style="text-align: center;">ALARA Review Class</div> <div style="text-align: center;">Check One</div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%; text-align: center;">1</td> <td style="width: 33%; text-align: center;">2</td> <td style="width: 33%;"></td> </tr> <tr> <td style="height: 20px;"></td> <td style="height: 20px;"></td> <td style="height: 20px;"></td> </tr> </table>	1	2				
1	2									
PART II ALARA REVIEW										
PART IIA ESTIMATED COLLECTIVE DOSE			PERSON/R							
PART IIB PROTECTIVE MEASURES			YES	NO						
			Reference/Explanation							
A.	Can any or all phases of the work be moved to an area with lower exposure levels?									
B.	Can the item or work area be decontaminated to reduce risk?									
C.	Can additional shielding be used to reduce dose rates?									
D.	Can time saving procedures, techniques, or mock ups be used?									
E.	Can Best Available Technology (BAT) alternatives be employed (i.e., special tools, ventilation systems, temporary containment structures, equipment)?									
F.	Can all hazards, conditional changes or variables that affect the work be planned for?									
G.	Can method for waste minimization, segregation, removal and/or disposal be planned for?									
H.	Can the number of personnel entering the work location be reduced?									
I.	Can existing material, tools, or equipment currently at the job location be used to complete the job (i.e., previously contaminated tools)?									
J.	Can alternate entry and egress routes be identified and planned for prior to initiating work?									
PART IIC ESTIMATED CORRECTED COLLECTIVE DOSE			PERSON/R							
PART III POST JOB REVIEW										
Is Post ALARA Review (PAR) required?				<div style="text-align: center;">Check One</div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%; text-align: center;">YES</td> <td style="width: 33%; text-align: center;">N</td> <td style="width: 33%;"></td> </tr> <tr> <td style="height: 20px;"></td> <td style="height: 20px;"></td> <td style="height: 20px;"></td> </tr> </table>	YES	N				
YES	N									
PART IV AMW REVIEW										
AMW Preparer			Date							
The PIC, Cognizant Engineer, or designee shall review the AMW and sign documenting the review in Part IV below. The completed AMW shall be forwarded to the locations/personnel listed in the distribution portion of this form as soon as possible.										
Person in Charge (PIC)			Date							
Cognizant Engineer			Date							
Other			Date							

DISTRIBUTION: Original - OH&S Central Files ALARA Program Office
Facility ALARA Team Chair Work Package

Figure C-2. Radiation Work Permit Request Form.

RWP REQUEST FORM (Type or Print)						
Requesting Org.:		☐ New ☐ Renewal		Previous RWP No.:		
Prepared By:				Date:		Phone:
Work Location Area:		Bldg:		Room:		Other:
Job Description: ☐ Cutting ☐ Grinding ☐ Welding ☐ Breaching Radioactive System						
Type of Work Station: ☐ Bench Top ☐ Fume Hood ☐ Hot Cell ☐ Glove Box ☐ Other (list)						
Primary Isotopes of Concern: ☐ MFP ☐ MAP ☐ Sr ☐ Cs ☐ H3 ☐ U ☐ Pu ☐ Other						
Work Package No.:				☐ Work Procedure/Instruction Attached		
Date RWP Required By:				Estimated Work Completion Date:		
Job Supervisor:		Organization:			Phone No.:	
ALARA WORK SCOPE						
Job Breakdown						
Component Tasks	Group	No. (A)	Hours (B) Estimate	(HP Use Only)		
				Dose Equiv. Rate (mrem/hr) (C) Estimate	Collective Dose Equiv. (person-mrem) (AxBxC) Estimate	
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
Total Estimated Collective Dose Equiv. (person-mrem)						
person-rem = person-mrem / 1000 =						
HP Use Only						
ALARA Review Class is: ☐ 1 ☐ 2 ☐ 3						
Request Received By:				Date:		
RWP Prepared By:				Date:		
Assigned RWP No.:						
Comments:						
ALARA Review Assigned To:						

Figure C-3. Pre-Job as Low as Reasonably Achievable Job Planning Checklist.

PREJOB ALARA REVIEW RECORD			
Job Description			
Work Package No.	RWP No.	Project Start Date	Estimated Completion Date
Topics for Discussion (check as discussed)		Additional Topics for Discussion (as applicable)	
1.	Scope of work to be performed	1.	ALARA, Time, Distance and Shielding a. b. c.
2.	Current radiological and hazardous conditions in the workplace		
3.	Protective clothing and dosimetry requirements/possible changes	2.	Entry and egress routes for the job location a. b. c.
4.	Entry and exit routes identified		
5.	All hazards, conditional changes, and variables that affect the work	3.	Low Dose Stand By Area (Cold Area) a. b. c.
6.	Occupational Health & Safety coverage requirements		
7.	RWP limitations (circumstances that would void the RWP)	4.	Other items, as applicable:
8.	Precautions or techniques used to reduce surface or airborne contamination levels		
9.	HP Hold Points/Signatures		
10.	Other safety related documentation applicable to the job (JSA, Hazardous Work Permit, MSDS, etc.)		
11.	Special tools, techniques, or equipment to be utilized		
12.	Specific task assignments of personnel involved in the job		
SIGNATURE/ATTENDANCE ROSTER			
PIC/Cognizant Engineer		Job Supervisor	
ALARA Point of Contact		Planner/Scheduler	
Support Personnel (list org. code/name/payroll no.)			
		If additional space for recording attendees is required, attach separate sheet.	
Briefing Chaired By		Date	

Figure C-4. Post-Job as Low as Reasonably Achievable Review Checklist.

Page 1 of 1

ALARA CHECKLIST

Project/Design Engineer Signature: _____ Date: _____

Work Package No.: _____

CRITERIA		REMARKS
I.	FACILITY DESIGN	
1.	Minimal contamination or hazardous waste production.	☐
2.	Designed for ease of contamination of hazardous waste control.	☐
3.	Surface coatings for ease of decontamination.	☐
4.	Designed to minimize exposure to uncontrolled areas.	☐
5.	Remote handling equipment provided.	☐
6.	Glove boxes required.	☐
7.	Solid and liquid waste systems designed for ease of operations.	☐
8.	Waste systems designed to minimize exposure to personnel and environment.	☐
9.	Sampling points in lowest practical exposure area.	☐
10.	Engineered controls for exposure and contamination controls.	☐
11.	Traffic patterns designed to minimize traffic through potentially contaminated areas or elevated exposure areas.	☐
II.	SYSTEM DESIGN	
1.	Equipment/instruments requiring routine maintenance calibration, servicing or inspection.	
	- Designed and located to minimize time of each task.	☐
	- Located in lowest practical radiation field.	☐
	- Movable to a low radiation field.	☐
	- Located away from hazardous substances and conditions.	☐
2.	Valves, piping, process equipment designed to minimize leakage.	☐
	- Designed to avoid "crud traps."	☐
	- Designed for contamination control during maintenance.	☐
	- Designed for internal decontamination before maintenance.	☐
3.	Ventilation System	
	- Filtered to remove airborne contaminants.	☐
	- Air balance designed to minimize spread of contamination.	☐
	- Designed for contamination control and exposure reduction during routine maintenance (i.e., HEPA replacement and test).	☐
4.	Fabrication materials selected for maximum radioresistance and low corrosivity.	☐

APPENDIX D

COST-BENEFIT ANALYSIS

CONTENTS

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D3.0	AI METHODOLOGY	D-4
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APPENDIX D

COST-BENEFIT ANALYSIS

A tool that the As Low as Reasonably Achievable (ALARA) Review Team can use to evaluate equipment and systems is an "ALARA cost-benefit analysis."

D1.0 BASIS

The ALARA concept is subjectively defined by: "as judged by the state of technology and the economics of improvements in relation to all the benefits from these improvements." This section describes and presents for use, a methodology developed for the U.S. Nuclear Regulatory Commission (in *Regulatory Guide 1.110*, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Reactors" [NRC 1976]) that can be used to obtain a quantitative evaluation of the management of occupational exposure. The methodology consists of the following two parts:

- Apparent reduction potential (ARP): a ranking method that can be used to set priorities for exposure reduction analysis and efforts
- Achievability index (AI): a cost-benefit analysis method that can be used to determine justification for exposure reduction projects/actions.

The ARP-AI methodology provides the means to concentrate exposure reduction efforts on those areas or projects which are most effective in reducing dose, establish whether exposures are indeed ALARA, and perform cost-benefit evaluations for radiation exposure reduction actions.

The purpose of this section is to provide the guidelines for quantitatively determining the effectiveness of ALARA design and operational features.

The basis for determining if exposure is ALARA is generally subjective and vague as indicated by the above definition. Furthermore, it is impossible to place a meaningful quantitative value on exposure to radiation, such as so many "dollar per person-rem" of exposure. Therefore, the quantitative justification of ALARA has to be based on a cost-benefit analysis which compares exposure savings to the costs of exposure reduction efforts without implying a monetary value for exposure to radiation. Such a method has been developed and is fully explained in *Regulatory Guide 1.110*, Appendix A, "Procedures for Performing Cost-Benefit Analysis."

D2.0 ARP METHODOLOGY

To separate the areas of operations and maintenance activities for which exposures are ALARA from those for which exposures may not be ALARA, a method of ranking areas according to their potential for exposure reduction was developed.

The two most influential factors in affecting potential for exposure reduction are exposure (rem) and dose rate (rem/hour). A low dose rate area, if frequently occupied, may involve a large total exposure usage. A high dose rate area may involve no exposure at all if no time is spent there. The exposure factor, then, plays a larger part in determining the potential for exposure reduction than does the dose rate term.

The ARP equation was developed such that the rankings provided fall in a reasonable range (0 to 100), approximately satisfying the following criteria:

- ARP <1.0
The area under consideration probably requires no further attention (i.e., exposure for this task is ALARA)
- ARP = 1.0
The area under consideration may require further attention (i.e., exposure for this task is probably ALARA)
- ARP >1.0
The area under consideration probably warrants further attention (i.e., exposure for this task may not be ALARA).

At least two of the three variables (exposure, dose rate, and occupancy) are required so that ARP calculations and ALARA assessments may be done.

Calculations may be done manually, but are most easily performed by a computer. The computer allows rapid recovery of information from within a large and expanding database, permitting quick assessment of ALARA criteria.

An ARP value by itself has no real significance. The purpose of the methodology is to provide a means of comparing various tasks to determine the tasks on which to concentrate exposure reduction efforts.

D3.0 AI METHODOLOGY

Once an exposure reduction analysis has been indicated as necessary (by the ARP value), and the analysis has identified the need for action to reduce exposure to ALARA, some method is required to determine exactly what costs (time, money, and exposure) are justifiable to reduce exposure by some specific amount. The AI methodology was developed to provide a method for this type of evaluation.

The AI method of cost-benefit analysis for exposure reduction actions was developed along the lines of a complex cost-benefit analysis. The ALARA problems are complex because the costs and/or benefits of exposure reduction actions are of differing types and/or units. The expression for the AI does not represent a mathematical identity but rather a relative expression for use in assessing the desirability of an action that affects exposure and monetary factors.

Costs, in exposure and/or money divided by benefits, in exposure and/or money, yielded the following expression for the AI, which is used to determine whether a particular action is justified:

$$AI = \left[\frac{k \cdot R \cdot G \cdot E_{ai} \cdot E_{ag} \cdot E_{qi} \cdot E_{qg}}{C \cdot L_a^2 \cdot L_q^2} \right]^B \cdot (P \cdot F_d)$$

The variables are defined as follows:

- B = +1 if exposure is decreased and cost is increased by the action (dimensionless)
- B = -1 if exposure is increased and cost is decreased by the action (dimensionless)
- k = a constant (dimensionless)
- R = net exposure difference
- G = annual salary and overhead (dollars) of individual employee(s) who will receive the exposure or whose exposure will be reduced
- C = net cost of action (dollars)
- P = planning and coordination factor
- F_d = dose rate factor
- E_{ai} = maximum annual individual exposure (rem)
- E_{ag} = average annual individual exposure (rem)
- E_{qi} = maximum quarterly individual exposure (rem)
- E_{qg} = average quarterly individual exposure (rem)
- L_a = annual exposure limit (rem)
- L_q = quarterly exposure limit (rem).

The AI value is compared to the stated "cost per person-rem saved" value to determine the exposure reduction actions to be taken.

D4.0 REFERENCES

NRC, 1976, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Reactors," *Regulatory Guide 1.110*, U.S. Nuclear Regulatory Commission, Washington, D.C.

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APPENDIX E

EXPOSURE REDUCTION ANALYSIS

CONTENTS

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E3.0	ALARA REVIEW APPLICATION	E-5

APPENDIX E

EXPOSURE REDUCTION ANALYSIS

The more regimented "exposure reduction analysis" methods, described in the following sections, are available to the As Low as Reasonably Achievable (ALARA) Review Team, if their use is determined to be warranted.

E1.0 INFORMATION

Radiation exposure reduction analysis is the study of work procedures, facilities, and equipment design to determine the radiation and contamination conditions that do or could exist, and the acts or actions of persons that could result in undue radiation exposure.

The purpose of radiation exposure reduction analysis is to ensure that occupational exposures are maintained ALARA. Included in the analysis are engineering designs and tests, operations and maintenance procedures, and radiation worker methods and techniques.

The fundamentals of designing for exposure control and reduction include the following:

- Provision and maintenance of optimum radiation working conditions
- Assurance that procedures and rules are applied
- Design of appropriate radiation protection engineering controls for the specific task to be done.

Radiation exposure reduction analysis provides information that is needed to perform the following activities.

- Eliminate radiation incident causes.
- Specify precautions, positive safeguards, shielding, equipment, devices, or conditions that should be provided and/or used.
- Establish the basis for sound operating or maintenance procedures.
- Develop training programs.
- Control and monitor personnel radiation exposure.

E2.0 METHODOLOGY

The initial step toward making an exposure reduction analysis is to gather and review currently known data relating to exposure usage for the tasks/projects concerned. Sources of information are as follows:

- Operational procedures detailing the tasks and radiation sources
- Historical files from other similar facilities providing a history of exposure usage by craft, task, and system. These reports will provide a history of person-hours required, special tools needed, problem areas, and recommendations for performing the task.

The first step in conducting a radiation exposure reduction analysis is to make a breakdown of the operation or job to determine the various elements to be considered. Most of this can be done through interviews, discussion, and review of the task/procedure. Items to be considered shall include the following.

- What. What is being or will be done is usually designated by a specific procedure. The extent of detail depends on the complexity of the work and possibilities of different radiation problems.
- How. This is the separation of the job into detailed steps or actions of people, equipment, or processes.
- When. The sequence or order in which various steps or actions are taken may be of utmost importance in exposure reduction or control.
- Where. The location of a person (e.g., behind shielding, in the next room, etc.) is of considerable importance in exposure reduction.
- Why. This question should be raised throughout exposure reduction analysis to determine if the movement or action is necessary and if it is done in a manner that will reduce personnel exposure and potential spreading of contamination.
- Who. The work group(s) involved should be identified.

In conducting an exposure reduction analysis, it is important that there be a recognition of process relationships that could affect the overall activity. Items to be considered include the following.

- Sequence. The sequence of various procedure steps in an operations or equipment maintenance task may be of specific concern in exposure reduction analysis. Determine the radiological consequences if one step fails or if one of the scheduled maintenance actions removes source material.

- Flow. The flow of materials should be considered to determine if the methods can create interference or radiation exposure problems which could increase the overall exposure usage. A good example of this point is the transfer of radioactive materials.
- Machine or manual tasks. It is important to know if the worker is going to be exposed directly to the source or if the task is done remotely. Determine if the worker must stand in one place or will be moving around.

E3.0 ALARA REVIEW APPLICATION

After the operation breakdown and process relationships have been reviewed, the following elements should be considered for potential exposure reduction.

- Individuals/groups. A study of the staffing and their skill levels.
- Operations. Systems or equipment operations can be studied to determine if exposure reduction practices used in one case can be applied to other situations.
- Processes. Exposure reduction can often be achieved through chemical or mechanical decontamination. Exposure reduction analysis can include evaluation of the benefits of chemical or mechanical cleaning of equipment or systems.
- Shielding. Permanent or temporary shielding of radiation sources may solve some problems. Shielding may be used in many forms, including iron, encapsulated lead, concrete bricks or blocks, lead blankets, water in basins and tanks, or water in containers such as drums or pipes. A significant reduction in exposure for a job may occur if shielding is provided, but the exposure required to install and remove the shielding may be more than is saved by the shielding. Thus, the exposure cost of using shielding should always be taken into account.
- Special tools and equipment. Special tooling or equipment may aid in exposure reduction. Remote equipment or long-handled tools that permit the worker to perform tasks at some distance from a radiation source may be desirable. In other cases, a remotely operated device may be used to permit the worker to perform work away from a radiation source. The use of special tools requires careful evaluation because the time required to perform a task using remote equipment or long-handled tools may be increased, resulting in little or no reduction in exposure.

Maintaining remote equipment also may require additional exposure.

• Radiation data. A knowledge of the location and intensity of radiation fields is required for an exposure reduction analysis. This knowledge may indicate that exposure reduction can be achieved by the following:

- Distance--increasing the distance between the source and the person

- Shielding--interposing a radiation-absorbing material between the source and the person

- Time--reducing the time personnel spend in radiation fields.