CONF-920468--

DE93 011222

Proceedings of the DEPARTMENT OF ENERGY ALARA WORKSHOP

Compiled by B.J. Dionne and J.W. Baum
Brookhaven National Laboratory

Held at
Brookhaven National Laboratory
Upton, Long Island, New York 11973
April 21-22, 1992

Work Performed Under Contract No. DE-AC02-76CH00016
B&R Code: HA-01-10-00-0

Prepared for
U.S. Department of Energy
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MASTER

ABSTRACT

The report contains summaries of papers, discussions, and operational exercises presented at the first Department of Energy ALARA Workshop held at Brookhaven National Laboratory, Upton, New York on April 21-22, 1992. The purpose of this workshop was to provide a forum for, and enhance communication among, ALARA personnel, as well as to inform DOE's field office and contractor personnel about the Office of Health's programs and expectations from the entire DOE complex efforts in the ALARA area.

The two-day workshop consisted of one day dedicated to presentations on implementing various elements of a formal ALARA program at the DOE contractors' facilities, regulatory aspects of ALARA programs, and DOE Headquarters' ALARA expectations/initiatives. The second day was devoted to detailed discussions on ALARA improvements and problems, and operational exercises on cost-benefit analyses and on ALARA job/experiment reviews.

At this workshop, 70 health physicists and radiation safety engineers from 5 DOE Headquarter Offices, 7 DOE operations/area offices, and 27 contractor facilities exchanged information, which is expected to stimulate further improvement in the DOE contractors' ALARA programs.

FOREWORD

Since its formation, the Office of Environment, Safety and Health's Office of Health has promoted the development and exchange of information related to As Low As Reasonably Achievable (ALARA) Program implementation within the Department of Energy (DOE). In support of this effort, the Office of Health has contracted with the Brookhaven National Laboratory (BNL) ALARA Center to assist the DOE radiation protection community in focusing attention and interest on ALARA issues; developing an understanding of underlying concepts; and sharing information and ideas on effective implementation. The DOE ALARA workshop, held April 21-22, 1992 at BNL and sponsored by the Office of Health, represents the first workshop dealing specifically with DOE ALARA implementation issues and concerns.

The workshop was targeted towards health and safety managers, health physicists, ALARA coordinators, and radiological engineers within the DOE community. The purpose was to improve communication among the DOE and DOE contractor personnel involved in the implementation and oversight of the operational ALARA programs, and to provide an opportunity for resolving technical issues and exchanging lessons learned related to ALARA program implementation. The agenda focused on the latest technical developments and operational practices in ALARA, including contamination reduction, radiological goal setting, ALARA training, and the regulatory aspects of operational ALARA programs. The attendees also participated in operational exercises to enhance their knowledge of methods used for reducing radiation dose to workers. This information exchange should stimulate further improvement in DOE contractor ALARA programs.

The general consensus of the 70 representatives from DOE and its contractor organizations was that the workshop provided for a worthwhile exchange of information. In light of the international pressure to reduce radiation dose limits for workers, this type of exchange should continue.

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DEPARTMENT OF ENERGY (DOE) EXPECTATIONS AND INITIATIVES RELATED TO ALARA

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Washington, D.C. 20585

ABSTRACT

The DOE Office of Health (EH-40) has several initiatives related to the development of policy and guidance for occupational ALARA programs. These initiatives include 1) the responsibility for DOE Order 5480.11, which establishes basic ALARA requirements, 2) the 10 CFR 835 rulemaking initiative, which will codify 5480.11 requirements, and 3) the development of the draft Implementation Guide IG 5.XX, Occupational ALARA Program, which provides specific guidance related to the basic, required elements of an occupational ALARA Program.

In January 1992, the Secretary of Energy directed the Assistant Secretary of Environment, Safety, and Health to prepare and issue a DOE Radiological Control Manual (RCM). On April 13, 1992, the draft RCM was distributed for DOE-wide review and comment. While the concept of ALARA is reflected throughout the RCM, the draft manual contains several requirements specific to ALARA Program organization and implementation. This paper gives an overview of those requirements.

INTRODUCTION

The Office of Health (EH-40) of the Office of Environment, Safety and Health (EH) has responsibility for promulgating and maintaining DOE policy and guidance related to occupational radiation protection, including the ALARA Program. Current occupational ALARA requirements are identified in DOE 5480.11, "Radiation Protection for Occupational Workers," effective date January 1, 1989. EH-40 recently revised DOE 5480.11 requirements for incorporation into the proposed rule 10 CFR 835, which was published in the Federal Register for public comment on December 9, 1991. In support of this rulemaking initiative, EH-40 has planned to develop a series of Implementation Guides (IGs), which would provide detailed guidance on implementation of the requirements of 10 CFR 835. The first five of these draft IGs were published for review in December 1991, and included IG 5.XX, "Occupational ALARA Program."

A further effort in EH policy development with significant implications in the ALARA area was recently started in response to a Secretarial directive. On January 16, 1992, in response to continuing radiological incidents throughout the DOE complex, the Secretary of Energy directed the Assistant Secretary for Environment, Safety, and Health (EH-1) to prepare and issue a comprehensive and definitive DOE Radiological Control Manual (RCM), with the objective of ensuring that radiological protection programs within the DOE are "...consistent with respect to standards and requirements." The Secretary's memorandum also directed EH-1 to establish a Task Force, consisting of representatives from various DOE Program Offices, to assist in this effort. The Secretary's directive established milestones of June 1, 1992 for completing the RCM, and December 1, 1992 for its implementation by the DOE complex.

DEVELOPMENT OF THE RADIOLOGICAL CONTROL MANUAL

The RCM Task Force, chaired by EH-1, includes representatives from the following Headquarters Offices:

- Office of Environment, Safety, and Health
- Office of Defense Programs
- Office of Nuclear Energy

- Office of Energy Research
- Office of Environmental Restoration and Waste Management
- Office of Nuclear Safety
- Office of the General Counsel

The RCM Task Force established an Editorial Board, consisting of various DOE and contractor personnel, to oversee the development of the RCM. The initial draft of the RCM, dated April 10, 1992, was distributed for DOE wide review on April 13, 1992. The following discussion of RCM requirements relate to the April 10, 1992 draft version; it should be noted that the RCM requirements may change based on subsequent revisions.

IMPLEMENTATION OF THE RADIOLOGICAL CONTROL MANUAL

The Secretary's January 16, 1992 directive stated that the DOE RCM would be used as a basis for developing contractor site-specific Radiological Control Manuals. It is intended that the DOE RCM be adopted by the contractors with little or no need for modification. Development and approval of the site-specific Radiological Control Manual by the contractor is anticipated to satisfy the requirements for a Radiation Protection Program Plan, as specified in the proposed 10 CFR 835.

ALARA REQUIREMENTS OF THE RADIOLOGICAL CONTROL MANUAL

The RCM is a broad-scope document directed towards DOE and contractor line management. The ALARA concept is reflected throughout the provisions of the RCM; however, the RCM identifies various specific requirements which traditionally fall into the area of ALARA Program implementation. These requirements are given below.

Organization and Management

The draft RCM contains the following provisions related to the organization and management of ALARA Program implementation.

- Requires the establishment at each contractor site of an ALARA Committee, with members from line management, technical support, and Radiological Control organizations. The RCM recommends that a line manager acts as chair of the committee.

- Requires the use of radiological goals to motivate and monitor improvements. Specific indicators to be tracked include:

    1. Collective exposure
    2. Number of contaminations of skin and clothing
    3. Number of uptakes of radioactive material
    4. Square footage of contaminated areas in the facility
    5. Cubic feet of solid radioactive waste generated.

- Requires the use of Administrative Control Levels to control exposures of workers. These levels are to be based on:

    1. Annual dose (level to be established from historical and projected exposures; 500 mrem recommended with upper limit of 1500 mrem)
    2. Lifetime dose (not to exceed N rem, where N is the worker's age in years).

Facility Design

The draft RCM contains the following provisions for the design and review of new facilities, or significant modifications to existing facilities:

- Establishes the following radiological design criteria:

  1. Worker dose maintained <500 mrem/year and ALARA
  2. Discharge of radioactive liquid to the environment should approach zero
  3. Control of contamination by containment at the source.

- Requires radiological review of designs for new facilities and for significant modifications to existing facilities.

Conduct and Control of Work

The draft RCM contains the following provisions related to the planning and control of radiological work activities:

- Requires the use of a Radiological Work Permit (RWP) system to control radiological work.

- Requires review of planned work to identify radiological requirements, such as engineering controls and techniques for dose and contamination reduction. This radiological review may be of two types:

  1. For routine tasks, the review and documentation of requirements may be conducted as part of the RWP process
  2. For nonroutine or complex work exceeding preestablished action levels, a formal radiological or ALARA review is required.

- Requires ALARA Committee review and approval of the following:

  1. Tasks exceeding preestablished individual or collective dose criteria
  2. First time or infrequently conducted radiological activities.

- Requires, at a minimum, pre-job briefings for the following activities:

  1. Work in Very High Radiation Areas
  2. Work in High Surface Contamination Areas
  3. Breach of contaminated systems
  4. Work with potential to generate airborne contamination in excess of 0.1 DAC
  5. Work where personnel exposures could approach an Administrative Control Level.

- Recommends that the Radiological Control Organization and line management periodically monitor collective dose accumulation for ongoing jobs, and compare this to pre-job estimates. Differences should be reviewed to identify the causes, need for intervention and implementation of corrective actions.

- Requires post-job reviews for significant or nonroutine radiological work.

Training

The draft RCM contains the following requirements and provisions related to ALARA training. These requirements are in addition to the basic general employee and radiological worker training requirements.

- Requires line managers (DOE and contractors) who manage, supervise, or oversee radiological control programs to receive specific training in the role and use of the ALARA concept, and the administrative control level and radiological performance indicator systems.

- Requires technical support personnel (including engineers, schedulers, planners, and procedure writers) to be trained in the principles of ALARA and basic techniques of dose reduction.

- Requires consideration of the use of mock-ups and performance of dry runs for significant radiological work.

Records

The draft RCM requires the maintenance of the following records typically associated with the ALARA Program:

- RWPs

- Radiological surveys

- Dosimetry records and associated collective dose data

- ALARA plans, goals, and minutes of the committee meetings

- Radiological performance indicator trends.

SUMMARY

The DOE RCM gives detailed and comprehensive provisions for the conduct of a Radiological Control program, and, once implemented, will significantly improve the overall consistency and quality of radiological controls within the DOE. The RCM places significant emphasis on the ALARA concept, and puts the responsibility for maintaining worker doses ALARA where it belongs - namely, on the worker and the worker's line management.

THE ORGANIZATION OF AN ALARA PROGRAM AT A DOE FACILITY

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ABSTRACT

The organization of an ALARA Program at a DOE Facility (Oak Ridge National Laboratory), its relevance to laboratory management, facility operators, and the radiation protection program are described. The function of chartered ALARA committees at two levels also is discussed.

INTRODUCTION

Much has been written about the organization of an ALARA Program since the term became popular some time ago. While the ALARA Programs instituted at nuclear power plants have been studied a great deal, little has been said about the programs that have been developed at DOE sites around the country. DOE Order 5480.11 mandates the use of the ALARA principle and refers to the PNL document "Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are As Low As Reasonably Achievable (ALARA)" (PNL-6577)[1] as a guide to establish such a program.

Before going farther, the following facts are noted.

1. The DOE facilities are not nuclear power plants. The power plants have one product (electrical power) and are governed by the profit motive, while the DOE facilities are multi-faceted and have many different goals and objectives.

2. The DOE facilities are not all alike, but are really broken down into two categories: production and research. Even among facilities that belong to the same category, there are considerable differences. The research going on at Los Alamos, for instance, is considerably different from that going on at Brookhaven. The same is true for the production plants.

3. While all of the DOE facilities are owned by the U.S. Government and administered by the Department of Energy, a lot of the similarity of administration ends there. The different field offices of the DOE sometimes act as independent entities, and their interpretation of regulations may differ: this is not altogether unreasonable because their problems and goals are quite different.

4. The DOE facilities are operated for the DOE by several different contractors under a GOCO arrangement (Government Owned Contractor Operated) and the organizations of these contractors differ, not only one from another, but within their own corporations. For example, Martin Marietta Energy Systems, Inc., operates five DOE facilities for the DOE, and recently, Martin Marietta Corporation (the parent company) won a contract to operate the Pinellas Plant. However, the Pinellas Plant will be operated by a different company, Martin Marietta Specialty Components, Inc., and will not be a part of Energy Systems. This type of organization is not uncommon throughout the DOE system. Furthermore, some DOE facilities are operated by Universities, or groups of Universities, and, by necessity, the philosophies of operation will be different.

Thus, it can be readily seen that there will be no single right way to organize anything, much less an ALARA program, but this paper will describe the steps taken to implement such a program at Oak Ridge National Laboratory.

MANAGEMENT INVOLVEMENT

To be effective, an ALARA program must have the support and involvement of the facility management. The extent of involvement, and how high in the management hierarchy this involvement extends is the main question.

Everyone must admit that our top facility management has many concerns in addition to ALARA. Management expects us to take ALARA as our prime responsibility, but it is one of many to them. However, there is one thing that must come from top management: the Charter, i.e. a commitment.

The establishment of a viable ALARA program begins with a charter that must be issued by top management giving responsibility and authority to the ALARA Program Manager and the various standing committees that help to implement the program. Examples of the ORNL charters are shown in the appendix.

ALARA STAFFING

At ORNL, the ALARA Program is a very small one and is split into two areas: Reactor Programs and Non-Reactor Programs. While the philosophy of ALARA may be the same at all facilities, the differences between the work at the various organizations within ORNL had to be taken into account.

ALARA COMMITTEES

To involve top management in the operation of the ALARA program, an ALARA Steering Committee was chartered and established. This Committee consists of the heads of the principal divisions doing radiological work at the Laboratory. The Committee is headed by a senior management official, not the ALARA Program Manager. The Committee meets once a quarter, at which time the ALARA Program Manager reports on tracking/trending, exposure control, radiation/contamination incidents, and the status of ALARA goals. The Steering Committee has the authority to set Laboratory-wide ALARA goals and to set action items for the ALARA program.

Because the ALARA Steering Committee is comprised of Division Directors, it stands to reason that they will not be able to devote large blocks of time to the program. Therefore, the Laboratory established the ALARA Working Committee. Each member of the ALARA Steering Committee was requested to nominate a counterpart from the division as a member of the Working Committee. This nominee was to be someone that the ALARA Program Manager could call on to "cut through the red tape" of their division to get to the heart of any problem that came up. This committee meets monthly and is chaired by the ALARA Program Manager. The duties of the Working Committee include the day-to-day problems of the divisions and the drafting of ALARA goals to submit to the ALARA Steering Committee. The relationship between management and the ALARA committees is shown in the appendix.

Furthermore, the operating company, Martin Marietta Energy Systems, Inc., has organized an ALARA Steering Committee at the Company level, with representatives from each of the five sites operated by the Company and chaired by the Company vice-president for Environmental Safety and Health. Each site is represented by the ALARA Program Manager from that site.

PROGRAM INDEPENDENCE

The PNL-6577 document mentions several ways in which an ALARA program might interface with the rest of the Radiation Protection program. One of these was a large Radiation Protection Program with a small, independent ALARA program. This method was used to establish the ALARA program at ORNL. The ALARA Program Manager answered directly to top management in the Environmental Safety and Health area.

Another method mentioned in PNL-6577 was a small ALARA program included inside a much larger Radiation Protection Program. Due to a reorganization of the Laboratory's Environmental, Safety, and Health program in August of last year, this is the current situation, which has presented some problems as to the independence of the ALARA program. The ALARA program should be in a position to offer constructive criticism, not only to the operating divisions of the Laboratory, but to the Radiation Protection program as well. The ability to offer such criticism depends upon the Radiation Protection program manager and his/her attitude toward the ALARA program. So far, there is no real problem at the managerial level, but there is some resentment in the field by field technicians and others because an outside group is looking at ALARA. While there should not be an "us vs. them" attitude between the groups, this attitude exists in some areas.

PROCEDURES

Rather than add to the burdensome number of discipline manuals already in place (e.g. Industrial Hygiene Manual, Environmental Protection Manual, Safety Manual) it was decided not to have a "stand alone" ALARA Manual, but instead, to have a section of the ORNL Health Physics Procedure Manual dedicated to the ALARA Program. This has been extremely helpful in integrating the program with the overall Radiation Protection Program at ORNL.

CONCLUSION

The involvement of top management, the formal charter of the ALARA program, and the establishment of an independent ALARA group with ALARA committees at the working and steering level have proved effective at ORNL.

REFERENCES

1. L.H. Munson, W.N. Herrington, D.P. Higby, R.L. Kathren, S.E. Merwin, G.A. Stoetzel, and E.J. Vallario, Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are as Low as Reasonably Achievable (ALARA), Pacific Northwest Laboratory, Richland, Washington, PNL-6577, June 1988.

APPENDIX

Charters of Responsibility, Accountability, and Authority for ALARA Program Elements.

The following are the Charters of Responsibility, Accountability, and Authority for the ORNL ALARA Program Manager, ORNL ALARA Steering Committee, and ORNL ALARA Working Committee. They are provided to illustrate how such charters might be worded. Also included is an organization chart showing how the committees interact with management.

CHARTER OF RESPONSIBILITY, ACCOUNTABILITY, AND AUTHORITY

Manager, ALARA Program
Office of Environmental and Health Protection
Environmental, Safety, and Health Compliance, Oak Ridge National Laboratory

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The Manager of the ORNL ALARA Program is assigned the following responsibilities, accountabilities, and authority. In carrying out these functions, the manager is accountable to the Director, Office of Radiation Protection.

(1) Actively promote ALARA practices in all operations being conducted at the Laboratory which involve the presence of radiation and/or contamination, general industrial health hazards, and environmental control requirements.

(2) Serve as Chairman of the ORNL ALARA Working Committee.

APPROVED: J A Setaro
J. A. Setaro

Functional Statement:
Manager
ORNL ALARA Program

Date Issued: 1/23/92

H M Butler Jr.
H. M. Butler
Acting Director
Office of Radiation Protection

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(3) Analyze personnel and environmental monitoring data provided by the Radiation Monitoring, Industrial Hygiene, and Environmental Monitoring Sections for trends which may indicate either good or poor employee/environmental protection practices.

(4) Develop action items for the ORNL ALARA Steering Committee and schedule meetings for the Committee to resolve them.

(5) Assist the ALARA Steering Committee and the Laboratory Director's Review Committees in their responsibility for:

   a. Approving ALARA goals for new facilities and/or operations.
   b. Reviewing facilities and operations that have recently become operational to determine if they are successfully meeting ALARA goals established in their design.
   c. Reviewing personnel exposure and environmental discharge experience related to facilities, ongoing operations, and experiments for specific attention within the ALARA Program.
   d. Recommending appropriate changes to procedures or to the ALARA Program.

(6) Review the content of ALARA training that is being presented to ORNL employees and making suggestions for improvement where needed. Ensure that ALARA training meets the requirements of US DOE as outlined in PNL-6577, Martin Marietta Energy Systems Good Management Practices and Policy Procedure ESH-7.

(7) Conduct audits of ALARA activities in the ORNL Divisions and Programs.

(8) Serve a liaison role between the ALARA Steering Committee, the Office of Radiation Protection, the Office of Operational Readiness and Facility Safety, and the divisions at the Laboratory conducting operations involving the presence of radiation and/or contamination hazards.

CHARTER OF RESPONSIBILITY, ACCOUNTABILITY, AND AUTHORITY

ORNL ALARA Steering Committee

The ORNL ALARA Steering Committee is assigned the responsibility, accountability, and authority for fostering the development of a comprehensive As Low As Reasonably Achievable (ALARA) Program for the Oak Ridge National Laboratory (ORNL) based upon utilization of the operational resources within the Laboratory. The Chairmanship of the Committee is assigned to the ORNL Associate Director of Environmental Safety and Health Compliance, who is accountable to the Environmental Safety & Health Committee chaired by the Deputy Laboratory Director.

APPROVED: J. H. Swanks
J. H. Swanks

Functional Statement:
Associate Director
Environmental Safety and Health Compliance
Chairman, ORNL ALARA Steering Committee

Date Issued: 1/23/92

A. W. Trivelpiece 1/13/92
A. W. Trivelpiece, Director
Oak Ridge National Laboratory

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Membership on the Committee consists of the following:

1. ORNL Associate Director of Environmental Safety and Health Compliance, Chairman
2. ORNL Director of Environmental Safety and Health Compliance
3. ORNL Engineering Site Manager
4 ORNL Plant and Equipment Division Director
5. ORNL Office of Radiation Protection Director
6. ORNL Analytical Chemistry Division Director
7. ORNL Chemical Technology Division Director
8. ORNL Research Reactors Division Director
9. ORNL Office of Operational Readiness and Facility Safety Director
10. ORNL Metals and Ceramics Division Director
11. ORNL ALARA Program Manager

The ALARA Steering Committee has been commissioned by the ORNL Laboratory Director to provide formal upper management involvement in the implementation of ALARA principles at Oak Ridge National Laboratory. This Committee has the authority and responsibility to audit the ALARA Program and to recommend changes as necessary.

The ALARA Steering Committee meets quarterly, or as needed for special topics, to consider the following subjects:

1. ALARA Program Progress Reports
2. ALARA Topical Reports and Issues
3. Major Facility Construction and Modifications
4. ALARA Suggestions
5. ALARA Goals
6. ALARA Awards

CHARTER OF RESPONSIBILITY, ACCOUNTABILITY, AND AUTHORITY

ORNL ALARA Working Committee

The ORNL ALARA Working Committee is assigned the responsibility accountability and authority for fostering the implementation of a comprehensive As Low As Reasonably Achievable (ALARA) Program for the Oak Ridge National Laboratory (ORNL). The Chairmanship of the Committee is assigned to the ORNL ALARA Program Manager. The Committee is accountable to the Director of Environmental Safety and Health Compliance, who is the Chairman of the ALARA Steering Committee.

APPROVED: J. A. Setaro
J. A. Setaro

Functional Statement:
Manager, ORNL ALARA Program
Chairman, ORNL ALARA Working Committee

Date Issued: 1/23/92

J. H. Swanks
J. H. Swanks
Associate Director, Environmental Safety and Health Compliance
Chairman, ORNL ALARA Steering Committee

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The Committee consists of representatives from the following Divisions/Programs/Offices:

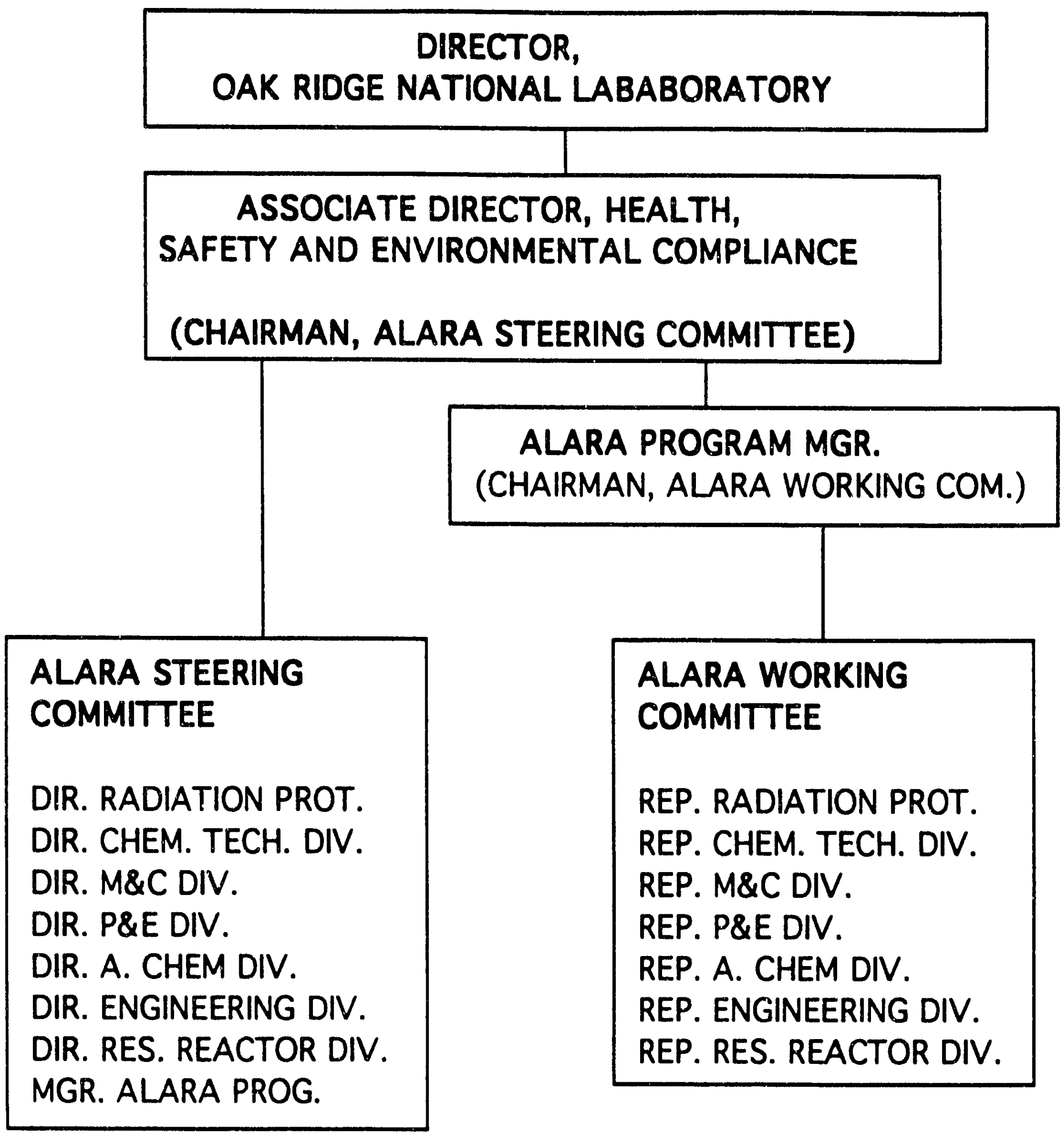
1. ORNL ALARA Program Manager, Chairman
2. ORNL Engineering
3. ORNL Plant and Equipment Division
4. ORNL Office of Radiation Protection
5. ORNL Analytical Chemistry Division
6. ORNL Chemical Technology Division
7. ORNL Research Reactors Division
8. ORNL Office of Operational Readiness and Facility Safety
9. ORNL Metals and Ceramics Division

The ORNL ALARA Working Committee has been commissioned by the Chairman of the ALARA Steering Committee to provide working level input to the ORNL ALARA Program, the Steering Committee and Laboratory divisions. Each member of the ALARA Steering Committee nominates a counterpart to serve on the ALARA Working Committee. These nominees are approved by the Associate Director of Environmental Safety and Health Compliance.

The ORNL ALARA Working Committee meets monthly, or as needed for special topics, to consider the following subjects:

1. Major Facility Construction and Modifications
2. Radiation Exposure Trends and Analysis
3. Environmental Concerns and Upgrades
4. Industrial Hygiene Concerns
5. ALARA Suggestions
6. Problem Areas

ORNL ALARA PROGRAM



DOSE CONTROL LEVELS AND RADIOLOGICAL GOALS: SAVANNAH RIVER SITE

L. S. Smith
Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29802

ABSTRACT

This presentation gives an overview of two selected ALARA practices implemented at the Savannah River Site (SRS): Administrative Exposure Limits and Goal Setting. These dose control methods are used to ensure that individual and collective occupational doses are within regulatory limits and ALARA.

INTRODUCTION

The Westinghouse Savannah River Company (WSRC) operates the SRS for the DOE. The charter of the Site is to produce special nuclear materials for use in the weapons programs for the nation's defense. On the approximate 300 square miles of land, there are 10 divisions, departments, and facilities with more than 16,000 trained radiation workers. Over 700 health protection personnel are assigned to various radiological control duties implementing a single Radiological Control Program of which the ALARA program is an integral part.

The ALARA program is described in the WSRC 5Q Manual, Health Protection (HP) Procedure Q1-1 Manual and the SRS ALARA Guide (U). Two parts of the program related to dose control, Administrative Exposure Limits and Goal Setting, are discussed here.

ADMINISTRATIVE EXPOSURE LIMITS

The SRS is operated under a conservative assumption that all radiation, no matter how little, has some associated risk. Stringent radiation exposure and contamination controls have been imposed to maintain exposures ALARA. An administrative dose control system, which consists of Administrative Exposure Limits and Exposure Reference Levels, is implemented sitewide at the SRS. The intent of this system is to gain management control over planned and actual doses within the bounds of DOE limits. Administrative limits and reference levels are used as guides and are not considered to be desirable dose levels to be achieved.

Table 1 shows the Administrative Exposure Limits for the site. Facility management and line management have established more restrictive limits for their operations. Approval from line management and HP management is required for deviating from an administrative limit.

The second level of control, Exposure Reference Levels, are designed to start reviews of existing exposure conditions at levels well below administrative exposure limits. Reference levels provide a margin of safety and are applicable for both external and internal exposure.

- Six hundred mrem per month to the whole body (WB) from penetrating radiation exposure is the whole body Reference Level. The facility manager and HP manager shall be notified immediately whenever a result from an individual external dosimeter exceeds 300 mrem in a month.

- Three thousand mrad per month to the skin of the whole body from beta and gamma radiation is the skin Exposure Reference Level.

Table 1. SRS Annual Administrative Exposure Limit (rem)

	ADMINISTRATIVE EXPOSURE LIMIT	FEDERAL EXPOSURE LIMIT
OCCUPATIONAL WORKER		
Whole Body (Effective)	2	5
Maximum Individual Exposure ALARA Goal	0.10 - 1.650	
PLANNED SPECIAL EXPOSURE (non-emergency)		
Unusual Situations	<5	10
Highly Unusual Situations	<10	
SITE EMERGENCY		
Saving Life	<100	10 - 25
Recovery of Deceased	<10	
Protection of Health and Property	10 - 25	

Administrative limits are consistent with recent recommendations in the International Commission on Radiological Protection, Publication 60 (ICRP60)[1], applicable to the whole body and pregnant worker exposures.

- People with a concentration of tritium between 20 and 40 microcuries per liter of urine are removed from further exposure to tritium until concentrations in urine samples fall below 10 microcuries/liter.
- People with a concentration of tritium greater than 40 microcuries per liter of urine are removed from all radiation work until the concentration falls below 10 microcuries/liter.
- For airborne contamination, radiological controls should be maintained until airborne concentrations are less than 0.02 DAC for all radionuclides.

Planned exposure in excess of exposure reference levels, but less than administrative exposure limits are reviewed and approved by both line management and HP management. Unplanned exposures in excess of reference levels are investigated by line management and HP management to assess and correct abnormal conditions.

Managers, supervisors, and radiation workers are responsible for maintaining individual and collective exposures as low as reasonably achievable. Supervisors are responsible for planning the work, distributing exposure as evenly as possible to all members of the group who perform similar jobs the entire year.

From the start of SRS in 1953, management has stressed the importance of minimizing radiation exposure to the workforce. The administrative exposure limit at that time for whole body radiation was at 3 rem, a dose 80 per cent lower than the 15 rem per year federal limit. The 1.650 rem accepted by the majority of facilities for 1992 is lower than the current 5 rem per year federal limit. As DOE limits and recommendations have been modified and as the ability to detect contamination has been improved, Administrative Exposure Limits and Reference Exposure Levels have decreased.

GOAL SETTING

ALARA Goals for 1992

The Savannah River Site established ALARA goals for 1992 for cumulative and maximum individual exposure, personnel contamination cases, and assimilations of radionuclides in excess of recommended criteria. Additionally, three reduction goals were established to demonstrate a decrease in the Site's overall radiological hazard. These reduction goals are for the size of airborne activity and contamination areas and the number of contamination events occurring outside of radiologically controlled area(s).

Discussion

Goal setting is a unique section of the formalized ALARA Program in the Savannah River Site ALARA Guide. Goals at the Site are established at the facility and work group level because of the overall size of the Site, the operational diversity and, most importantly, to convey a sense of personal ownership in achieving the goal. Reviewing goals at the facility or work group level establishes accountability and ensures that ALARA must be considered in all facets of work.

Goals are motivators for improvement. The purpose of a goal is not simply to meet a numerical value, but also, to improve and monitor health protection performance. Goals are challenging, yet clear, achievable, and based on standards of excellence.

ALARA Organization

An organization was established with each facility or major work group assigning an individual to be an ALARA Coordinator, as shown in Figure 1. The Coordinator is responsible for providing technical support and assistance in implementating' ALARA principles, which includes coordinating the goals, developing and tracking. The ALARA Coordinators represent disciplines of construction, operations, engineering, and health protection.

The ALARA Coordinators are a part of the ALARA Steering Committee (ASC). The Steering Committee centralizes ALARA responsibilities at the SRS. The Committee is a forum that is responsible for providing guidance and oversight of ALARA issues, including goal setting. Coordination and cooperation within the ASC are essential to ensure continued program support. Goals of individual facility and work groups are reviewed, evaluated, and collated through the ASC for upper level management approval, which includes the Manager of Health Protection, the Vice-President of Engineering, and the WSRC President.

Methodology

The development of goals for an upcoming year has required facilities to review operational work experience and exposure database records, in addition to anticipated production and maintenance schedules. Historic data, exposure estimates, and contamination levels per work task have been extensively used. The Radiation Work Permit (RWP) program and associated pre-job and post-job ALARA reviews were included recently. The key to accurately predicting exposure goals rests with the ability to assess the type and amount of work that is to be performed during the year. Once this information is developed and the exposure numbers are quantified, the amount of exposure that is saved through implementing ALARA principles is subtracted; this is the exposure estimate. Once the estimate of exposure is determined, the realistic goal for achievement is taken to be 20 to 30 percent less than the estimate.

The work is categorized either as a Base Routine Operations (normal facility/work group functions which result in incidental radiation exposure) or Special Work Operations (short- and long-term projects which may have the potential to result in significant radiation exposure). The following information is requested:

- Estimate the total exposure for each activity using historic exposure data.
- Estimate the percentage of exposure received in four month cycles: January-April, May-August, September-December.
- Determine all work groups involved for each activity.
- Estimate the percentage of exposure to be received by each work group involved in each activity.
- Estimate the total exposure received by the facility or work group.

After the facilities develop an activity plan, all work groups involved establish goals. Work groups which have responsibilities in one or more facilities must coordinate their goals based on these activity plans. Each work group must participate in the initial facility goal setting process to improve the accuracy of the original estimates. The ALARA Coordinators must take an active role in determining whether or not the activity plans provide the information that is needed to develop accurate goals.

With respect to contamination cases, specific actions are identified that reduce skin and personal effects contamination, and a realistic goal based on operational experience is developed. Establishing contamination cases goals is a combination of past performance and the activities which will take place in each facility. The activity plans are used by the facility and work group to estimate the number of contamination cases per facility. The type of activities scheduled to take place (i.e., decontamination and decommissioning) dictates if the possibility for contamination cases exists. The work groups will take the facility estimates and develop their individual goals. Past performance and lessons learned should be factored into the contamination cases goals. The ALARA Coordinators are responsible for coordinating the development of contamination case goals for their facilities and work groups.

The ASC recommends goals for the number of internal assimilations of radionuclides and the maximum individual radiation exposure. The maximum individual exposure goal is based on previous established goals, past performance, and current standards, orders or Site guidelines. Because an objective of the radiation protection program is to limit all intakes of radionuclides, especially those that result in a committed dose of 100 mrem or greater over one year, a goal for confirmed assimilations of radionuclides of zero is strongly recommended. All of the above goals need to be challenging but not overly. restrictive for facility functions. Goal setting is an interactive and dynamic process, as shown in Figure 2.

Each ALARA Coordinator collates the radiation and contamination case goals by the facility and work groups from the required work sheet documentation. The ASC Chairperson coordinates a review of the goals. If during this review the projected goal is unacceptable, the Chairperson requests that the ALARA Coordinators return to the facilities and that work groups reconsider the proposed goals. Once acceptable recommendations have been completed, the Chairperson presents the recommendations for radiation exposure, contamination cases, maximum individual exposure, and internal assimilations to the Radiological Quality Improvement Review Committee (RQIRC). The RQIRC, as the second level review and approval, may identify a potential for goal reductions and finally request the ASC to revise the goals. A recommendation is made to the WSRC Policy Review Committee, as the third level review and approval only when the RQIRC is satisfied.

Tracking of Goals

Facilities and work groups document their activity plans using the Radiation Exposure Worksheet. Once complete, the worksheets are retained as working records. The document tracks the actual exposure, thus assisting in reviewing the performance in achieving the goal.

During the year, typically in May and September, there are scheduled, periodic reviews of radiation exposure goals. Radiation exposure goals are compared to the actual pro-rated exposure performance. Exposure goals are permitted to be increased or decreased as required, if there is proper supporting documentation. The job schedule for the remaining part of the year also is reviewed. This review is to accommodate incomplete and delayed jobs, as well as those not anticipated when the original goal was established.

When the facilities and work groups have completed the review of the radiation exposure goals, any revisions to the established goals are recommended and approved using the methodology described here. The contamination case, maximum individual exposure, and assimilation goals are generally not revised during these reviews.

Performance Indicators

The Health Protection Department generates monthly performance indicator reports during the year. A part of this report is dedicated to the status of goals.

Managers and supervisors have the opportunity to monitor exposure versus work performed. This monthly report is collated on a year-to-date basis. The trending of radiation exposures is a method used to quantify the success or failure of the ALARA program, which applies both at the Site level and facility level.

The goals established have provided a baseline to view performance. Annual goals have been pro-rated monthly with a variance of $\pm$ 10 per cent. There is prominence to ALARA and to realistic goal setting. The philosophy is that poor planning is apparent when the actual exposures are significantly over or significantly under the goal.

Since 1983, the Health Protection Department has issued an Annual Radiation Exposure Report. This report contains the specific year's goals and the actual exposures broken down by various areas. Trending of past years' exposure is included for comparison, as well as the collective dose for major radiological jobs and associated ALARA initiatives that were implemented.

SUMMARY

The ALARA program implemented at the SRS is comprehensive. The dose control system and the goal setting process are only two elements of this program. Reducing radiation exposures to workers, visitors and the general public as far below federal exposure limits as practical is a major influence in design and operations of the SRS facilities. The protection from potential risks associated with exposure to radiation is a primary concern that is more important than production, quality, or costs.

REFERENCES

1. International Commission on Radiological Protection, "1990 Recommendations of the Internal Commission on Radiological Protection" (Adopted November 1990), Pergamon Press, Oxford.

Figure 1 **GOAL SETTING ORGANIZATION**

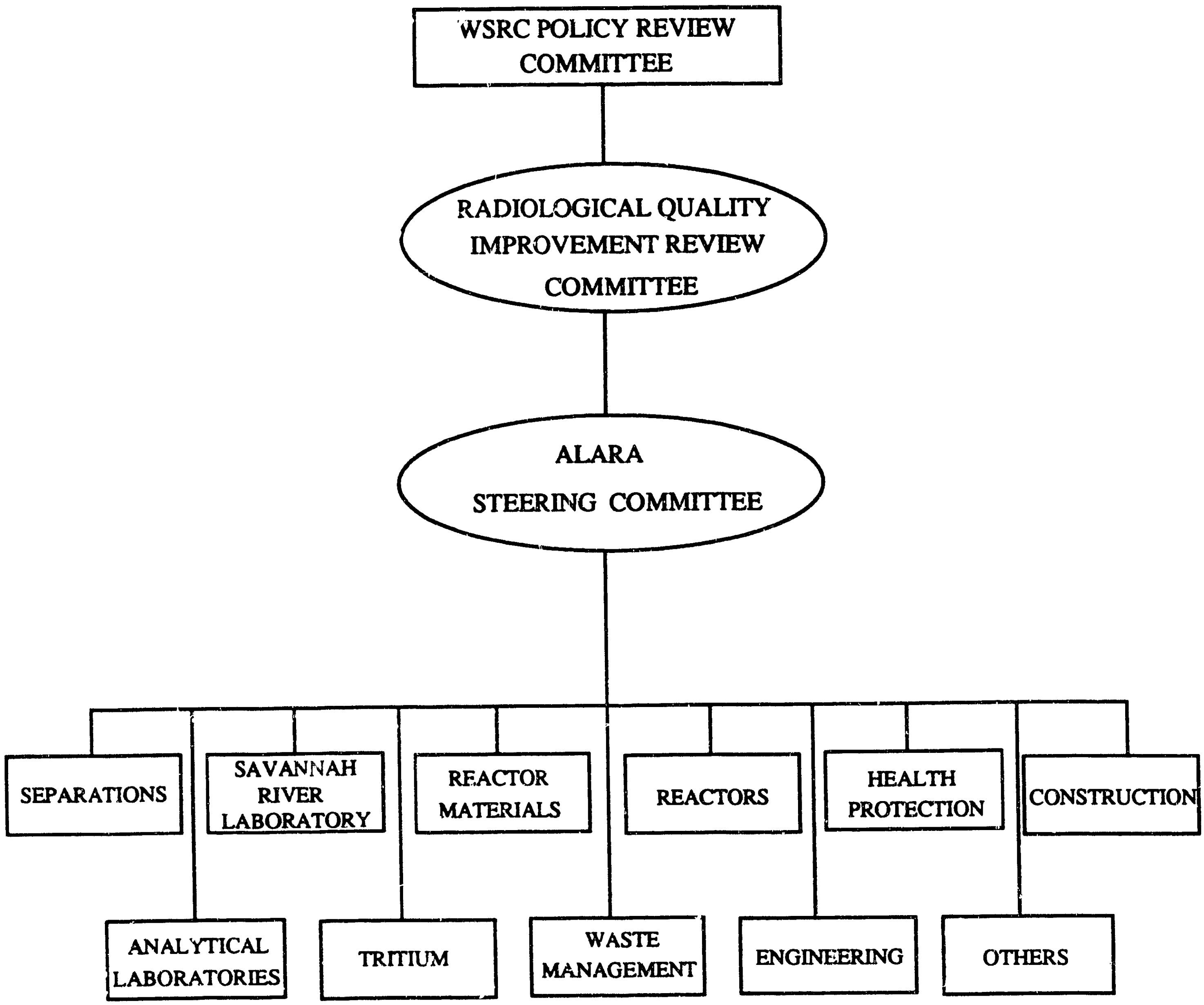
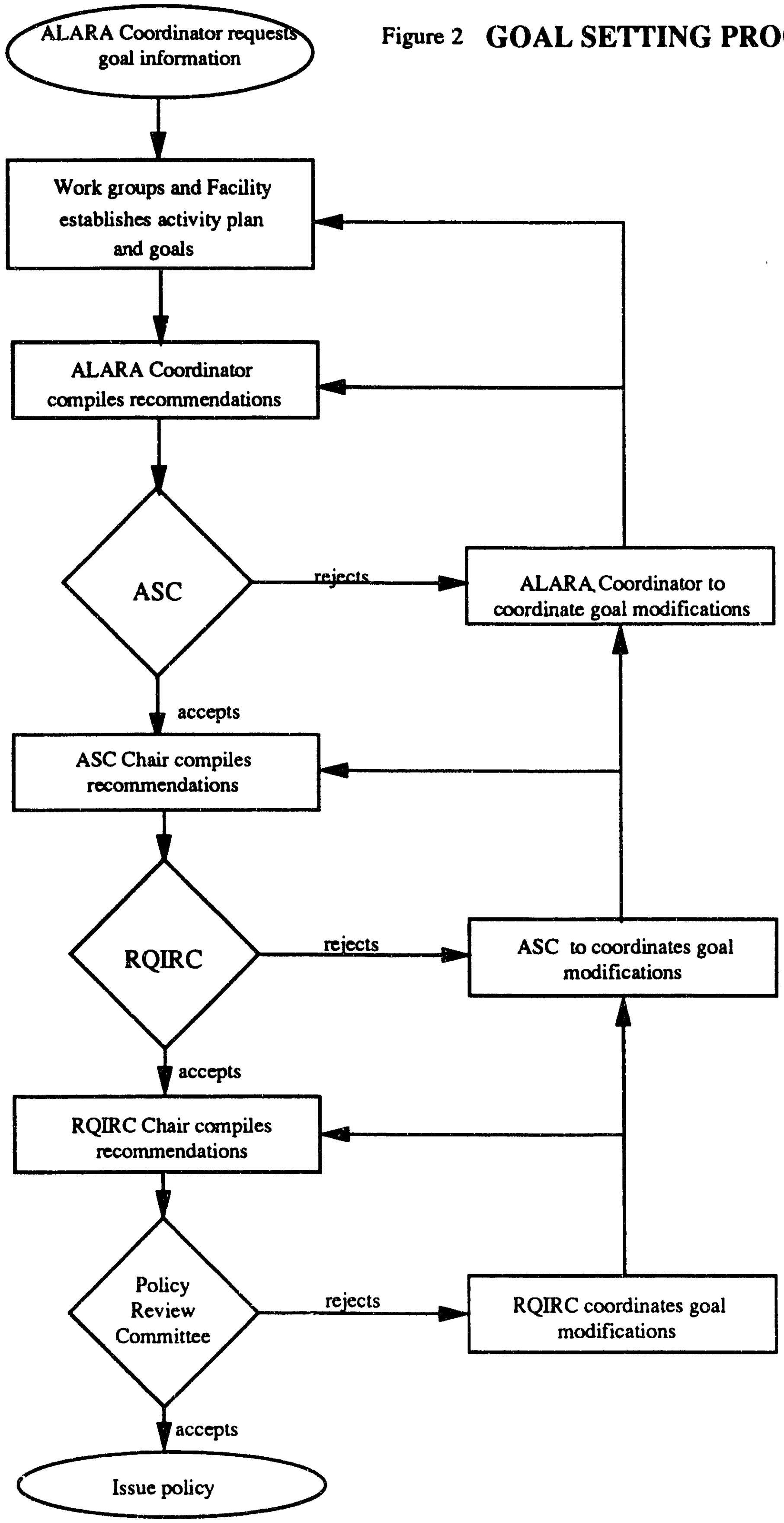


Figure 2 **GOAL SETTING PROCESS**



ALARA PROGRAM APPRAISALS: SAVANNAH RIVER SITE

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ABSTRACT

ALARA Program audits are recommended in PNL-6577,[1] "Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are As Low As Reasonably Achievable (ALARA)." The Department of Energy (DOE) Order 5480.11,[2] "Radiation Protection For Occupational Workers," requires contractors to conduct internal audits of all functional elements of the radiological protection program, which includes the ALARA program, as often as necessary, but at a minimum of every three years. At the Savannah River Site (SRS), these audits are performed as part of the Health Protection Internal Appraisal Program. This program was established to review the site radiological protection program, which includes the ALARA program, on an ongoing basis and to recommend improvements directly to senior Health Protection management. This paper provides an overview of the SRS Health Protection Internal Appraisal Program. In addition, examples of specific performance criteria and detailed appraisal guidelines used for ALARA appraisals are provided.

INTRODUCTION

The SRS Health Protection (HP) Department developed a formal internal appraisal program in 1989 to monitor the effectiveness of the radiological protection program at SRS facilities and to ensure compliance with applicable procedures and regulatory requirements. The internal appraisal staff periodically evaluates all major functional elements of the radiological protection program, including the site ALARA program. The appraisal program is designed to meet the requirements of DOE Order 5480.11, "Radiation Protection For Occupational Workers." The HP Internal Appraisal Program is conducted to meet the requirements set forth in DOE Order 5482.1B,[3] "Environment, Safety, and Health Appraisal Program."

DESCRIPTION OF THE APPRAISAL PROGRAM

The HP Internal Appraisal Program is administered by the Program Assessment and Support Services Section of the HP Department. The appraisal staff are experienced health protection professionals with applied HP experience in both commercial nuclear power and DOE nuclear facility operations. The HP Internal Appraisal Program consists of routine appraisals and special appraisals.

Description of the Routine Appraisals

Routine appraisals are used to evaluate the performance aspects of all functional elements of the radiological protection program at various SRS facilities. Each major functional element is assessed against specific performance criteria using detailed appraisal guides to ensure thorough and consistent appraisals. In addition, HP policies, procedures, organization, administration, staffing, training, communication, and program documentation are reviewed. The appraisals are conducted to ensure that all major functional elements of the radiological protection program are reviewed at least every three years. To ensure independence and objectivity, the appraisals are conducted by people who are not directly responsible for performance of the activities being appraised. To facilitate the preparation and conduct of the routine appraisals, the radiological protection program was separated into 12 major functional elements (Table 1).

Table 1. Major Functional Elements of the Radiological Protection Program

- Contamination Control
- External Exposure Control (ALARA)
- Respiratory Protection
- Internal Dose Assessment
- External Dosimetry
- Radiological Surveys and Surveillance
- Radioactive Waste Management
- Instrument Calibration and Control
- Health Protection Training and Qualification
- Effluent Monitoring
- Industrial Hygiene Surveys
- Organization and Administration

The overall ALARA program is reviewed during appraisals of the functional element for External Exposure Control. In addition, ALARA philosophy and concepts are examined during appraisals of other functional elements of the radiological protection program, e.g., Contamination Control, Respiratory Protection, and Radioactive Waste Management, because the effectiveness of these functional elements affect the overall effectiveness of the site ALARA program. The performance criteria and appraisal guide used to evaluate the SRS ALARA program are given in Appendices A and B, respectively. The ALARA appraisal guide provides detailed instructions for performing the appraisal and includes references and specific lines of inquiry.

A schedule for routine appraisals is normally developed by the appraisal staff at the beginning of each calendar year. The same major functional area is appraised at all SRS facilities concurrently to enable the appraisers to compare programs and procedures among the various facilities. Findings, responses, and commitments are tracked using the HP Commitment Tracking System.

<u>Description of the Special Appraisals</u>

Special appraisals are performed, as needed, to review unusual incidents or when directed by management to review particular aspects of a program. During infrequent operations and/or maintenance activities which may involve significant radiological hazards, special appraisals may be performed to evaluate the adequacy of ALARA activities related to the job. Special appraisals also may be performed before new facilities are started or before existing facilities are restarted.

Periodic facility walk-through inspections are another type of special appraisal. Periodically, appraisers make unannounced plant tours to inspect facility conditions and to observe work related to radiological protection, including ALARA practices. The purpose of the periodic facility inspections (walk-through inspections) is to provide HP managers with a quick general appraisal of conditions in their facilities. These inspections may be performed anytime deemed appropriate by the appraisal staff, or as directed by management. Walk-through inspections are not intended to be an in-depth look at radiological conditions, but to point out obvious discrepancies.

Appraisal criteria and assessment guides are not used for special appraisals, and formal findings and recommendations are not made. Deficiencies are identified as observations and are not entered into the HP Commitment Tracking System, unless deemed appropriate by HP management. The facility management implement corrective actions at their discretion.

Appraisal Methodology

Routine appraisals are performed in accordance with the annual schedule. The appraisals are usually conducted by a single person, but in some cases an appraisal team is used. When a team is used, one member of the team serves as the team leader to direct the appraisal and is responsible for overall coordination in preparing the appraisal report.

Before the appraisal, the appraiser reviews all applicable procedures, regulations, and standards pertaining to the major functional element being evaluated. During this review, deficiencies in procedures are identified. Approximately two weeks before starting a routine appraisal, the appraiser verbally contacts the HP section manager to set up an entrance meeting. HP personnel and line management representatives are requested to attend the entrance meeting, as well as division/department ALARA Coordinators for ALARA appraisals. During the entrance meeting, the scope of the appraisal is discussed and a tentative agenda is agreed upon to ensure that personnel are available to meet with the appraiser with minimum disruption of work. Effective coordination and cooperation from the line organization are essential for a successful appraisal.

All pertinent facts pertaining to program strengths, potential findings and observations are documented. Program strengths and weaknesses are easily identified by observing various radiological protection work practices. Observation also is an excellent way to determine if effective ALARA practices are implemented. An observation is simply what the appraiser saw while touring the facility or watching a particular activity. Findings are either positive or negative conclusions the appraiser makes based upon observations. The appraiser provides periodic verbal briefings to facility managers to inform them of the appraisal progress, including potential findings. This allows the manager the opportunity to provide additional information which may affect the appraiser's decision on a potential finding. Program strengths are mentioned in the appraisal report as a positive finding only if a particular aspect of the program is noted to clearly exceed acceptable standards. Negative findings are made for inefficient or ineffective work practices as well as for violations of procedures or regulations.

An exit meeting is held with the HP and line management representatives to discuss the results of the appraisal. All findings, observations, and recommendations are discussed. The exit meeting serves as a forum to ensure that any concerns related to the content of the appraisal findings or recommendations are identified and resolved.

Routine appraisal findings are assigned severity categories and causal factors to make trending easier and to aid in identifying programmatic deficiencies. The severity categories and causal factors are listed in the appraisal report to help managers determine priority and apparent cause of deficiencies to ensure that corrective action can be taken. As mentioned previously, observations from special walk-through inspections are normally not assigned severity categories or causal factors and are not tracked or trended.

The causal factors used at SRS are identical to those used by DOE Tiger Teams. Appendix C lists all causal factors. Table 2 presents the definition of the five severity categories used.

Appraisal Documentation

Appraisals are documented in a summary report within 20 working days upon completion of the appraisal (exit meeting). Appraisal reports are reviewed and approved by the Appraisal Group Leader and forwarded to the HP section manager with copies to other HP and line organization managers, as appropriate. A written response to all findings is required within 30 working days of receipt of the report. If the responsibility for corrective action lies with other line operating organizations, the HP section manager coordinates the response with line management to ensure that corrective action is planned and implemented. The status of all appraisal findings and recommendations are maintained on the computerized HP Commitment Tracking System.

Table 2. Severity Categories For Appraisal Findings

Category 1 Health & Safety

Significant potential for personnel injury.

Category 2 Radiation & Contamination

Significant potential for radiation exposure above administrative limits, internal assimilation, or the spread of contamination outside the RCA.

Category 3 Compliance

Violation of DOE Orders, prescribed policies or referenced standards, or WSRC policy or procedures.

Category 4 Level of Performance

Performance does not comply with DOE recommended standards, industry good practices or INPO Guidelines. Concern may be based on professional judgment in pursuit of excellence.

Category 5 Observation

Practice or condition noted by the appraiser that may need management attention but is less severe or not covered by any of the above categories.

SUMMARY

The effectiveness of a site or facility ALARA program is significantly improved through the use of audits. ALARA program audits are effectively incorporated into a routine HP internal appraisal program. SRS has found this integrated approach to be very effective. In addition to the specific appraisal of the ALARA functional element, it also is appropriate to review ALARA philosophy and concepts as they relate to the other functional elements of the radiological protection program. This review is important because the effectiveness of these program elements affect the overall effectiveness of the ALARA program.

A successful internal audit program helps to ensure that the fundamental goals of the ALARA program are met and that responsible personnel are made aware of areas in which the ALARA program might be strengthened. At SRS, ALARA program audits have enhanced our ability to maintain radiation doses ALARA.

REFERENCES

1. PNL-6577, Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are As Low As Reasonably Achievable (ALARA), June 1988.
2. DOE Order 5480.11, Radiation Protection For Occupational Workers, July 20, 1989.
3. DOE Order 5482.1B, Environment, Safety, and Health Appraisal Program, September 23, 1986.

APPENDIX A

CRITERIA FOR EXTERNAL EXPOSURE CONTROL (ALARA)

PERFORMANCE OBJECTIVE

External radiation exposure controls should minimize personnel radiation exposure.

CRITERIA

1. Major aspects of the external exposure control program (i.e. radiation work permits, (RWPs), ALARA, exposure tracking, administrative controls) are described in approved procedures.

2. Radiation Work Permits (RWPs) or similar administrative controls are used to control personnel exposures in work areas where radiation hazards are present.

3. Accurate and timely radiological survey information is used when determining radiological protection requirements for RWPs.

4. RWPs correctly reflect the job and radiological conditions in the work area.

5. Routine or "Standing RWPs" are used for recurring jobs that are routine and have minimal or predictable radiological hazards (i.e. inspection, surveillance, and valve operation).

6. Radiological protection requirements listed on RWPs are adequate to protect workers from all expected radiological hazards.

7. Radiological Controlled Areas, Radiation Areas, High Radiation Areas, Very High Radiation Areas, and "Hot Spots" are clearly defined and properly posted to warn personnel of radiation hazards.

8. Proper controls are used to minimize beta exposure to the skin and eyes.

9. Administrative controls used to control and limit personnel radiation exposure are effective.

10. Workers adhere to prescribed radiological protection requirements and procedures.

11. Radiation sources (X-ray equipment and gamma sources) used in radiography operations are operated in accordance with Ebasco Services Incorporated (ESI) approved procedures.

12. Exposure reduction techniques are used, when feasible, to maintain personnel exposure ALARA.

13. An ALARA Coordinator or other staff has been designated with specific ALARA responsibilities. These responsibilities are documented and integrated into the radiation protection program.

14. ALARA reviews are routinely performed for jobs with significant exposure potential before issuing Radiation Work Permits.

15. Jobs are reviewed in the conceptual and early planning stages to identify specific job-related exposure reduction techniques.

CRITERIA FOR EXTERNAL EXPOSURE CONTROL (ALARA)

16. Personnel traffic is routed through lower exposure rate areas; waiting, staging, and office areas are established in low background areas.

17. Collective radiation exposure goals and action plans are established that are measurable and realistic.

18. Exposure trends are monitored and actual exposures are compared to established ALARA goals.

19. Adequate staff and resources are available to effectively implement the exposure control program.

APPENDIX B

APPRAISAL GUIDE: EXTERNAL EXPOSURE CONTROL (ALARA)

DOE Orders:

1. DOE 5480.11, Radiation Protection for Occupational Workers.
2. DOE 5482.1B, Environmental Safety & Health Appraisal Program.
3. DOE 5483.1A, Occupational Safety & Health Program For DOE Contractor Employees at Government-Owned Contractor-Operated Facilities.
4. DOE 6430.1, General Design Criteria.

SRS Documents:

1. WSRC 5Q, Radiological Controls Manual.
2. WSRC 5Q1.1, SRS Radiation & Contamination Control Procedures.
3. WSRC 5Q1.2, Procedure 480, Survey and Audit of Radiography Operations at SRS.
4. WSRC 5Q1.2, Procedure 481, Survey & Audit of X-Ray Producing Equipment.
5. WSRC 5Q1.3, Radiation Survey Instruments.
6. WSRC-IM-90-140, SRS ALARA Guide.

Reference Documents:

1. PNL-6577, Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are As Low As Reasonably Achievable (ALARA).

ASSESSMENT TECHNIQUES:

A. Review applicable facility procedures before the appraisal.

   1. Are there any technical or typographical errors?
   2. Are procedures current?
   3. Are procedures clear and easy to understand?
   4. Are major aspects of the program covered in written procedures?
   5. Do RWP procedures and job plans address the need for ALARA action before start of job?

B. Review RWPs and radiological survey information.

1. Are routine RWPs (standing RWPs) used?

a. Is the scope of allowed work excessive?
b. Have adequate radiological surveys been performed in the work areas?
c. How were the protection requirements established? Are they adequate?
d. Are dose rate instruments required for entry into High Radiation Areas?

2. Review non-routine RWPs.

a. Is the scope of work clearly defined?
b. Have current radiological conditions in the work area been determined?
c. Are protection requirements adequate?
d. Is continuous or periodic Health Protection coverage required? Is this coverage sufficient?
e. Are high exposure jobs in progress? Has an ALARA review been performed?
f. Are man-hour and man-rem estimates made? Who makes these estimates?

3. Are RWPs and associated records maintained in accordance with facility procedures?

C. Review administrative exposure control methods.

1. How is access to the RCA controlled?

a. Are entry and exit times recorded? How and by whom?
b. Are dosimeter readings "in" and "out" recorded? How and by whom?
c. Is the method of access control effective?

2. How are pocket dosimeters issued and controlled? Is this method effective?
3. How are daily exposure limits or guidelines determined and/or maintained?
4. May Administrative Dose Limits be extended? If so, is this practice minimized?
5. Are exposure control procedures being followed?

D. Review radiation exposure records.

1. Have any workers exceeded the Site Monthly Exposure Reference Level (600 mrem)?
2. Have any workers exceeded the Site Annual Administrative Limit (2 rem)?
3. Have any workers exceeded the Site Annual Goal (1.65 rem)?
4. Have any workers exceeded the DOE Annual Limit (5 rem)?
5. Are exposure records maintained in accordance with Site procedures?
6. Is there an effective method for tracking Employee Radiation Exposure Cards for accountability?

E. Tour facility to observe zone postings, jobs in progress, exposure control methods, and compliance with radiological protection procedures.

1. Are areas zoned correctly?

a. Are signs and labels the proper size, shape, and color?
b. Are entrances to Radiologically Controlled Areas clearly defined?
c. Are radioactive material storage areas properly posted?
d. Spot check area dose rates via survey measurement. Are these areas posted correctly?
e. Are Hot Spots clearly identified?
f. Do signs at High Radiation Areas indicate that a dose rate instrument is required for entry?
g. Are "Very High Radiation Areas" (> 5 rem/hr) locked or access controlled in accordance with DOE Orders?

2. Is personnel exposure being minimized?

a. Are workers waiting or loitering in radiation areas?
b. Are efforts taken to shield Hot Spots or flush the piping to lower the dose rate?
c. Are containers of radioactive material or waste stored in readily accessible locations that contribute needlessly to personnel exposure?
d. Does each container of radioactive material have a durable, clearly visible label identifying the material with enough information to permit personnel to take precautions to minimize exposure?
e. Are all radioactive waste containers properly labeled?
f. Are radiation levels posted on cabinets, samples, glove boxes, when needed?

3. Review jobs in progress.

a. Do jobs have an RWP or work plan?
b. Does the scope of work on the RWP match the scope of the work actually in progress?
c. Are workers in compliance with the RWP requirements?
d. Are the protection requirements adequate?
e. Are Health Protection personnel present if continuous coverage is required?
f. What exposure reduction methods are being used? Has an ALARA evaluation been performed?
g. If working in a High Radiation Area, do the workers have a dose rate instrument?
h. Is extremity dosimetry needed?
i. Has an extremity dosimetry study been made in the facility? If so, is there a record of the study on file?

F. Review tritium sampling and monitoring techniques.

1. Are hood monitoring valves identified?
2. Is the work area papered and clearly delineated?
3. Are workers wearing plastic suits that are most impermeable to tritium?
4. Have process lines been purged or baked out before line break?
5. Are receptacles on hand to catch or absorb water and/or oil during line breaks?
6. Is there a back-up operator on hand while work is in progress?
7. Is the back-up operator qualified to cut personnel out of plastic suits?
8. Is there a spare plastic suit available for the back-up operator?
9. Is there an HP inspector at the job site and also at the monitor panel continuously, and are they maintaining radio contact?

G. Review sub-contractor methods of using X-ray and gamma cameras for radiography operations.

1. Are all X-ray and gamma source handlers certified in their job? If not, are they working under the supervision of a certified radiographer? Does the certified radiographer have certification papers at the job site?
2. Is the work area properly roped and posted with warning signs?
3. Are personnel beyond the wall of the work area aware of radiography operations in the adjacent area?
4. Has a radiation survey been made on all sides of the work area while X-ray and gamma sources are in use?
5. Does the radiographer leave the control key in the X-ray machine after making an exposure?
6. Is the gamma camera locked and placed in a locked box after completion of operation?
7. Are permanent X-ray facilities audited quarterly for operable interlock, shutters, alarms, and lights? Is the radiation dose rate to the operator at 30 cm from the machine < 1 mR/hr?
8. Are checks made for leaks in facility shielding, including doors? Are signs posted outside a facility where the maximum dose rate is > 1 mR/hr? Is an annual audit of the facility made for DOE?

H. Review administration of the ALARA program.

1. Discuss the ALARA program with the HP Facility Manager.

a. Is a record of monthly dose to facility workers disseminated to supervisors?
b. Is there a mechanism to communicate dose information down to the workers?
c. Are personnel with highest dose rotated to jobs with lower exposure rates?

2. Does the facility have an ALARA Coordinator designated for specific ALARA responsibilities?

   a. Is ALARA action documented?
   b. Do job plans, procedures, or RWPs list ALARA action to be completed before start of job?

3. Are the following items considered in the ALARA review process, and applied when appropriate to minimize radiation exposure?

   a. Is portable or permanently installed shielding used?
   b. Are special or extended tools and manipulators used?
   c. Have process lines been flushed and monitored to determine effectiveness of flush?
   d. Have tritium lines been baked out?
   e. Has a pre-plan meeting been held with all workers assigned to the job and briefed on work procedures and special radiological considerations?
   f. Has specialized training and mock-up equipment been used for jobs of high dose potential?
   g. Is the minimum number of personnel being used to perform the job successfully with the least exposure?
   h. Are routes to and from the job, waiting, staging, and office areas in the lowest background areas?

4. Are collective radiation exposure goals and action plans measurable and realistic?

   a. Are radiation exposure goals presented to workers as an obtainable challenge?
   b. Are goals and status publicized to facility workers?
   c. Are goals monitored monthly, and actual exposures compared to the ALARA goals?
   d. Is a report issued to facility work groups periodically showing how prorated goals compare with actual performance?

I. <u>Review staffing and resources.</u>

1. Are there sufficient personnel and resources to perform all functions of the exposure control program?
2. Is training of HP inspectors and first-line supervisors adequate to fully implement the ALARA program?

APPENDIX C

CAUSAL FACTORS

Policy	Ineffective, outdated, or nonexistent policies contributed to the finding.
Policy Implementation	Written policies reflecting federal, state, and local laws and regulations, codes, and standards are not appropriately disseminated, implemented, and updated.
Procedures	Written procedures were not prepared to effectively implement Site policy, DOE Orders, and federal, state, and local laws and regulations. A lack of familiarity or availability of the procedures may have contributed to the finding.
Personnel	Lack of educational and/or work experience for personnel holding responsible positions or the level of personnel knowledge about the technical and safety aspects of their jobs contributed to the finding.
Resources	The number of personnel assigned to the job was inappropriate, or inadequate facilities and equipment contributed to the finding.
Training	Inadequate personnel training on implementing site policy, DOE Orders, and applicable Federal, state, and local laws and regulations was a contributing factor to the finding.
Change	Changes in site mission, function, operation, and established requirements, which rendered existing policies or procedures inadequate or inappropriate were contributing factors to the finding. Timeliness and effectiveness of changes to Site and DOE policy, and the implementing procedures, may have been a contributing factor to the finding.
Risk	Site personnel responsible for a situation contributing to a finding have not assessed and/or were not aware of the relative degree of risk involved in the action.
Safety	Inadequacies in the Site safety program contributed to the finding, or an inappropriate level of importance has been given to the safety aspects of the operation(s) being evaluated.
Appraisals, Audits/Reviews	Ineffective or insufficient appraisals, audits, and reviews, and/or inadequate follow-up, contributed to the finding.
Design	Inadequate design of a system contributed to the finding.
Human Factors	Human factors, such as fatigue or deliberate circumvention of a safety system, contributed to the finding
Quality Assurance/Control	Inadequacies in the quality assurance/control program contributed to the finding.
Barriers & Controls	Inadequacies in established barriers and controls, both administrative and physical, including operational readiness, routine inspections, and preventive maintenance, and/or a lack of these controls contributed to the finding.
Supervision	Ineffective supervisory controls for implementing policies, directives, procedures, standards, and laws contributed to the finding.

ALARA PROGRAM MANUAL: EG&G ROCKY FLATS

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ABSTRACT

In 1990, EG&G Rocky Flats committed itself to revising and upgrading its facility ALARA Program. The initial process required developing documents to provide direction for addressing and implementing the upgraded ALARA Program. Specific program procedures were written, ALARA committee charters were developed, and a ALARA Program Manual was produced.

The EG&G Rocky Flats ALARA Program Manual has been developed using DOE Orders 5480.11 and 5400.5, as well as PNL-6577, "Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are As Low As Reasonably Achievable (ALARA)" as guidance. In addition, a variety of ALARA programs and associated documents in use in the nuclear industry were reviewed and used. The draft reports and studies that were provided by BNL on ALARA Programs, and Good Practices Documents, also were used to identify the requirements and elements for a comprehensive ALARA program.

INTRODUCTION

EG&G Management is committed to achieving excellence in radiological safety. This commitment has been demonstrated in the support and attention EG&G's upper management has given the Rocky Flats ALARA Program. This support is expressed by upgrading and intensifying the program, and by Management's approval of the ALARA Program Manual.

The ALARA Program Manual provides direction, guidance, and outlines responsibilities when addressing ALARA issues at Rocky Flats. This Manual provides the basic standards, and is not intended to define the specific details of the program. Departmental procedures together with this Manual, will contain the specific ALARA methods, practices, and individual duties required to conduct an operational program.

METHOD

In September 1990, the following documents and programs were reviewed in identifying the requirements of an ALARA Program at a DOE facility. The documents provided requirements, guidance, and structure for an ALARA Program.

- DOE Order 5480.11, Radiation Protection for the Occupational Workers
- DOE Order 5400.5, Radiation Protection of the Public and the Environment
- PNL-6577, Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are As Low As Reasonably Achievable (ALARA)
- NUREG/CR-3254, "Licensee Programs for Maintaining Occupational Exposures to Radiation As Low As is Reasonably Achievable"
- NUREG/CP-0066, "Proceedings of an International Workshop on Historical Dose Experience and Dose Reduction (ALARA) at Nuclear Power Plants"
- INPO Good Practices, RP-601, INPO 86-011, Use of Goals in Reducing Radiation Exposure
- INPO Good Practices, 82-001-DEN-08A, ALARA Planning for Station Work
- 10 CFR 20

- INPO Good Practices
- Regulatory Guides 8.8 & 8.10
- Limerick Nuclear Generating Stations ALARA Program
- Northeast Utilities ALARA Program
- Brookhaven National Laboratory (BNL) Draft Study of ALARA Programs at DOE Facilities

ALARA Program Elements

After reviewing these documents and programs, three categories were developed to organize the various ALARA program elements. These elements form the foundation for the program and identify the requirements to support the overall program.

Those categories and elements are:

- Administrative Features

  1. Management Commitment
  2. ALARA Oversight Committee
  3. ALARA Action Committee
  4. Training
  5. Audits

- Quantitative Features

  1. Optimization
  2. Cost/Benefit Analysis
  3. Administrative Dose Control Levels
  4. Administrative Contamination Control Levels
  5. ALARA Goals
  6. Dose Tracking
  7. ALARA Progress Reports

- Conduct of Operations

  1. ALARA Planning
  2. Formal ALARA Review
  3. ALARA Job/Experiment Review
  4. ALARA Design Review
  5. ALARA Suggestion Program
  6. Dose Reduction Methods

A category description was written to support each of these program elements for the ALARA Program Manual. Each category also gives an explanation of the program element, and its purpose in supporting the ALARA Program.

ALARA Program Responsibilities

Individuals who have responsibilities in supporting the ALARA Program are identified. The responsibilities that were assigned are specific for EG&G's Rocky Flats management structure:

- General Manager
- Management

- Operations Managers
- ALARA Program Coordinator
- Health & Safety (H&S) Area Manager
- Radiological Building Engineer
- Radiological Engineering Manager
- Radiological Operations
- Design Engineers, Planners, and Schedulers
- Performance-Based Training
- Radiation Workers

Responsibilities should be clearly defined and established to implement an effective ALARA Program. The effective application of the ALARA philosophy by workers requires the support and coordination of numerous functional groups. The responsibilities of the various personnel involved in the ALARA Program are well defined and documented in the Manual.

The ALARA Program Elements and Responsibilities Sections are the most important parts of the ALARA Program Manual. They contain most of the information needed to implement and address ALARA issues and concepts at Rocky Flats.

Section Requirements/References

Identified with each program element and responsibility section are the requirements and references used to support that section. The requirements and references identify the sources of the information on program requirements (i.e. DOE Orders) and site-specific documents that provide guidance (i.e. departmental procedures). These requirements and references used with the section describing each element will contain the details of specific methods, considerations, and individual duties to conduct the operational ALARA Program.

Identifying the requirements and references independently, and not including them in the manual, allows the ALARA Manual to address specific ALARA elements and concepts. This particular format allows for easy reference to ALARA requirements and guidelines; furthermore, it keeps the document thin, easy to read, and allows the text to stay current. An example of the format used in the manual is included.

Additional ALARA Program Manual Sections

In addition to the Program Elements and Responsibilities Sections, there are sections for the Scope, Application, Definitions, and Bibliography.

The Scope requires that all operations are conducted so that radiation exposures to employees, contractors, and the public and environment are ALARA.

The Application of the ALARA Program Manual applies to all site employees, contractors, and subcontractors.

The Definitions section defines the terminology that is used in the manual.

The Bibliography section identifies the references used in developing the ALARA Program Manual.

3.3 Conduct of Operation

3.3.1 ALARA Planning

A high level of radiological awareness among workers at Rocky Flats provides the basic foundation of the ALARA Program; however, good planning is the key to achieving aggressive goals. For this reason Rocky Flats requires thorough planning of all tasks which involve receiving radiation dose. Prior work planning promotes efficiency and results in both dollar and dose savings. Every manager and supervisor shall be held accountable for sufficient and effective planning of all tasks under their responsibility.[15]

[15]REQUIREMENTS/REFERENCES

DOE 5400.5, "Radiation Protection of the Public and the Environment," 2/8/90.
DOE 5480.11, "Radiation Protection for Occupational Workers," 12/21/88.
DOE 5481.19, "Conduct of Operations Requirements for DOE Facilities," 7/9/90.
HSP 1.02, "Program Document for As Low As Reasonably Achievable (ALARA)," 2/28/91.
PNL-6577, "Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are As Low As Reasonably Achievable (ALARA)," 6/88.
RE-1001, "ALARA Design Review," 1/91.
RE-1002, "ALARA Job Review," 6/92.
RE-1004, "Radiation Work Permit," 3/91.

ALARA . . . A TEAM CONCEPT!

ALARA Program/Manual Implementation

Senior management's support and commitment to reducing individual and collective exposures is a critical element in ensuring a successful ALARA program. Senior and line management should demonstrate their support of the program in their discussion and actions. Management's involvement and their commitment should be made obvious to all plant personnel. This commitment is demonstrated in EG&G's Rocky Flats Management participation in ALARA Committees.

Two levels of ALARA Committees have been established at Rocky Flats. The ALARA Oversight Committee (AOC), and ALARA Action Committees (AAC). The ALARA Committees are the methods used for implementing the ALARA Program and Manual at Rocky Flats, Inc. The AOC provides the senior management support and attention to address ALARA issues. The AAC implements the ALARA Program and concepts at the building level.

The ALARA Oversight Committee (AOC): Consists of senior management representatives of the departments/organizations involved in radiological work activities, and relevant radiological safety representatives. This committee is chaired by the General Manager or an individual that reports directly to the General Manager. This committee advises the General Manager on the effectiveness of the ALARA efforts and makes recommendations to strengthen the ALARA Program. The AOC consists of the following members:

Administration and Planning
ALARA Program Coordinator
Engineering
Environmental and Waste Management
Health and Safety
Non-Plutonium Operations
Performance Based Training
Plutonium Production
Plutonium Recovery
Quality Assurance
Technical Support
United Steel Workers of America (USWA) President

Establishing an oversight committee initially will provide the upper management with the support and attention needed to implement an ALARA Program, and will ensure that the resources needed for a successful program are identified.

The ALARA Action Committee (AAC): Organized when the AOC, Management, or Radiological Engineering has identified a building, project, or activity as requiring additional attention on radiological concerns and ALARA issues.

The ALARA Action Committee(s) is chaired by the Operations Manager for the identified building, area, or project. The Radiological Building Engineer serves as the secretary for the committee, and membership shall be representatives of the departments that support that area of radiological activity. The AAC addresses and implements the ALARA Program at the building level.

ALARA Awareness

For the ALARA Program to be implemented successfully, facility personnel must be informed of the revised and upgraded ALARA Program. This program awareness must identify the program structure and organization, and individual responsibilities for supporting the ALARA Program. Personnel at EG&G Rocky Flats, Inc. are informed of the ALARA Program improvements and progress through plant publications, training, and an ALARA video.

Plant publications have identified the increased emphasis placed on the ALARA Program by the formation of the ALARA Committees, and the development of facility, organization, and building specific ALARA Goals.

Performance-Based Training has incorporated the ALARA Program improvements into Rad-Worker and Radiation Protection Technologies training. Also, mock-up training has been developed for several operations that have significant radiological concerns.

The ALARA video provides an overview of the EG&G Rocky Flats, Inc. ALARA Program. The video describes the program structure, ALARA Committee and individual responsibilities. The video also identifies the program philosophy, concepts, and elements.

SUMMARY

The development of the ALARA Program Manual began in September 1990. The manual had gone through four major revisions with the final revision approved by EG&G's General Manager on July 15, 1991. Each organization involved in radiological activities at Rocky Flats provided input on the manual development and revisions. Following the approval of the manual, presentations were given to each major organization on the revised ALARA Program and their responsibilities in supporting the program. Operations Managers were informed of their responsibilities in implementing ALARA concepts, supporting AAC, and addressing issues at the building level.

The ALARA Program Manual, departmental procedures, and committee charters provide the framework for the paper ALARA Program. Implementation for the revised program began on site and at the building level on January 1992.

The ALARA Program is beneficial during any phase of facility operations, during non-operation and operational periods, and the decontamination and decommissioning (D&D) of any facility at Rocky Flats. The problems in implementing the program have been changing the focus of addressing ALARA issues. The focus of pre-planning the work and addressing ALARA issues before performing the job task has been a culture change. The support of radiological records in tracking and trending ALARA Goals, and generation of ALARA reports at regular intervals, also have been difficult.

By approaching occupational dose reduction on a broad front, using a variety of cost-effective approaches, and excellence in radiological safety, the advantages of ALARA concepts will prove to be beneficial.

REFERENCES

1. T. J. Corbett, EG&G Rocky Flats ALARA Program Manual, July 1991.
2. U. S. Department of Energy, Draft Implementation Guide 5.XX Occupational ALARA Program, 1991, Washington, D. C.
3. B. J. Dionne, C. B. Meinhold, T. A. Khan, and J. W. Baum, Occupational Dose Reduction At Department Of Energy Contractor Facilities: Study Of ALARA Programs-Good Practices Documents, 1990, BNL-47339, March 1992.

ALARA TRAINING PROGRAM AT DOE CONTRACTOR FACILITIES

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ABSTRACT

ALARA training is an important element of a sound ALARA program. ALARA training at a nuclear facility needs to be conducted for all occupational workers, for radiation workers, for radiation protection technicians, and for all other employees who have ALARA responsibilities. Each of these groups needs to receive ALARA training specific to their responsibilities. This report describes how to develop this training and also outlines what should be included in an acceptable ALARA training program.

ALARA TRAINING DEVELOPMENT

To develop a good ALARA training program, follow DOE Implementation Guide 5.XX[1] (draft) Occupational ALARA Program. Section 5 "ALARA Training" of this guide lists the components to be included in an acceptable ALARA training program. Design your training to meet the listed topics. To develop the lessons, use the ALARA lesson plans that have been developed by the BNL ALARA Center. Modify these lesson plans to make them specific to your facility.

DOE Order 5480.11,[2] Radiation Protection for Occupational Workers requires radiation safety training for occupational workers, radiation workers, and radiation protection technicians (RPTs). ALARA training can be included in the radiation safety training conducted by your company for these groups of employees.

ALARA training at Westinghouse Idaho Nuclear Company (WINCO) is included in our radiation safety training classes. These classes are based on the TRADE Guide to Good Practice in Radiation Protection Training[3]. There are three levels of training: general employee radiation safety training, radiation worker training, and radiation protection technician training. To be hired, radiation protection technicians must have completed a nine-month Radiation Protection Technician course at a vocational-technical school.

ALARA TRAINING PROGRAM ELEMENTS

An acceptable ALARA training program will meet the training requirements of DOE Implementation Guide 5.XX (draft) Occupational ALARA Program. Training requirements from Section 5 "ALARA Training" are listed next in the left column and a discussion of how to implement those requirements is listed in the right column.

IMPLEMENTATION

Occupational Workers

Occupational workers are all individuals who will be working at a nuclear facility, including those who are not radiation workers. The objective of ALARA training for these employees is to inform them of the ALARA concept and how they are protected from radiation. They need to know their ALARA responsibilities and the company's commitment to their protection. They need assurance that they are working in a safe workplace.

All occupational workers who may enter a controlled area should receive a brief orientation on the ALARA policy and philosophy and their biological basis. Retraining frequency should be consistent with the requirements of DOE Order 5480.11.

This requirement can be met in the occupational workers' radiation safety training class. To meet ALARA training requirements, this training should include:

- stochastic effects of radiation
- the ALARA concept
- DOE ALARA policy
- the company's ALARA policy
- the company's ALARA responsibilities
- the employee's ALARA responsibilities.

Retraining must be completed at least every two years or whenever there is a significant change in the company's ALARA program. Standard practice is to conduct this refresher training annually.

Radiation Workers

ALARA training for radiation workers should cover all the topics covered in the occupational workers' radiation safety class, but in more detail. In addition, it must also include training on good work practices for using ALARA techniques in radiologically controlled areas. The training should emphasize the active role workers need to play in keeping their own dose ALARA. Radiation workers need to see the importance of carefully preplanning their work in radiation areas. The instruction must emphasize that because even low doses of radiation may carry some health risk, it is only prudent for radiation workers to keep their doses ALARA.

Radiation workers should receive additional training and retraining on the fundamentals of radiation protection and ALARA.

ALARA training is a key element of the ALARA program. If workers do not know how to apply dose reduction techniques, they will not know how to keep their doses ALARA. If workers do not appreciate the importance of the ALARA concept, they will not fully support it. They will feel like the extra effort involved in the ALARA process is not worth it.

A good ALARA training program will give workers a sense of confidence in the safety of the work they do with radioactive materials. It will let them know the extent of the measures taken to keep their doses as low as reasonably achievable. It will also train workers to use good work practices to minimize their exposures.

ALARA training for radiation workers should be met by the company's radiation worker training course. ALARA training for radiation workers needs to include everything that is in the occupational worker ALARA training program plus the following:

- *Company ALARA policy.*

The company ALARA policy needs to be covered in detail. First, the ALARA concept must be explained. Then the DOE's ALARA policy and the company's ALARA policy must be discussed. Employees need to be informed of the company's ALARA policy statement, where it can be found, and management's commitment to it.

If employees do not understand the ALARA concept, they will think that as long as dose limits are not violated, then everything is fine. A proper understanding of the ALARA concept will let them know that this is not the case. It will let them know that every reasonable effort must be made to keep doses as far below dose limits as possible.

The company's ALARA program should be discussed and each of the following elements of the program should be explained:

- ALARA committee
- ALARA collective dose goals
- ALARA design reviews
- ALARA work procedure reviews
- ALARA training
- ALARA incentives
- ALARA reminders.

As radiation workers learn about the company's ALARA program, they will gain an appreciation of the importance of ALARA. New employees need to see the extent of the company's commitment to dose reduction.

- *Basic protective measures (time, distance, and shielding), as well as general methods and uses of ventilation, filtration, and containment.*

How time, distance, and shielding are controlled to minimize exposure should be explained. The training should motivate radiation workers to carefully plan all radiation work. It should also train them in the methods they can use to minimize their dose. Before each job, workers need to think about how they can use time, distance, and shielding to minimize their exposure.

WINCO uses computer-based training to teach radiation workers general knowledge requirements. This allows for an interactive approach to teach how time, distance, and shielding determine dose.

To teach the time principle, the computer monitor displays dose rate, time, and dose for a radiation area. The trainee starts the clock and the dose increases as a function of dose rate and time. The trainee can stop the clock to see the dose at any time.

To teach the distance principle, the trainee moves a worker various distances from a point source of radiation and the display shows the dose rate at each distance.

To teach the shielding principle, the trainee selects various thicknesses of shielding and a display shows the shielded dose rate associated with each.

The computer-based training program also has a section which allows the trainee practice using various ALARA strategies for work in a radiation/contamination area. The trainee is given a task to have a valve in the radiation/contamination area replaced. The trainee has a list of ALARA techniques to use. The cost of implementing each technique is displayed. The trainee has to select which ALARA techniques to use. When this is done, the program displays the dose received and the cost of implementing the ALARA measures that the trainee selected. The program then evaluates each decision, based on the cost involved and the dose saved.

Radiation worker ALARA training must also describe how filtered ventilation and containment are used to control contamination.

- *Responsibilities of radiation workers or researchers to reduce their exposure and the spread of radioactive material.*

Radiation workers need to be informed that they are responsible for knowing and observing company radiological safety procedures. They need to be informed of these responsibilities in radiation worker training.

Radiation workers need to know that they must play an active role in keeping their own dose ALARA. When a company has a sound safety program, some employees may tend to think that because they are being watched out for, they do not need to take personal responsibility for their own safety. The training program must emphasize that both company management and the worker are responsible for keeping the worker's dose ALARA. Workers need to know the importance of practicing the ALARA techniques they have learned to keep their doses low.

- *Specific procedures to control dose and the spread of radioactive materials for the type of work or research they are expected to perform.*

In addition to general radiation worker training, specific radiation worker ALARA classes should be conducted for certain jobs. This could include training for workers that use hoods, glovebags, gloveboxes, or do certain types of maintenance work.

Job-specific training and practice sessions using "mock-ups" or nonradioactive equipment should be used to reduce exposures during repetitive work that results in a high collective dose, or during work requiring significant skill and dexterity in high-radiation areas.

To conduct job-specific training, trainees must identify those jobs resulting in a high collective dose. Trainees must also identify those jobs in high radiation areas that require significant skill and dexterity. The training department needs to work together with radiation safety and the field organizations to identify these jobs. Training should be based on written operating procedures and should be conducted under simulated field conditions.

Retraining frequency for radiation workers should be consistent with the requirements of DOE Order 5480.11.

Refresher training is required every two years or whenever there is a significant change in ALARA policy. It is a good practice to conduct this refresher training annually. A written examination should be included with all training.

Radiation Protection Technicians

The objective of ALARA training for radiation protection technicians (RPTs) is to make sure they know the importance of their role in the company's ALARA program. In the field, radiation workers rely on the RPT to warn them of exposure hazards. During jobs in radiation areas, the RPT needs to ensure that ALARA controls are implemented.

Radiation-protection technicians should receive special training and retraining on radiation protection and the proper procedures for maintaining exposures ALARA, including:

Radiation protection technicians should receive extensive ALARA training. This can be accomplished by a radiation protection technician course at a vocational-technical school.

- *Company ALARA policy and philosophy.*

Training must include the company's ALARA policy and where it is found. The RPT also needs to know the extent of the company's commitment to ALARA. This can be accomplished by discussing such things as the company's policy on cost/benefit analysis involving ALARA techniques.

- *Advanced protective measures (time, distance, shielding), as well as methods and uses of ventilation, filtration, decontamination, and containment.*

Vocational-technical training provides extensive training in dose rate calculations, shielding, and contamination control methods. Site-specific training needs to be provided by the company in such areas as:

- Ventilation flow paths for each facility.
- Inspection of containments.
- Decontamination procedures.
- Other RPT contamination control responsibilities.

- *Responsibilities of radiation protection technicians in implementing the ALARA program.*

Radiation protection technicians need to know the importance of their role in the ALARA program. They need to be informed that they have stop-work authority and should stop a job if they determine that the ALARA controls for the job are not adequate.

- *Exposure and contamination controls established for specific activities.*

To provide RPTs with training on exposure and contamination controls established for specific activities, a system needs to be in place that identifies those activities. RPTs will not necessarily need specific ALARA training on all of the activities. The need for training should be identified when the procedures for this type of work are written.

- *Proper documentation of ALARA records.*

RPTs need to be trained on how to fill out and keep ALARA records. These records include such things as radiation work permits and survey reports. This training should state how these records are used in the ALARA program and emphasize the importance of keeping accurate records.

This ALARA training should include classroom and applied training. The applied training for various ALARA assignments should be directly supervised by a trained person. Retraining frequency should be consistent with the requirements of DOE Order 5480.11.

Classroom and applied training should be conducted at a vocational-technical school and by the company. Applied training provided by the company should be documented on a qualification standard. Applied training can be conducted under the direction of an RPT supervisor, a qualified RPT, or an RPT trainer.

Retraining must be conducted at least every two years.

Written examinations should be included with initial and refresher training.

Others

ALARA training needs to be conducted for other groups that have specific ALARA functions. The purpose of this training is to familiarize these groups with their responsibilities toward the ALARA program. Each group needs to know how to incorporate ALARA procedures into their activities.

Specific ALARA training of the appropriate functional groups should ensure their effective participation in implementing the ALARA program. The groups that may need specific ALARA training include ALARA and other appropriate radiation protection staff, radiological engineering staff, operations, maintenance, production, research, engineering, planners and schedulers, and their line managers and supervisors.

Groups that have specific responsibilities in implementing the ALARA program should receive specific ALARA training. Training for each group should cover their responsibilities toward the ALARA program. For example, line managers and supervisors should be trained on ALARA incentives, company ALARA program components, how DOE evaluates an ALARA program, and responsibilities which a manager must fulfill to have a successful ALARA program. Job planners need to be trained in how to incorporate ALARA practices into work procedures.

ALARA training lesson plans, attendance records, and examinations generated in support of the above training activities should be documented and maintained.

ALARA training records should be kept in accordance with DOE Order 5480.11 and in the same manner that permanent training records are kept. DOE Order 5480.11 requires that training records for occupational workers, radiation workers, and radiation safety personnel be retained to document the level of understanding and proficiency of personnel working with radioactive materials. Certification of successful completion of training programs and performance records should also be retained.

REFERENCES

1. DOE Implementation Guide 5.XX (draft) Occupational ALARA Program, November 1991, Revision 1.
2. DOE Order 5480.11 Radiation Protection for Occupational Workers.
3. DOE TRADE Guide to Good Practice in Radiation Protection Training, October 1988.

COST/BENEFIT ANALYSIS AT WESTINGHOUSE HANFORD COMPANY

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ABSTRACT

This document provides the Westinghouse Hanford Company's methodology for cost/benefit analysis. The primary focus of the document is on the development of a sliding scale for the nonhealth-related detriment of radiation. This sliding scale is based mainly on the cost of replacing or reassigning a worker who has approached a preset limit for effective dose equivalent.

INTRODUCTION

The purpose of this document is to explain the Westinghouse Hanford Company's (Westinghouse Hanford) method of performing cost/benefit analysis (CBA). This technique is applicable to any occupational effective dose equivalent received, but the specific values generated in the text are valid only for effective dose equivalents less than 1.9 rem/yr (19 mSv/yr). This is because Westinghouse Hanford employees are limited to 2 rem/yr by internal administrative levels. This document is not intended for evaluating nonoccupational workers or pregnant women.

THE CONCEPT OF COST/BENEFIT ANALYSIS

Cost/benefit analysis uses the As Low As Reasonably Achievable (ALARA) method to assign a cost to detriment caused by exposure to radiation. By assigning a dollar value, detriment can be expressed in terms that will allow evaluation against the real cost of implementing a dose reduction plan, hereafter referred to as an ALARA Protective Measure (APM).

The former CBA technique used by Westinghouse Hanford was based on values provided by *A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable (ALARA)*, DOE/EV/1830-T5.[1] U.S. Department of Energy (DOE) Order 5480.11,[2] issued December 21, 1988, replaced 1830-T5 with *Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are As Low As Reasonably Achievable*, PNL-6577.[3]

COST OF DETRIMENT ASSOCIATED WITH RADIATION

Concept of Detriment

PNL-6577 expresses the detriment associated with exposure to radiation as follows:

$$X = \alpha + \beta. \tag{1}$$

Where:

α = Cost of a person-rem due to health detriment ($)
β = Cost of a person-rem due to nonhealth-related detriment ($)
X = Cost of a person-rem due to total detriment ($).

Various values have been assigned to the total detriment associated with a whole-body effective dose equivalent of 1 person-rem (10 person-mSv). These values have ranged from $10 to $1,000 outside the DOE;[1] within the DOE network, 1830-T5 established a range of $2,000 to $60,000.[1] Instead of using these, or other, static values, Westinghouse Hanford uses a variable range from $2,500 to $22,500. This is considered appropriate because the cost associated with a person-rem is not constant, but varies with application.[3]

Establishing a Value for Health Detriment (α)

Data assigning a specific dollar value for the health effects of radiation are extremely limited. Title 10, Code of Federal Regulations, Part 50 (10 CFR 50), Appendix I, provides a guidance value of $1,000/person-rem ($100/person-mSv) for use by reactor facilities in determining the cost effectiveness of measures affecting public exposure. If it is assumed that the entire $1,000/person-rem ($100/person-mSv) value is related to the health effects, this could serve as guidance for supplying a minimum value for α. The accepted Westinghouse Hanford value for α is $2,500.[4]

Establishing a Value for Nonhealth Detriment (β)

A value for the β component is not assigned in PNL-6577, but is considered to be variable; the actual value depends on application.[3] As applicable to Westinghouse Hanford, the value of β is considered to be a range from essentially zero dollars to an upper value dependent on application.

The maximum value for β is limited, in practical terms, to the cost of replacing the individual worker in the specific work force who has approached a preset limit. For the purpose of this document, an exposure-limited worker is considered to be any worker who has received 95% of an applicable control level. Because of this, three key factors were considered in determining the upper value of β:

- productivity of an exposure limited worker
- time needed to train replacement workers
- cost of training.

In almost all situations assessed at Westinghouse Hanford, workers who have approached a preset exposure limit can perform other functions within their current assignment. Workers who must be reassigned are usually productive in their new jobs. The number of workers in a single work group who can approach a limit, without requiring this concept to be reassessed, will vary; any assessment of the nonhealth-related detriment should reflect this.

The assumption was made that an exposure-limited worker in an organization would be among the most senior qualified. The replacement was assumed to be among the least qualified, but of comparable generic qualifications. For example, if a health physics technician working at one facility were approaching a preset exposure limit and reassigned to a nonexposure intense position, the time to requalify a technician from a different facility would be considered an adequate measure of training time. In the event that a new hire was required, the values shown in this section would not apply.

Line management and training functions provided estimates for training times at various facilities at Westinghouse Hanford. From these estimates it was determined that the average time to bring the replacement worker to full productivity is approximately 12 weeks. Assuming an equivalent amount of time to retrain the exposure limited worker, a total assessment of lost time is approximately 24 person-weeks.

It should be noted that this time period may vary depending on the different crafts and availability of replacements. For instance, if persons are readily available to fill the position of the exposure-limited worker, and the exposure-limited worker can be reassigned with little or no training, then the value for ß would drop significantly. Because of our changing mission at Westinghouse Hanford, we are preparing to reassess the training time to more accurately represent the organizations whose workers are approaching a limit.

The training cost associated with a single exposure-limiting event is approximately $40,000, based on the average weekly wages and benefits and assuming 12 person-weeks to train each affected worker. Because Westinghouse Hanford exposure limits are set at an effective dose equivalent of 2 rem/yr (20 mSv/yr), the cost of ß in this situation is up to $20,000/person-rem ($2,000/person-mSv). While the exposure limit is not the only factor affecting the value of ß, it is a quantifiable figure and provides the most limiting value that will be assigned for the purpose of this document.

Establishing Upper and Lower Limits for Total Detriment (X)

As noted earlier, the upper limit for the value of total detriment (X) is the sum of α and ß, and the minimum value is equal to α. Since α is established as $2,500 and ß ranges from $0 to $20,000 a range of $2,500 to $22,500 for X is reasonable.

Defining the Actual Value for Total Detriment (X)

Because individual doses do not affect employee availability significantly until the worker's effective dose equivalent approaches a preset limit, the upper limit of X does not rise dramatically until annual preset limits are approached. At Westinghouse Hanford we have three known data points:

10 mrem (1 mSv)	No cost
300 mrem (3 mSv)	Cost of idling a worker for a week
1.9 rem (19 mSv)	Cost of replacing a worker.

An empirically derived equation to approximate the upper limit of X (X_{ul}) for the limits used at Westinghouse Hanford is presented below:

$$X_{ul} = e^{(J + DK)} \tag{2}$$

Where:

X_{ul} = Application-dependent limit of the X limited to $22,500
D = Highest individual effective dose equivalent
J = Constant 7.9 (obtained empirically)
K = Constant 1.1 (obtained empirically).

Equation 2 provides the capability to determine X for any individual effective dose equivalent. This range is smaller than the current $2,000 to $60,000 range. This allows a more structured approach and limits dependence on qualitative analysis. It should be noted that any facility that can determine the cost of ß for different levels of effective dose equivalent can use this methodology to develop their own range of values.

OTHER FACTORS AFFECTING THE COST EFFECTIVENESS OF AN ALARA PROTECTIVE MEASURE

The previous section discusses the methodology used to determine the upper and lower value for a person-rem. In many cases, determining the cost of an APM does not provide all of the information needed to evaluate whether an APM is appropriate. In some cases other factors may override the apparent cost effectiveness of an APM; in others the cost will fall within the established range, and the decision to implement the APM must be based on factors deemed relevant and appropriate. Because of this, Westinghouse Hanford uses assessment factors.

Assessment factors are divided into two categories: "overriding factors," which preclude all other options, and "ALARA factors," which are used to evaluate an ALARA protective measure for which the cost effectiveness is indeterminate.

Determination of Overriding Factors

Overriding factors may affect implementation of an APM in two ways: by preventing the implementation of an APM that is considered cost effective, or by requiring the implementation of an APM that is not considered cost effective. Before any APM is evaluated to determine cost effectiveness, an initial analysis should be done to determine the existence of overriding factors that would not be addressed by the CBA.

The following list provides examples of overriding factors that could influence the implementation of an APM. Other factors may be encountered that are equally relevant and should be considered.

- Complying with a DOE order, Federal regulation, or state law.
- Creating of an unsafe condition that could lead to worker injury.
- Adding a significant quantity of "land banned" materials to the facility that could not be disposed of (i.e., contaminated lead).
- Causing workers to exceed dose limits.

ALARA Factor Analysis

When the cost an APM falls between the upper and lower limits of X, it must be evaluated against established ALARA factors. The following ALARA factors have been established for Westinghouse Hanford.

Evaluation of an ALARA factor analysis is determined by balancing the weighted "yes" answers against the weighted "no" answers. If there is a higher total of "yes" than "no," the APM is considered cost effective. If there is a higher total of "no" than "yes" the APM is not considered cost effective. The effort expended in quantifying these factors should be comensurate with the scope of the project.

1. Will the maximum individual doses for occupational workers exceed 10 mrem (0.1 mSv) for the duration of the relevant timeframe?

   Weighting Factor: 3

   Discussion: This is an extrapolation of the negligible individual risk level recommended by the National Council on Radiation Protection and Measurements, 1 mrem (0.01 mSv).[5] The 1-mrem (0.01-mSv) dose cited by the report was in reference to nonoccupational workers; since occupational limits are traditionally a factor of 10 higher, a value of 10 mrem (0.1 mSv) was selected. This does not indicate that 10-mrem (0.1 mSv) effective dose equivalents are insignificant, but for defining individual factors to be used to assess the overall cost effectiveness of a measure, it is a valid consideration.

2. Does the APM maintain or decrease the current level of risk for occupational incidents or accidents?

   Weighting Factor: 2

   Discussion: APMs that increase the risk of occupational incidents or accidents possess an inherently negative factor.

3. Does the APM decrease the risk of environmental incidents or accidents?

   Weighting Factor: 2

   Discussion: APMs that decrease the risk of environmental incidents or accidents possess inherently positive factors.

4. Does the APM result in collective dose savings in the postoperational phase of operations?

   Weighting Factor: 2

   Discussion: APMs can affect the effective dose equivalents to be received in the postoperational phase of a facilities operation. If the proposed APM can be shown to reduce exposure during this phase, even if not quantifiable, this can be considered a positive factor in the overall process.

5. Does the APM result in cost savings during the postoperational phase of operations?

   Weighting Factor: 1

   Discussion: APMs can affect a facility in a variety of ways. If it can be shown that the APM will provide a future cost savings, even if not specifically quantifiable, such cost savings would be considered a positive aspect of the APM.

6. Does the APM increase the flexibility of personnel or other resources?

   Weighting Factor: 2

   Discussion: Certain APMs may not contribute to significant exposure reduction but would have a positive effect on facility operations. The APMs that affect entry requirements or other administrative controls should be considered in this area.

7. Does the APM result in an improved relationship with internal or external organizations?

   Weighting Factor: 1

   Discussion: If an APM can be said to improve the relationship between union and management, company and customer, or customer and outside oversight group, this is a positive consideration in evaluating the APM.

8. Does the APM decrease or not increase employee exposure to adverse working conditions or extreme discomfort?

   Weighting Factor: 2

Discussion: Specific APMs often rely on additional protective clothing, masks, or other similar factors. When these factors result in adverse working conditions or extreme worker discomfort, this should be considered a negative aspect of the APM.

9. Does the APM reduce the release of radionuclides to the environment?

   Weighting Factor: 3

   Discussion: Reduction of radionuclides to the environment, even if existing levels are within current limits, is a positive factor in considering an APM.

10. Does the APM improve or maintain current level of operability for an activity or facility?

    Weighting Factor: 2

    Discussion: If the implementation of an APM will restrict access to portions of a facility, curtail operations, or in some significant way hamper routine operations, this would be considered a negative aspect of the APM.

11. Is the adverse impact of the APM on the activity schedule minimal?

    Weighting Factor: 2

    Discussion: Implementation of an APM will invariably have some adverse impact on schedule. Only when the impact is extreme, i.e., a significant milestone is missed, should this be considered a negative aspect.

12. Does the APM contribute to waste minimization?

    Weighting Factor: 1

    Discussion: Waste minimization is a key concept of ALARA; therefore, any contribution to the waste minimization program is a positive factor to be considered.

APPLICATION OF COST/BENEFIT ANALYSIS METHODOLOGY

This section outlines the steps required to perform a CBA based on the above methodology. Completion of a CBA requires that a significant amount of background information be quantified, evaluated, and documented to support the selection of a cost for total detriment (X) and to justify conclusions as to the cost effectiveness of an APM. As stated before, the effort spent quantifying these factors should be commensurate with the scope of the project.

To ensure that a proposed measure is implementable, even if cost effective, all APMs should undergo a preliminary assessment against the criteria shown in the section titled *Determination of Overriding Factors* before formal assessment to ensure evaluation is merited. These criteria address issues that may override the results of a CBA.

Definition of Terms

ALARA Protective Measure--An APM is any measure that will reduce effective dose equivalent. An APM generally falls into a category of time, distance, and shielding (the basic tenets of ALARA), or source reduction, containment, or ventilation.

Cost of the APM--The cost of the APM requires consideration of a wide range of cost factors. Cost of the APM must include considerations for procurement, installation, operation, and maintenance. Considerations must include the evaluation of dose savings over the long term if operations will occur over the long term.

Relevant Activity--The relevant activity will define and limit the application of the APM. A relevant activity can consist of a job or series of jobs, a scheduled survey, or a maintenance activity. Application of the APM is limited to the scope defined by the relevant activity.

Relevant Timeframe--A relevant timeframe can be any period of time for which the application of the APM to the relevant activity occurs. For periods greater than 1 yr, each year should be evaluated separately.

Anticipated Effective Dose Equivalent--Anticipated effective dose equivalent must be stated in two terms: (1) collective dose, the total effective dose equivalents of all persons; and (2) individual effective dose equivalent, a determination of how the collective dose will be distributed among individuals. Collective dose estimates need to be made in person-rem (10 person-mSv).

EVALUATION

Evaluation of an APM begins with a compilation of assumptions. The following steps must be taken and appropriate information gathered for an effective CBA to be performed.

1. Define the scope of the CBA by identifying the APM, Relevant Activity, and Relevant Timeframe. This should be done clearly using as much explanation as necessary.
2. Calculate the cost of the APM showing all assumptions.
3. Calculate effective dose equivalents, collective and individual, for the relevant activity over the relevant timeframe. These should be calculated with and without implementation of the APM. When assessing the effective dose equivalent without implementation of the APM, routine and existing applications of ALARA must be considered. For estimates using the APM, care must be taken to ensure that the effective dose equivalents are expressed as a net value, taking into account doses received implementing the APM.
4. Using individual effective dose equivalents as determined above and the graph in Figure 2 or equation 2, determine the upper value for X as applicable for this analysis.
5. Using the collective dose determined above, establish a ratio of (1) the cost of the APM and (2) the collective dose (APM $\div$ collective dose). Compare this cost ratio to the value obtained for X in step 4. If the cost exceeds the upper limit established for X, refer to the section titled *Measures Where the Cost Exceeds the Upper Limit of X*; if the cost per person-rem (10 person-mSv) is less than $2,500, refer to the section titled *Measures Where the Cost of the APM is Below $2,500/person-rem ($250/person-mSv)*; if the cost is greater than $2,500 but less than the limiting value for X, as determined in step 4, refer to the Section titled *Measures Where the Cost of the APM is Within the Range of X*. A simplified flow chart is shown in Figure 1.

Measures Where the Cost Exceeds the Upper Limit of X

If the cost per person-rem (10 person-mSv) of the APM exceeds the upper limit of X value, and no overriding criteria apply, the measure cannot be considered cost effective based on dose reduction. This does not preclude the use of dose reduction as one of several factors used to justify an APM with positive effects in areas not solely related to radiation exposure.

Measures Where the Cost of the APM is Below $2,500/person-rem ($250/person-mSv)

If the cost per person-rem is less than $2,500 value, then the measure is considered cost effective, unless overriding criteria apply.

Measures Where the Cost of the APM is Within the Range of X

If the cost per person-rem falls within the range of X, then assessment of the measure will require the completion of an ALARA factor analysis as shown in the section titled *ALARA Factor Analysis* and an overriding criteria review. Criteria for an ALARA factor analysis are found in the section titled *Determination of Overriding Factors*.

ALARA FACTOR ANALYSIS

An ALARA factor analysis is a method of evaluating APMs that are within the range of X. Provide a yes or no answer to each criteria, as applicable to the proposed APM. A weighting factor has been assigned to each in an effort to balance the assessments. A weighting factor of 3 carries 3 times the impact as a weighting factor of 1. A checksheet incorporating the ALARA Factor Analysis has been developed and is included as Figure 3.

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Figure 1. Cost Benefit Analysis Flow Chart.

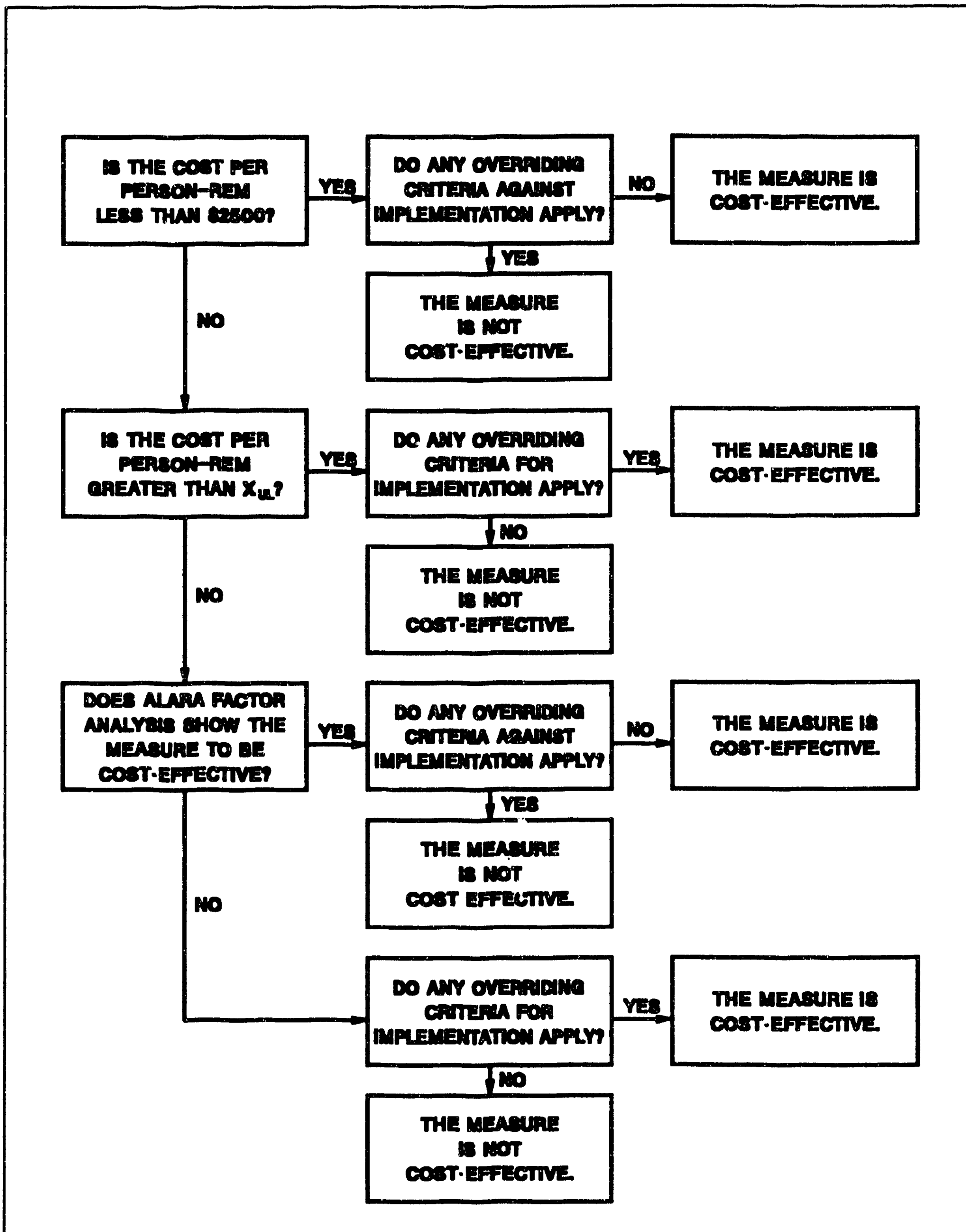

Figure 2. Value of Detriment Associated with a Person-Rem.

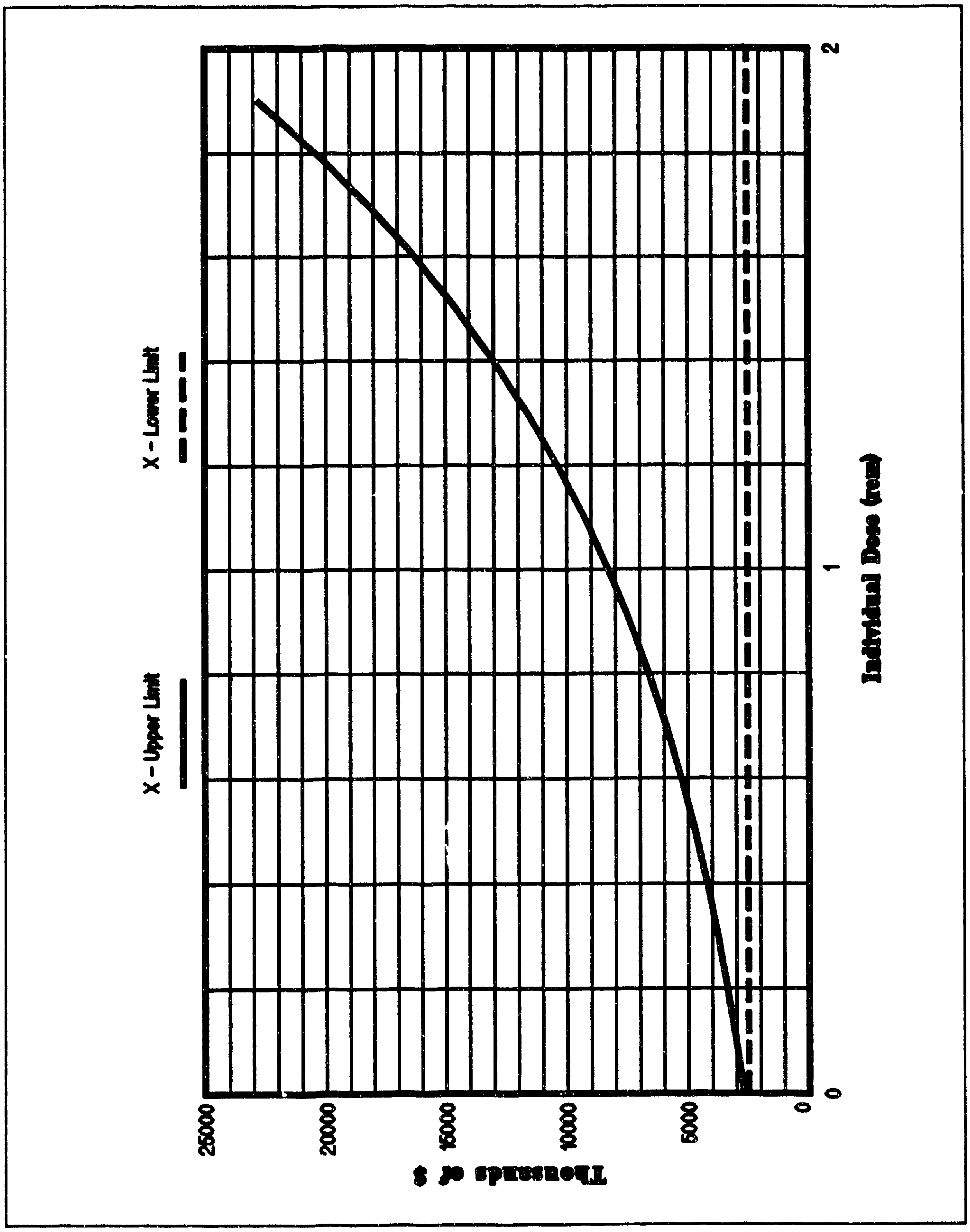

Figure 3. ALARA Factor Analysis Checksheet

Question	Weighting Factor	Yes	No
1. Will the maximum individual doses for occupational workers exceed 10 mrem (0.1 Msv) for the duration of the relevant timeframe?	3		
2. Does the APM maintain or decrease the current level of risk for occupational incidents or accidents?	2		
3. Does the APM decrease the risk of environmental incidents or accidents?	2		
4. Does the APM result in collective dose savings in the postoperational phase of operations?	2		
5. Does the APM result in cost savings during the postoperational phase of operations?	1		
6. Does the APM increase the flexibility of personnel or other resources?	2		
7. Does the APM result in an improved relationship with internal or external organizations?	1		
8. Does the APM decrease or not increase employee exposure to adverse working conditions or extreme discomfort?	2		
9. Does the APM reduce the release of radionuclides to the environment?	3		
10. Does the APM improve or maintain current level of operability for an activity or facility?	2		
11. Is the adverse impact of the APM on the activity schedule minimal?	2		
12. Does the APM contribute to waste minimization?	1		
Total			

CONTROL OF JOB EXPOSURE:
AN ESSENTIAL ELEMENT OF A FUNCTIONAL ALARA PROGRAM[1]

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ABSTRACT

In 1990, the EG&G Idaho Inc., Power Reactors Program started a program to track job exposure at the INEL (Idaho National Engineering Laboratory). Control of job exposure quickly distinguished itself as a useful tool in the administration of the ALARA program. The tracking system for job exposure was later formalized into a Radiation Work Permit (RWP) system. The methods of controlling job exposure and the benefits of the RWP process are discussed in this presentation. The requirements and recommendations of the DOE Draft ALARA Implementation Guide concerning Radiation Work Permits are introduced, and the INEL RWP system measured against the Guide. This presentation also discusses the use of commercial automated dosimetry systems used to support the RWP process.

INTRODUCTION

ALARA (As Low As Reasonably Achievable) does not imply the continued reduction, or minimization, of personnel exposure. ALARA is a principal of optimization. A successful ALARA program should be based upon optimizing personnel exposure. It is common practice to base performance assessments upon the facilities' total annual radiation exposure. Annual totals do not provide a true measure of the success of the ALARA program. The total annual exposure does not take into account work scope nor personnel changes. Unplanned repairs, periodic preventive maintenance, and planned overhaul/outage periods will increase the total annual exposure. This increase does not represent a lack of ALARA.

Annual exposure totals will only indicate the quality of an ALARA program if this total is balanced against work scope and manning. To be effective, an ALARA program should be able to measure the exposure cost of individual jobs. This data then can be used to estimate planned exposure, set ALARA goals, measure the success of added ALARA controls, and identify jobs requiring further ALARA evaluation. Tracking job exposure, in conjunction with total facility exposure, provides an effective tool for measuring the adequacy of the ALARA program.

METHODS

The Power Reactors Program had been successful at consistently reducing the annual facility exposure total since 1986. The effectiveness of the ALARA program was based upon the continued reduction of annual exposure. Because no specific data on job exposure was collected, it was difficult to be certain of the contributing causes for the reductions. Accurately evaluating the ALARA program required dissecting the annual total into the individual job exposures related to the operation and maintenance of the facility. This required using a new system of exposure tracking.

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[1]Work performed under the auspices of the U.S. Department of Energy, DOE Idaho Field Office, Contract DE-AC07-76ID01570.

Initial Evaluations

The PRP (Power Reactors Program) started a job-exposure tracking system in 1990 by including a single data sheet into work documents for workers to record their personnel dosimeter readings. Upon completion of the work, the total job exposure was recorded in a format including job number, job description, and exposure total. Radiological Engineers distributed this information to all organizations. This system provided a surprising amount of information and helped in evaluating the affect of individual jobs on total facility exposure.

The main thrust of former Radiological Engineering ALARA evaluations and improvements had been directed to jobs in areas of high dose rate. Some repetitive tasks in low dose-rate areas (5 - 10 mRem/hr) had not received significant ALARA evaluation, although many of these jobs involved hundreds or thousands of person-hours per year. However, the results of the job exposure data indicated that some of these jobs were major contributors to the cumulative annual exposure of the facility. The data confirmed the usefulness of specific job exposure tracking and allowed easier identification of tasks requiring further ALARA evaluation. The importance of tracking was recognized and the Power Reactors Program decided to take steps toward establishing a formal data collection system. This system was expected to be similar to the Radiation Work Permit programs in wide use by commercial utilities.

Radiation Work Permit Program

The PRP reviewed the RWP forms and procedures of several commercial facilities. This review revealed that, although there was no standard RWP program completely compatible with the PRP, most programs provided basically the same capabilities and objectives:

1. Describe the radiological conditions in the work area.
2. Specify the personnel protective clothing and dosimetry required to accomplish the task or enter the area.
3. Estimate person-hours and personnel exposure required to complete the work.
4. Specify protective requirements to reduce dose and the spread of radioactive materials.
5. Document personnel entries into an area covered by an RWP and track the total exposure/person-hours involved with the completion of the task.

The PRP established a formal Radiation Work Permit program[1] and implemented a pilot program in March 1991. The PRP used the latter on a voluntary basis to familiarize workers and Health Physics technicians with the RWP and identify any procedural problems. The pilot program continued through the remainder of 1991. During this time, use of the RWP in work documents increased to include approximately 80% of jobs, total man hours or collective dose of all work conducted at the facility. In March 1992, the RWP program was fully implemented for all work in radiation and contamination areas.

The original purpose of the RWP program was to collect information on job-specific exposure. However, job exposure tracking was only one of several benefits achieved by the RWP program. Other benefits of the RWP include the following:

- A comprehensive single form is used to completely document pre- and post-ALARA reviews. Historical job information can be easily retrieved and is available for future work activities.
- Data fields included on the RWP provide the capability to sort exposure totals by job as well as by job type/classification, or facility area. This provides valuable information on exposure used on activities, such as decontamination, unplanned maintenance, or exposure received within specific areas of the facility.
- The RWP provides workers with complete instructions on radiological controls required for the area/task. Individuals document their understanding of these requirements by signature on the RWP. This places direct responsibility for the safe conduct of work on the individual. Increased worker

responsibility will allow a reduction of the amount of HP coverage without sacrificing the quality of radiological controls employed.

- Actual person-hour totals provide a useful tool for scheduling future work and aid in identifying problems with jobs.
- A method is provided for accurately measuring the collective dose and productivity achievements resulting from ALARA improvements.
- Specific ALARA Action Levels requiring special review/approvals, additional controls, or documentation are included into the RWP process.

All of the collective benefits of the RWP program provide a complete framework for ALARA control of job exposure. The RWP provides excellent documentation of the overall ALARA organization and management of job exposure.

DOE ALARA Implementation Guide

The Department of Energy has drafted an ALARA Implementation Guide[2]. This guide outlines the basic requirements of an acceptable ALARA program. The ALARA Guide specifies the use of a Radiation Work Permit system. The guide defines an RWP as "...an administrative control method by which radiological work can be planned, controlled, and documented, so that radiological conditions and job-specific information on radiological controls are communicated to the worker(s) involved..." The regulatory position on implementing this guide requires at "least an equivalent level" of compliance. The guide describes the following required capabilities of an RWP program:

- Pre-job or work ALARA exposure estimates, and documentation of actual exposures received.
- Collective doses received by the total facility and, as appropriate, by specific work group and for specific jobs.
- Establishing criteria for completing post-job reviews (e.g., actual doses differ by >25% of pre-job estimates).
- Facility procedures describing the review process for the RWP job/experiment process for its associated records.
- Formal ALARA review of a job/experiment for those work activities or experiments that have the potential to exceed radiological action levels.
- Estimates of the collective dose saved and any productivity improvements or reductions in work schedules resulting from the ALARA program.
- Inclusion of the capabilities to control work activities in radiological areas that are not effectively controlled by another specific radiation protection procedure.

The Guide states that the RWP should contain the following items:

- A job description.
- A preliminary estimate of the time and radiation dose for the activity.
- The start and finish dates for the work.
- The results of the radiological survey in the work location.
- The requirements for protective clothing.
- Any special instructions, including ALARA controls and approval signatures.

The DOE ALARA guidelines for RWP are similar to RWP programs already in place at many commercial facilities. The DOE guide was not available for use in developing the EG&G RWP program; however, a subsequent check revealed that the EG&G's RWP program meets all of the applicable DOE ALARA guidelines.

Cost Considerations

Implementing an RWP program includes some costs of personnel resources. Processing and documenting a RWP is a time-consuming activity and will require dedication of some facility personnel. The amount of time involved in maintaining such a program will be proportional to the amount of ongoing work at the facility. The level of resources invested in implementing and managing such a program should always be kept in perspective with the potential benefits produced. The resources invested in documenting historical job information can only be justified if this information is available and will be used in future work. For a facility to achieve the maximum benefit from the RWP program with the lowest cost, every effort should be made to make the program as efficient as possible. There are several simple methods of streamlining the RWP program and making the system more cost-effective.

1. Document all engineering ALARA reviews in a word processing format (i. e. Word Perfect). The reviews can be saved and then retrieved for future use or edited for similar activities. The ALARA reviews should be kept in a format compatible with the RWP forms so that they can be transferred directly to the RWP form. This increases the consistency of the engineering ALARA reviews and provides a foundation for improving the detail of future reviews.

2. Break down the RWP into job specific and routine categories. Repetitive tasks, such as trash and laundry pick-up, transmitter calibration, or area inspections can use a routine RWP. The routine RWP provides the instructions for repetitive tasks when the radiological conditions and ALARA controls are not expected to change significantly from day to day. Using a routine RWP will reduce the number generated without sacrificing the benefits of job exposure control.

3. Use automated dosimetry systems with software designed to document the RWP process and provide real-time tracking of personnel/job exposure.

These items can reduce the time and resource investment required for an RWP system. Additionally, these items can make the management of such a system more effective and increase the ALARA benefits realized from the use of the RWP.

Automated Dosimetry Systems

In the past five years or so, a host of automated dosimetry systems have become available. These systems provide an excellent method for implementing the RWP process of job exposure control. The features of various dosimetry systems vary between manufacturers. There are differences in types of detectors, means of dosimeter/network communication, and software features. The system selected for a specific facility should be based upon the features best suited to the needs of the facility.

The following are some of the more common features of these systems:

- Dosimeters capable of providing a wide range of dose and dose rate measurement with built in alarms for both rate and total dose.
- Software systems that can incorporate a RWP management system for tracking job exposure control.
- System network capability to allow real time communication with a central data base to control both job and personnel exposure.
- Control of personnel access with system software, which includes all personnel medical and training records.

Additionally, some of the systems available offer enhanced features which may be more desirable or necessary to facilities:

- Real-time remote dosimeter communication that is accomplished using a miniature radio transmitter attached to the personnel dosimeter. This system allows remote monitoring of individual dose and dose rate.
- Extremity dosimeter attachments for the personnel dosimeters.
- A software package for multiple dosimetry control.
- RWP Software. Facility specific RWP forms can be included into the system's software. This allows the generation, approval, and management of the RWP on the same network used to track job exposure.

These systems offer several distinct advantages not possible with a purely administrative job exposure control system:

Dosimeter Accuracy/Reliability - The dosimeters used for most of these vendors' available systems use semi-conductor detectors. These detectors offer improved accuracy and range compared to pocket ionization-chambers. Some of the automated dosimetry systems available will respond within 3% of TLD readings.

Area Reader Stations - Dosimeter reader stations can be located at strategic locations to make it easier for individuals signing in and out of RWP using reader stations near the job site.

Personnel Access Control - These systems provide the ability to control personnel access. All training, qualification, and exposure histories are incorporated into the system data base. System access is granted only to personnel authorized and qualified to work in radiological areas.

Time Savings - Operating system software requires less time than using a similar paper system. Additionally, the generation of records and reports is an inherent feature of most of the automated dosimetry systems. The reports generated will provide rapid identification of high exposure jobs and evaluations of estimated versus actual exposure results.

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CONTROLLING CONTAMINATION: COSTS, BENEFITS, AND OPTIMIZATION[1]

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ABSTRACT

A methodology is described that illustrates a practical decision-making technique to evaluate the best option for controlling contamination. The methodology is illustrated by a specific example. In addition, the paper examines various factors that affect contamination control and the optimization process. Among these are suggestions for evaluating the monetary worth of a unit of radiation dose, and guidelines for radiation and contamination monitoring under various levels of contamination. The inefficiencies imposed on radiation workers from the use of protective apparel also are discussed and suggestions are made about when it is appropriate to use various items of protective apparel. It is recommended that the optimization of various contamination control approaches should be pursued, although the extent of detail used should match the magnitude of the problem.

INTRODUCTION

It is important to understand precisely why controlling contamination is desirable and why it is necessary to seek the optimum approach to its control. The main reasons for controlling contamination are the following:

- It increases work efficiency
- It reduces the cost of operating the facility
- It reduces work-planning requirements
- It reduces on-the-job effort
- It keeps contamination from spreading to outside areas, avoiding risks to other workers and to the public
- It creates a more pleasant and benign working environment for the occupational worker
- It improves the institution's public image
- It enhances safety by increasing access to equipment

Although the need for reducing contamination is very real, one cannot allocate every resource and all of the funds to eliminating contamination completely. First, it would be a very inefficient use of resources, and second, even if contamination was eliminated, it may not be the most effective strategy. Therefore, it is necessary to have a clear appreciation of the factors involved and their impact on reducing contamination, and then develop an optimum strategy.

This paper begins by suggesting a procedure for optimizing contamination control and then outlines the various factors that are needed to evolve an optimum strategy. Finally, it illustrates the approach by a specific example of a contamination removal project. More detailed information is provided in Reference 1.

[1]This work was carried out jointly under the auspices of the Office of Nuclear Regulatory Research, United States Nuclear Regulatory Commission and the Office of Health, United States Department of Energy.

THE OPTIMIZATION PROCEDURE

The optimization procedure we use is, in essence, very simple. The basic steps of the procedure are shown in Figure 1. We start by comparing a particular option for removing contamination with existing conditions in which "nothing is done." The benefits of the option are examined first. There are initial benefits and there are annual benefits which one would get during the lifetime of the project. To make comparisons simple, the periodic annual benefits are converted to a present-day value by means of a present-worth factor, which is added to the initial benefits to obtain the total aggregate benefits. The procedure is repeated for initial costs and annual costs to arrive at a figure for total aggregate costs. The ratio of benefits to costs gives the benefit/cost ratio, R. The difference between the benefits and costs gives the net benefit, Q. The analysis also shows the dose savings from the proposed option.

The next option is considered in a similar manner and compared the benefit/cost ratio R and net benefit Q with the previous option until all reasonable alternatives have been exhausted. The option with the highest value of R is then the most cost-effective option. The option with the highest net benefit Q provides the largest dollar savings.

One may wish to keep the analysis very simple if the problem is small, or to pursue it very rigorously, considering every factor that has an impact on the problem. In the latter case, it is advisable to use a personal computer spreadsheet program. Once the spreadsheet program has been set up, by making a few changes, new options can be examined. Moreover, by using a spreadsheet, one can quickly analyze the sensitivity of the solution to changes in a parameter.

FACTORS THAT AFFECT OPTIMIZATION

Several factors need to be examined to carry out optimization. First, a monetary value for a unit of radiation dose is needed. This may be confined to whole-body dose, but, in some cases, values for single units of skin and extremity dose. A monetary value for a unit of dose is required because without it one cannot rationally compare dollar costs with dose savings.

Second, one needs to know how much work efficiency would improve if the environment was cleaner. Thus, one needs to know how much a worker's efficiency is reduced by working in a contaminated environment. A related question is what level of protective apparel should be used under various levels of contamination. Thus, as an area is cleaned, less and less cumbersome attire should be required, saving costs and improving the worker's efficiency.

Third, occupational workers require less training if they are working in an area that is not contaminated; this fact, too, needs to be factored into the optimization process.

Finally, a clean environment needs less contamination monitoring and fewer radiation surveys, which will save time and reduce costs. Therefore, it should be factored into the optimization process.

MONETARY VALUE ASSOCIATED WITH A PERSON-REM

In using the optimization procedure, costs and savings may involve both money and dose. For a proper comparison, everything should be in the same currency; therefore, a monetary worth for a unit of collective dose is required, i.e., a dollar equivalent value for a person-rem. There are several approaches to do so. We suggest a simple approach which is based on the fact that when people are exposed to a dose that exceeds the administrative limit set by the organization, then they have to be removed from radiation work and replaced. Although this is a simplification, it has several advantages: first, one can calculate a dollar value not only for whole-body dose, but, by analogous reasoning, for skin and extremity dose. Second, instead of making the dollar value a static entity, it takes into account inflation in the cost of dose as salaries increase. In the final analysis, an organization has to decide how many dollars it is prepared to spend in saving dose to its workers. Once the value is approved, a factor can be applied to make the needed adjustments. This arbitrary factor is called the "utility dose worth factor," which takes account of the organization's decision. The formula takes care of the rest, including inflation and the values of single units of skin and extremity dose. The proposal for calculating the dollar worth of a unit of radiation dose is displayed in Help Sheet 1 of Appendix B.

EFFECT OF PROTECTIVE APPAREL ON WORK EFFICIENCY

It is well known that the use of protective apparel impedes radiation workers in carrying out their tasks.[2] Unfortunately, this fact has not been adequately studied and quantified. The only detailed quantitative study we could find is one carried out in Canada by Ontario Hydro[3] (Table 1). Two things are apparent: first, gloves have the greatest effect on worker efficiency, because they have the largest effect on a worker's manual dexterity. Second, although the apparel factor for each item of apparel is small, their effect together can substantially lower a worker's efficiency.

EFFECT OF WORK DURATION ON WORK EFFICIENCY

The adverse effect of cumbersome protective apparel on efficiency is increased even further the longer the workers are required to wear it. This, too, was quantified by the Canadian study[3] (Table 2). The final effect of protective apparel on workers is the product of the gross apparel factor obtained from Table 1, and the duration factor obtained from Table 2, i.e., $U = U' \times U''$.

GUIDELINES FOR USE OF PROTECTIVE APPAREL

A set of guidelines is needed on what type of protective apparel to use under specific levels of contamination. As one cleans up, less and less protective apparel should be required. Table 3 suggests a set of guidelines based on Reference 4 and on private discussions with several U.S. and Canadian utilities. One may prefer using the protective apparel guidelines in use at one's own facility.

TYPICAL TIMES FOR OTHER TASKS ASSOCIATED WITH RADIATION PROTECTION

Apart from the above inefficiencies imposed on radiation workers from a contaminated environment, there are other tasks that they are required to carry out because of the contaminated environment. These tasks are carried out outside the radiation area but are related to radiation and contamination. Table 4 lists the tasks, and provides estimates of the times required to carry them out. The table is based on consultations with several U.S. utilities; they may not apply to DOE facilities or other data may be used.

TIME SPENT ON WORKER TRAINING

In dealing with a contaminated environment, it is necessary to provide extra training for the workers so they can work safely. Two utilities were consulted about the duration of training they give to their workers who work in radiation areas. The total training given is shown in Table 5. Again, facility-specific values for duration of training may be used.

GUIDELINES REQUIRED FOR CONTAMINATION CONTROL

In optimizing contamination control, a set of guidelines may be needed on the extent of radiation and contamination monitoring required for different radiation fields and levels of contamination. Tables 6 and 7 provide guidelines based on Reference 5 and private discussions with several U.S. and Canadian utilities. Guidelines may be preferred that are more suited to particular circumstances. However, such guidelines are essential, not only in deciding what to do in a specific set of circumstances, but also from the viewpoint of optimization.

SPECIFIC EXAMPLE OF OPTIMIZATION

The essential elements of the optimization procedure have been described. The extent of detail required is governed by the importance of the problem. One can either consider only the essential items in a simple manner or consider the problem in minute detail as accurately as possible. To assist in developing a fairly comprehensive approach, a set of four Work Sheets and two Help Sheets have been developed. Templates for these sheets are available for commercial software packages (Lotus 1-2-3 and SYMPHONY) from the ALARA Center. The optimization procedure is illustrated by an example.

The example involves a reactor facility in which the reactor cavity pool required decontamination.[6] Two options were available to clean the pool walls; the first required the use of hand scrubbing; the second used the "WEPA process" in which floor- and wall-cleaning machines could be used. The optimum solution to this problem is obtained by working through the four Work Sheets and the two Help Sheets. The following steps are required:

a. Compare the first option, "hand scrubbing," with the reference "do-nothing" case.
b. Obtain the total annual benefits by working through Work Sheet 1.
c. Use this result and Work Sheet 2 to obtain the total aggregate benefits.
d. Use Work Sheet 3 to evaluate the total aggregate cost.
e. Use Work Sheet 4 to calculate the benefit/cost ratio (R), the net benefit (Q), and the dose savings (X rem).

The results yield the savings associated with the first option. Next, repeat the procedure for the second option, using WEPA, by comparing it with the "do-nothing" scenario in a similar manner, again using the Work Sheets and the Help Sheets. The values of R, Q, and X for the two cases can be compared to arrive at the optimum solution.

The parameters R, Q, and X provide a clear understanding of the problem. R shows how many dollars of benefits accrue from each dollar spent and the highest value of Q indicates which option provides the largest savings in dollars. The highest values of X indicate those options with the largest dose savings. Thus, R, Q, and X can be used to decide which of the three parameters is most important in a particular problem; that parameter should then be used for optimization.

Other factors must also be taken into account before a decision is made. For example, the option with the highest value of Q, the highest dollar savings, may entail very high costs which the budget may not allow. The general approach should, therefore, be to first analyze the options, and then make decisions based on good common sense, which is helped by the analysis.

The two Help Sheets assist in working out related problems. The first may be used to arrive at the dollar worth of a person-rem; the second helps to calculate the total time saved for the option under consideration.

SENSITIVITY ANALYSIS

Although the above procedure seems lengthy, if a personal computer and a spreadsheet program is used then most of the numbers need be set up only once and then may be used again and again for many clean-up options. Moreover, the sensitivity of the solution to uncertainties in various parameters can be tested; this may be illustrated by the above example.

For the above optimization, a certain value for the dollar worth of a person-rem was calculated, and also the dollar savings resulting from a reduced critical path for each of the two options. Critical path time is the time during which a utility has to provide replacement power because the reactor is shut down. Any work that prolongs this time can be very expensive. Suppose one wanted to see how sensitive was the optimization to variations in these two parameters. Figures 2 illustrates what happens to the benefit/cost ratio R for each option as the dollar worth of a person-rem is varied. First, the more cost-effective option is WEPA for all dollar values of a person-rem. Second, R remains essentially constant for either option whether or not the dollar worth of a person-rem increases. The dollar value assigned to a person-rem is, therefore, not a sensitive parameter in determining the value of R and changes in it do not play a significant role in this example.

Figure 3 illustrates the variation in the value of R resulting from changes in the value of the critical path time. From experience on previous jobs, a value of 40 hours was used for hand scrubbing in the analysis. Experience at other utilities indicated 6 hours for the WEPA option. The figure shows that most of the cost-effectiveness of the WEPA process is bound up with the savings in critical path time. If there is a smaller difference in the critical path savings between the two options, then the cost-effectiveness of the WEPA process becomes more questionable.

RECOMMENDATIONS

- A serious approach to the control of contamination requires an examination of the various options to arrive at the optimum approach.
- The optimization process should be as detailed as the significance of the problem permits. For small problems, it should be simple; for large problems, it should be more detailed.
- There should be an organization-wide agreement on the base value of the dollar worth of a person-rem. This base value may be escalated over time, perhaps using the formula proposed in Help Sheet 1 (Appendix B).
- Guidelines for using protective apparel and for radiation and contamination monitoring should be evolved and followed.
- If possible, spreadsheet templates should be maintained on personal computers. The templates should carry the bulk of the information required for optimization. For specific cases, the required data should be filled out to investigate options.
- The "what if" feature of the spreadsheets should be used to see which are the most important parameters that affect the solution; these sensitive parameters should be as accurate as possible.

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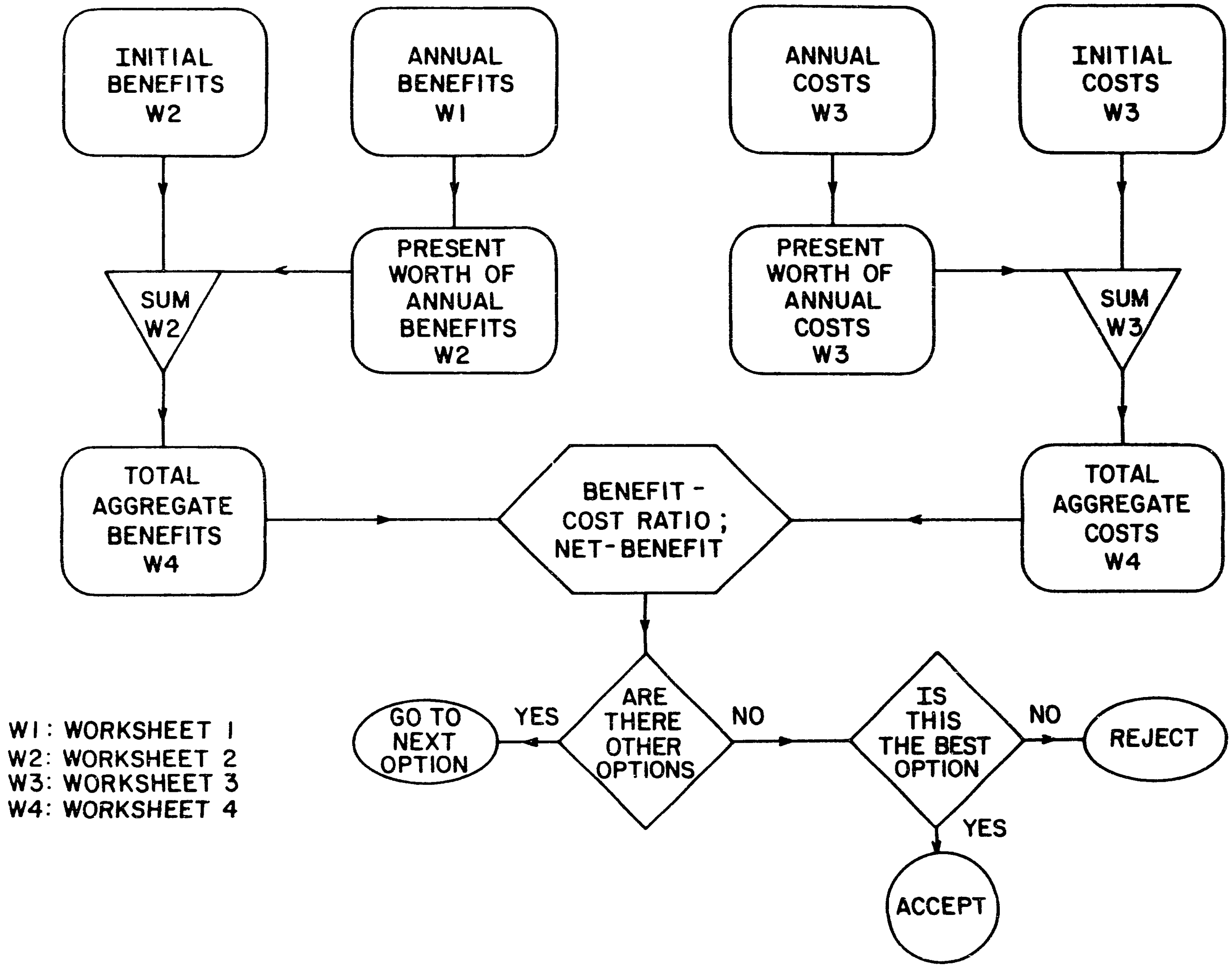
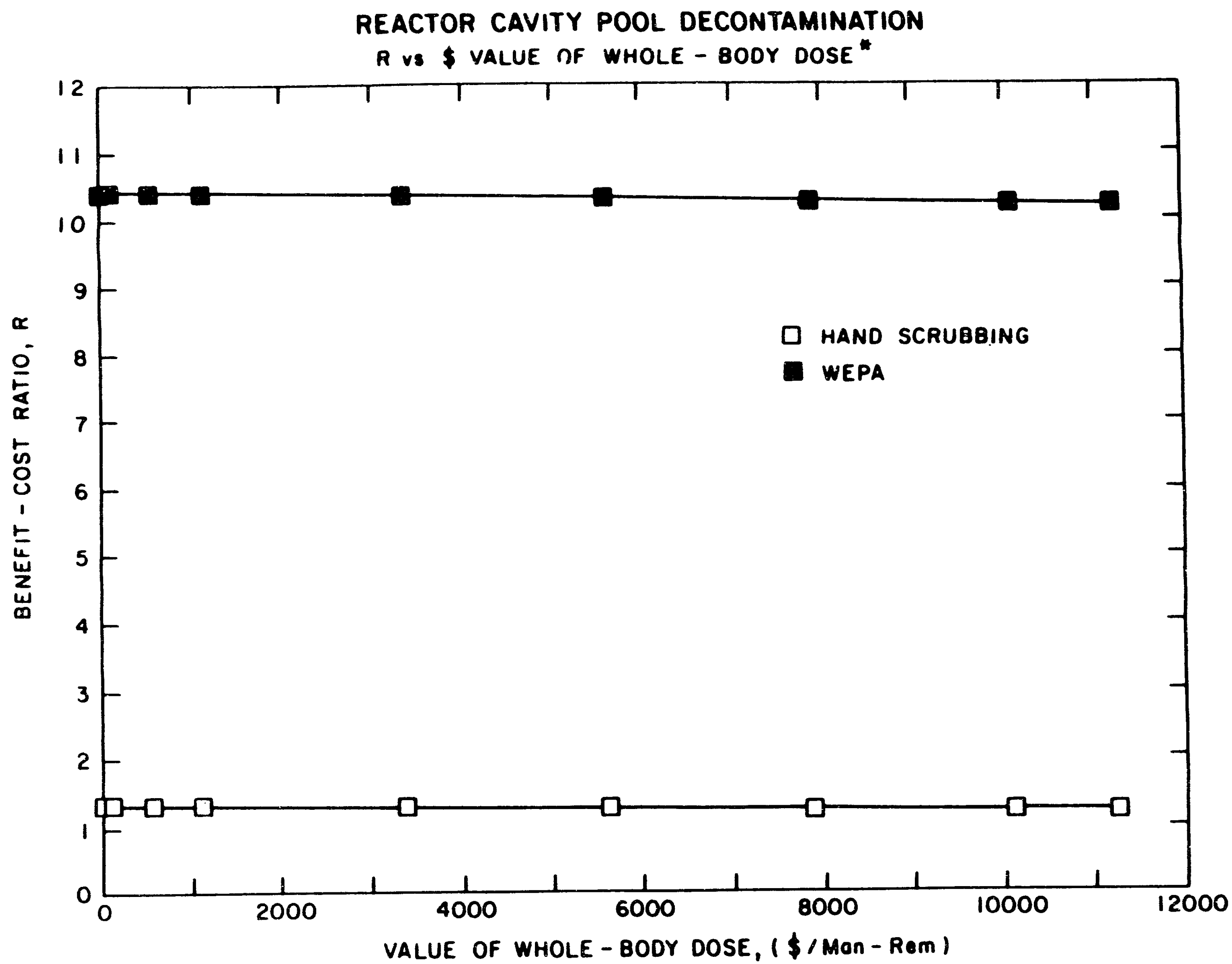

INITIAL BENEFITS W2
ANNUAL BENEFITS W1
ANNUAL COSTS W3
INITIAL COSTS W3
SUM W2
PRESENT WORTH OF ANNUAL BENEFITS W2
PRESENT WORTH OF ANNUAL COSTS W3
SUM W3
TOTAL AGGREGATE BENEFITS W4
BENEFIT - COST RATIO ; NET-BENEFIT
TOTAL AGGREGATE COSTS W4
W1: WORKSHEET 1
W2: WORKSHEET 2
W3: WORKSHEET 3
W4: WORKSHEET 4
GO TO NEXT OPTION
YES
ARE THERE OTHER OPTIONS
NO
IS THIS THE BEST OPTION
NO
REJECT
YES
ACCEPT

Figure 1



*Skin and extremity dose is proportionately affected

Figure 2

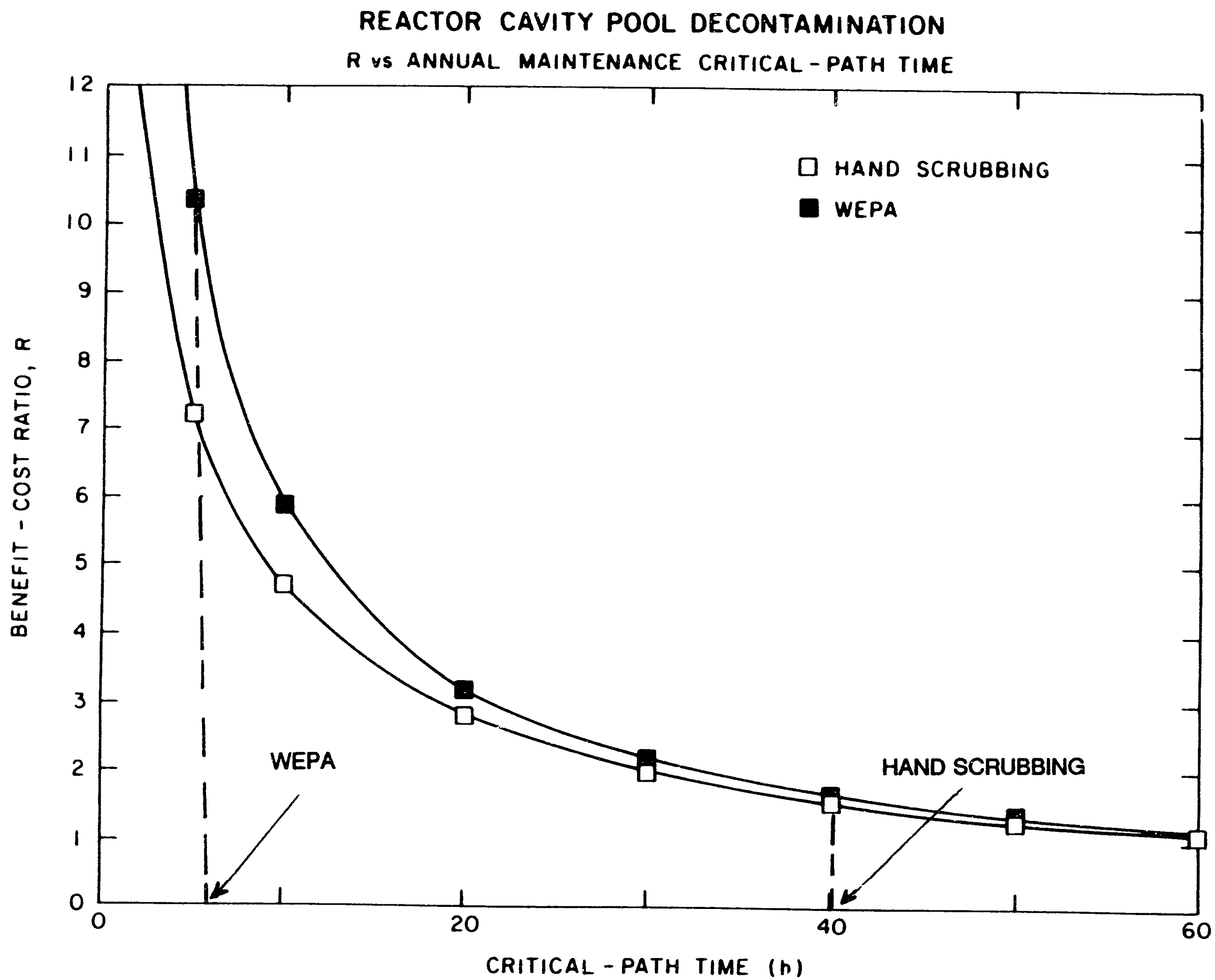

REACTOR CAVITY POOL DECONTAMINATION
R vs ANNUAL MAINTENANCE CRITICAL - PATH TIME
HAND SCRUBBING
WEPA
WEPA
HAND SCRUBBING
BENEFIT - COST RATIO, R
CRITICAL - PATH TIME (h)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
20
40
60

Figure 3

Table 1. Effect of Protective Apparel on Efficiency (Ref. 3)

Apparel	Type	Apparel Factor[1] u
Gloves	Cloth	0.90
	Rubber	0.80
	Heavy Rubber	0.50
Hood	Cloth	1.00
	Disposable	1.00
	Wet Suit	0.98
Coverall	Cloth	1.00
	Disposable	0.99
	Wet Suit	0.98
	Supplied-air	0.97
Shoe Covers	Disposable	0.97
	Rubber	0.96
Respirator	Air Purifying	0.97
	Air Supplied	0.96

[1]Gross Apparel Factor U' for a task is the product of apparel factors for each item of apparel used, i.e.,

U' = u(gloves) x u(hood) x u(coveralls) x u(shoe covers) x u(respirator)

Table 2. Effect of Work Duration in Efficiency (Ref. 3)

Work Duration (hours)	Duration Factor, U"	
	Heavy Apparel	Light Apparel
1	0.8	1.0
1 to 2	0.7	0.9
>2	0.6	0.8

Table 3. Utility Guidelines for the Use of Protective Apparel

Contamination Level dpm/100 cm^2	Apparel	Type Recommended
< 5,000	No protective clothing	
5,000 to 10,000	Gloves	Cloth and rubber or heavy rubber if necessary
10,000 to 100,000		Cloth and rubber or heavy rubber if necessary
> 100,000		Cloth, rubber, and heavy rubber (or second pair of rubber gloves)
5,000 to 10,000	Shoe covers	Rubber or disposable and rubber
10,000 to 100,000		Disposable and rubber
> 100,000		Disposable and rubber
5,000 to 10,000	Hood	Cloth or disposable
10,000 to 100,000		Cloth or disposable, and wet suit if necessary
> 100,000		Cloth or disposable, and wet suit if necessary
5,000 to 10,000	Coveralls	Cloth or disposable
10,000 to 100,000		Disposable and cloth or wet suit
> 100,000		Disposable and cloth or wet suit
> 100,000	Respirator	Full-face, air-purifying
> 10^6		Full face, air supplying

Table 4. Typical Times for Tasks Outside Radiation Area for Utilities

Item	Average time per person (hours per work shift)
Radiation and Work Control Procedures	0.5
Obtain, Put on, Take off Protective Apparel	0.3
Access Control Procedures	0.2
Dosimetry and Bioassay Procedures	0.2
Other Tasks	0.1

Table 5. Total Time Spent on Training at Two Utilities

Purpose of Training	Time Required per Person (hours/year)	
	Utility 1	Utility 2
General	160	250
Radiation Protection	40	16
Job Specific (e.g., mockup)	24	16

Table 6. Guidelines for Radiation Monitoring for Utilities

Before starting a job:

Complete radiation survey.

During the job:

Radiation Level mR/h	Action
2 to 5	TLD[1] or film badge and low-range direct reading dosimeter. No further radiation survey.
5 to 100	TLD or film badge and low-range dosimeter. Intermittent beta-gamma surveys.
100 to 1,000	TLD or film badge and dosimeters with alarms. Area monitor with alarm. Periodic beta-gamma surveys.
1,000 to 10,000	TLD or film badge and alarming and high-range dosimeters. Area monitor with alarm. Periodic beta-gamma surveys of work area during work.

[1]Thermoluninescent dosimeter (TLD).

Table 7. A Set of Guidelines for Contamination Monitoring for Utilities

Before starting a job:

Complete contamination survey of the work area.

During the job:

Contamination Level dpm/100 cm^2	Action
5,000 to 10,000	A survey of beta-gamma surface contamination if system is opened.
10,000 to 100,000	A survey of surface contamination when system is opened and intermittently after that. An air particulate sample may be necessary if contamination is stirred up during the job.
over 100,000	Periodic surveys of air particulates. Periodic surveys of surface contamination.

ALARA ASPECTS OF DECONTAMINATION AND DECOMMISSIONING AT GRAND JUNCTION

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ABSTRACT

The Grand Junction Projects Office (GJPO) of the U.S. Department of Energy (DOE) is responsible for the remediation of a variety of properties contaminated by radioactive materials resulting from the use of uranium mill tailings for construction material. The varied properties and situations require an elastic approach to the application of ALARA principles. This paper explores the process for developing health and safety plans that will meet the needs of these non-uniform projects and incorporate the safety measures and benefits of the ALARA philosophy.

INTRODUCTION

The GJPO is a government-owned site managed by Chem-Nuclear Geotech, Inc. (Geotech). Under the administration of the DOE Albuquerque Field Office (DOE-AL), the GJPO has one contractor (Geotech), and three tenants (Oak Ridge National Laboratory [ORNL], the General Services Administration [GSA], and the U.S. Army). Table 1 illustrates the historical activities conducted at the GJPO.

In 1978, the U.S. Congress enacted Public Law 95-604, creating the Uranium Mine Tailing Remedial Action (UMTRA) Project. Under this project, 24 former uranium millsites throughout the United States and properties near these millsites are to be remediated. The scope of this activity is to reduce the potential for radon-daughter concentrations associated with the uranium mill tailings to less than 4 pCi/L.

Under the UMTRA Program, the DOE-GJPO is responsible for remedial actions involving all vicinity (i.e., off-site) properties in Grand Junction, Colorado; approximately 4,000 properties with an estimated 1.2 million tons of contaminated material require cleanup.

The DOE established the Decontamination and Decommissioning (D&D) Program to provide for the safe caretaking (surveillance and maintenance) and disposition (decommissioning) of retired DOE-owned and DOE-sponsored nuclear facilities that were used for defense production and to support energy research and development of nuclear power. The DOE-GJPO has three D&D projects: the Grand Junction Projects Office Remedial Action Project (GJPORAP), the Monticello, Utah, Vicinity Properties (MVP) Project, and the Monticello, Utah, Remedial Action Project (MRAP).

[1]Work conducted under the auspices of the U.S. Department of Energy, DOE Contract No. DE-AC04-86ID12584.

Table 1. Historical Use of the Grand Junction Projects Office.

August 1943	GJPO facility land acquired by the U.S. War Department for the Manhattan Engineer District.
1943–45	U.S. Vanadium Corporation (USVC) constructed and operated a central refinery for the Federal Government for the purpose of roasting and further concentrating green sludges of uranium oxide that were obtained as by-products of vanadium production.
December 1947	Colorado Raw Materials office was established by the Atomic Energy Commission (AEC) to manage the domestic uranium procurement program.
1953	Pilot-plant program initiated with construction of a small plant for the research and development of a resin-in-pulp milling process.
1954	Pilot-plant program dedicated to amenability testing of uranium ores and the development and testing of a new uranium milling process.
1958	Pilot plant closed.
1965	Last shipment of vanadium.
1974–81	Program mission redefined establishing the National Uranium Resource Evaluation (NURE) program and the Ore Reserves Supply Analysis Program.
1975	Last shipment of uranium.
1983	A portion of the Uranium Mill Tailings Remedial Action (UMTRA) Program and several Decontamination and Decommissioning (D&D) programs assigned to the GJPO.

During the 1950s and 1960s, before the hazard associated with mill tailings was identified, uranium mill tailings were used in western Colorado and eastern Utah as material for construction. Uranium mill tailings were used in many aspects of construction: fill dirt, sand for the manufacture of bricks and concrete blocks, and for sidewalks and roadbeds. The potential for airborne radioactivity is not solely dependent on the concentration of radioactive material in the medium being removed, but on the mechanics of removal. Highly contaminated soils may be removed with no detectable airborne radioactivity, while concrete with low levels of contamination may present a significant airborne radiological hazard because of the aggressive and destructive method required for removal.

The random manner in which the tailings were acquired for construction activities resulted in varied concentrations of contaminants in each property. The early processes of uranium extraction were inefficient and the tailings retained high concentrations of uranium. Later processes were more efficient, resulting in a lower uranium content. As a result of this difference, each property may display radically different concentrations of contaminants throughout the course of remediation.

The As Low As Reasonably Achieveable (ALARA) program must be flexible enough to adjust protective requirements as the radiological conditions change. In addition to considerations of worker safety, the program also must have the latitude to evaluate the impact of the work in progress on adjacent properties and occupants.

The health physics technicians and the responsible health physicist must be alert for changing conditions following the initial ALARA assessment. Unlike the controlled environment existing around a reactor or processing facility, control of emissions from a property under remediation is virtually impossible. The ALARA evaluation and the ALARA program must include an evaluation of the exposure impact on the general public.

In addition, the health physicist must evaluate the historical use of a given property or facility that may have involved the use of nonradiological hazardous materials (e.g., toxic materials, heavy metals, and carcinogens). These conditions, each with their own unique control requirements, must also be considered in each ALARA evaluation.

APPROACH

When a property is identified as an included property (a property under the cognizance of the UMTRA/D&D Programs), the following sequence is initiated:

1. Inclusion survey—a survey structured to assess the radiological conditions present is performed on an undisturbed property or facility.
2. Historical investigation—an investigation is conducted by reviewing historical property records and holding discussions with nearby residents, the property owner, and (in some cases) the previous owners.
3. Hazardous waste investigation—an investigation is often conducted that consists of the collection and laboratory analysis of soil samples in the area to determine the presence of hazardous materials mingled with the radioactive materials.
4. Development of a Radiological and Engineering Assessment (REA)—this document is the basic work plan to identify the radiological conditions in the general area, other hazardous materials, surface and subsurface levels of contamination, and the location and contents (if possible) of tanks and underground objects, or other hazards pertinent to the accomplishment of the remediation activities.
5. Development of the Project Health and Safety plan—this document defines the personal protective measures required, the engineering controls, area boundaries, and the specific approach to the removal of contaminants.
6. Property remediation—the removal of contaminants identified in the previous steps resulting from a DOE operation or process on the property.

   NOTE: As the excavation of contaminants progresses during the remediation process, it is often necessary to re-evaluate the property and associated hazards.

Typical environmental remediation projects exhibit a negligible external radiation hazard. The ALARA planning must be based on analytical data, a prediction of the hazard associated with the contaminants contained in the soil, and the methods used in their removal.

The ALARA controls required for these properties are designed to limit the potential for an intake of airborne radioactivity by occupational workers and the general public. Techniques for the reduction of airborne contaminants (i.e., ventilation, dust suppression, containment) must be implemented carefully to ensure that adjacent properties and residents are not affected and that the potential for transport of contaminated materials outside the boundaries of the property under remediation is not increased.

In the clearly regulated world of reactors, general area radiation levels are typically constant for a given reactor configuration or mode of operation. The sources of airborne radioactivity are known and, in most cases, controllable and stable. The health physicist is able to evaluate current survey data and system contents to easily identify potential sources of airborne radioactivity and maintenance situations that could cause a change in a previously identified radiological condition. The remediation of a property under the cognizance of the

UMTRA or D&D Program is not as orderly. The radiological conditions and the presence of other hazardous materials identified before the start of work may change with each cubic yard of soil removed.

The health physicist performing an ALARA evaluation for a remediation project must review the location and form of contamination, the concentration of radioactive materials, and the proposed method of removal. The information available from this review can be applied to determine the necessary personal protective equipment, type and feasibility of engineering controls, and the practicality of implementing these controls.

In some cases, where the property owner was employed in a mining or milling operation, there are private collections of ore which may pose a significant radiological hazard to the homeowner and the occupational worker. Because this naturally occurring material is not regulated, the health physicist must be constantly alert for these privately owned sources of exposure. Typically, if the property owner insists on retaining these souvenirs after they are aware of the hazard, the hazards are clearly identified, and controls necessary for the protection of the occupational worker are implemented. This is just one example of the unusual situations frequently encountered in environmental remediation.

Work involving a low external radiation hazard and a significant internal radiation hazard requires an aggressive personnel monitoring program. Area air-sampling devices must be placed so that the general area conditions are accurately measured, and lapel air samplers must be provided to workers to ensure accurate assessment of personnel exposure. As a side benefit, this sampling regimen also ensures the proper implementation of the internal dosimetry program.

It is appropriate to note that the sample data is retrospective in nature; therefore, accurate time record keeping is essential for assessing worker exposure.

The guidance provided by PNL-6577, Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels That Are As Low As Reasonably Achievable (ALARA), may be readily adapted to an UMTRA/D&D Program.

The UMTRA/D&D programs are unique in that the exposure hazard is typically from internally deposited radionuclides as opposed to the quantifiable external exposure hazards. Constant vigilance is required to ensure unsuspected changes if the radiological conditions are identified quickly.

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ALARA PROGRAM IMPLEMENTATION: PROBLEMS AND ISSUES

Chairperson:

A.A. Weadock (Department of Energy - Office of Health)

DOE ALARA WORKSHOP
BROOKHAVEN NATIONAL LABORATORY
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Comments from the Participants

ALARA PROGRAM IMPLEMENTATION - PROBLEMS AND ISSUES

Implementation of the ALARA program on the Uranium Mill Tailing Remedial Action Project (UMTRAP) presents many challenges. The most difficult problem is that of enforcing the ALARA program on fixed-price construction subcontractors. The ALARA concept is very subjective and highly dependent upon one's point of view (i.e., HP staff vs. fixed-price subcontractor), and unless specific limits are provided, making a reasonable fixed-price bid can be very difficult. Further, if limits are specified to the subcontractors when bids are solicited, requiring action beyond those limits constitutes a change to the contract which leads to renegotiations of the contract, and invariably, costs the DOE more money.

Another difficulty with implementing the ALARA program on UMTRAP is the fact that exposures are currently very low and it is difficult to further reduce doses. Engineering controls, and the use of respirators, when necessary, have effectively controlled intakes to the point where there has not been a confirmed uptake. The average annual effective dose equivalent from external exposure was 6 millirem in 1991, which is typical. The only reasonable means to further reduce external exposure would be reducing the time personnel spend in controlled areas. Furthermore, the public is currently, and will continue to be, exposed to radon and radon daughters as long as these piles of tailings remain unremedied. Therefore, remediation of UMTRAP sites in the most expeditious and controlled manner possible is ALARA. - ***R. Jacobs, CWMFES, UMTRAP.***

The Fernwald Environmental Management Project (FEMP) is a former Uranium foundry currently undergoing CERCLA restoration and remediation. Uranium contamination is widespread. During 1991, the total dose recorded was 53.3 Person-Rem. Of this, 19 Person-Rem was attributed to easily tracked high dose-rate tasks involving FEMP's inventory of radium and thorium. The remaining 34.3 Person-Rem is attributed to routine activities involving the uranium inventory and contamination. The major problems at FEMP are as follows:

- There are many jobs that occur in a low-dose-rate environment.
- Each worker has multiple tasks.
- The ALARA concept needs adaptations for the control and reduction of contamination.

M.E. Crotzer, Radiological Safety, Fernwald Environmental Management Project

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I feel that our major problem in implementing a more effective ALARA program is the age-old problem of communication. It has been my experience that people respond when they know the driving force behind the issues (and agree with it). I'm of the opinion that a major help in getting the word out is the incentive (small reward) program. We have endeavored to do this, but so far have not been successful in convincing the financial comptrollers to make the monies available. - ***N.G. Reece, EG&G Idaho.***

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ALARA PROGRAM IMPLEMENTATION - PROBLEMS AND ISSUES

Problems with the ALARA Program at the Idaho Chemical Processing Plant (ICPP)

The primary problem concerning ALARA at the ICPP involves the control of access to radiation areas. Personnel may enter several radiation areas (routine inspections) or may make multiple entries into areas with low levels of exposure without having a TLD badge assessment. There is no way to track incidental exposure.

Another problem we face is the retrieval of information from several computer program systems. Cross-referencing these systems is very time consuming.

Currently, there is no method to warn us or otherwise indicate when the total exposure for a specific job is approaching, or exceeding the forecasted exposure, which should result in a re-evaluation of that job. Presently, several access control systems are being evaluated. - ***R. Reavis, WINCO-Westinghouse Idaho, Nuclear Company, Inc.***

The As Low As Reasonably Achievable (ALARA) concept has been a fundamental operating principle and commitment since the formation of the Waste Isolation Division (WID) by Westinghouse to develop and operate the Department of Energy's (DOE's) Waste Isolation Pilot Plant (WIPP) near Carlsbad, NM. ALARA commitments are formed in applicable procedures at WIPP. Recently, WID speculated that a more focused ALARA authority, outside that shared by the Radiological Engineering and the Operational Health Physics sections, might more effectively steward WID's ALARA program. The ALARA program was, therefore, recently contracted to the Safety Analysis and Review Section.

To date, there have been no major problems implementing the ALARA program at WIPP, largely because no wastes have been permitted to be shipped to WIPP. The WID does anticipate that the challenge will come from tracking the effectiveness of the program in terms of exposure reductions and the complications of including hazardous materials (chemicals) under the program auspices. - ***Don Mayfield, Westinghouse, WID***

The problems that we face at Argonne National Laboratory-East are the following:

- Establishing the need for a formal ALARA program in a low-dose environment.
- Developing a separate program document (primarily for auditability) vs. incorporation into an already thick ES&H manual.
- Setting up pre-experiment reviews in a multi-disciplinary research environment, and keeping track of visitors, term appointees, and students.
- Dealing with conflicting requirements in DOE guidance.

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Comments from the Participants

ALARA PROGRAM IMPLEMENTATION - PROBLEMS AND ISSUES

- Convincing people that "we've always done it that way" is not necessarily a good reason for continuing to do it so.
- Convincing radiophobic people that ALARA does not mean zero acceptable dose.
- Getting timely input from divisions for goal setting and tracking.
- Dealing with confusion between annual administrative control limits (1.5 rem/yr), monthly administrative control guides (100 mrem/mo), and ALARA goals.
- Having no DOE guidance on the dollar value of detriment of a person-rem.

Richard E. Toohey, Argonne National Laboratory - East

Our biggest problem currently is to try to convince our staff to live and breathe ALARA, when our largest dose in the last three years was 1200 mrem and our average dose is 34 mrem. - ***Grant Ceffulo, Battelle, PNL***

At Oak Ridge National Laboratory, there are different divisions arranged more or less according to academic discipline (research divisions, e.g., Biology, Physics, Chemical Technology) or type of operation (functional divisions, e.g., Research Reactors, Radiation Protection, Waste Operations). As is often stated, but only half in jest, these are run like separate companies, each having a great deal of autonomy. Many people, including some Health Physicists (HPs), think ALARA should be left to the HPs assigned to cover a division's work and to the divisional Radiation Control Office (RCO) -- anybody can "do" ALARA, in this view. This makes it hard for our ORNL ALARA program to assert any authority or extend their scope beyond what is provided in the Health Physics Manual of procedures. Yet with the DOE Orders invoking ALARA (5480.11, 5400.5, 6430.1A), the draft Implementation Guides for 5480.11, and the proposed 10 CFRs, it is clear that having these field HPs and the RCOs try to implement ALARA so as to meet all requirements is ridiculous. They do not have the time, nor, in many cases, the understanding to do so. In particular, ALARA design reviews and optimization may confuse them or be incorrectly carried out. On the other hand, a central ALARA group such as ours can cost-effectively do this. In addition, a quasi-independent ALARA group can be -- and has been in our case -- useful in the investigation of incidents. We are more accepted now than we were at first (late 1989), but we are trying to see how design reviews and optimization can be worked into the "every division for itself" organization at ORNL. - ***Janet Westbrook, Oak Ridge National Laboratory***

DOE ALARA WORKSHOP
BROOKHAVEN NATIONAL LABORATORY
UPTON, NY 11973

Comments from the Participants

ALARA PROGRAM IMPLEMENTATION - PROBLEMS AND ISSUES

The Sandia National Laboratories (SNL) ALARA program is, for the first time, being formalized into a standard program document which identifies management, health physics, and employee responsibilities. Because the program document will require standardization (ie. reporting, tracking training) effort will be, and has been, focused on getting "buy in" from the line organizations. Training is expected to require a large amount of time and incur one of the largest costs of the program. The diversity of work at SNL has also required many customized ALARA plans to be generated. - ***Martha Charles, Sandia National Labs, Health Physics org: 7714***

I was recently assigned to the Hot Cell facility as the Radiological Engineer. This is an old facility with many cell penetrations. A major problem with radiation beams being emitted from these cells was recently identified. The existence of a particular beam is dependent on the location of the source within the cell. Past practice has not required radiation surveys each time the source was moved within the cell. It is believed that in the past as the source was moved around within the cells, undetected radiation beams were created. These beams may have contributed to the exposure of the facility personnel. - ***Christine Baccus, Power Reactors Program, EG&G, Idaho***

OPERATIONAL EXERCISES
ON
COST-BENEFIT METHODOLOGIES

Workshop Proctors:

John Baum (BNL)
Robert Brown (Westinghouse Hanford)
Bruce Dionne (BNL)
Bruce Mann (BNL Consultant)
Steven Masciulli (BNL Consultant)

COST-BENEFIT METHODOLOGY
INSTRUCTIONAL PORTION

The purpose of this operational exercise is to demonstrate a method of how to decide if an ALARA protective measure (APM) is cost-effective or considered reasonable to implement. The objective is to successfully perform net benefit and multi-attribute analyses for an ALARA protective measure, using the data and worksheets provided. The methodologies that will be used are a composite between the cost-benefit analysis used at Westinghouse Hanford Company and radiation detriment values and cost-benefit worksheets developed at Brookhaven National Laboratory. The assumptions that will be used for this operational exercise are as follows:

- Time frame for analysis is short
- No escalation of costs
- No carrying charges for capital investments
- No property taxes for capital equipment
- No depreciation for capital equipment
- No allowances made for uncertainties in estimates

It is important to note that as a result of these and other simplifying assumptions, these analysis results will only be approximations and should therefore be used only as a screening tool. ALARA protective measures that will require significant capital investments in excess of tens of thousands of dollars should undergo a more rigorous analysis using standard engineering economics.

There are four major steps to this cost-benefit methodology (see the ALARA Protective Measure Analysis Flow Chart):

1. Define the radiological problem,
2. Perform the overriding factor analysis,
3. Calculate the net benefit, and
4. Perform the ALARA factor analysis.

The types of data that will be needed to define the problem are a written description of the radiological problem, a description of the alternatives for protective measures, the time frame for which the protective measure will be used, the savings, the costs, and the estimates for collective and maximum individual dose (see Worksheet Part A).

After the problem is defined and the data are collected, an overriding factor analysis is performed. This involves asking such questions as:

- Will a violation of a DOE Order, federal regulation, or state law occur?
- Will a violation of a collective bargaining agreement occur?

These questions are answered yes or no for each scenario: an APM should be implemented or an APM should not be implemented (see Worksheet Part B). If there are overriding criteria against implementing the APM, then it is not justified. Conversely, if there are overriding criteria for implementing the APM, then it is justified regardless of the costs or benefits.

Next, the net benefit analysis will be performed. First, one must calculate the marginal or differential economic benefits, including such benefits as maintenance labor savings, operational/production savings, inspection/surveillance savings, process efficiency/reliability savings, as well as other miscellaneous saving (see Worksheet Part C). Second, one must calculate the marginal potential costs, such as those costs associated with design and engineering; materials, equipment and fabrication; installation/construction; training and procedures;

operating and maintenance; as well as other miscellaneous costs, e.g., chemicals, consumables, special tools, and radwaste disposal (see Worksheet Part D). Third, one must calculate net dose savings. This equates to the dose associated with the existing radiological activity minus the dose with the APM implemented and the dose to implement the APM (see Worksheet Part E).

Next, one must evaluate whether or not the net benefits are positive. To obtain the net benefit, one subtracts from the estimated economic benefits (Box C in Worksheet Part C) the estimated economic costs (Box D in Worksheet Part D). In addition, one must add the benefits to be accrued by the dose savings to the net benefit. But, to do this one needs to convert the net dose savings (Box E in Worksheet Part E) to its equivalent dollar value. For this exercise, a two-tiered detriment value system will be used which is based on a study on the evaluation of a unit of dose performed by Brookhaven National Laboratory. This methodology is based on the estimated dose to the maximum individual without the protective measure. A value of $2,000 per person-rem is suggested as a nominal value for low dose operations where the maximum individual is estimated to receive a dose less than 1 rem/yr. An upper level value for dose detriment of $10,000 per person-rem will be used for those high dose activities where the maximum individual is estimated to receive a dose equal to or greater than 1 rem/yr.

If, after adding the benefit of net dose savings expressed in dollars, for the lower level detriment value of $2,000 to the previously calculated economic net benefit (see Worksheet Part F), the net benefit is greater than zero, then the protective measure is justified. If, on the other hand, it is not; then an ALARA factor analysis should be performed (see Worksheet Part H). If for the upper level net benefit evaluation, i.e., $10,000/person-rem, the net benefits are not less than zero, then an ALARA factor analysis should be performed (see Worksheet Part H). If, on the other hand, the net benefits are less than zero, then the measure is not justified. However, at this point, one could perform a case-specific evaluation to determine if assignment of a radiation detriment value of greater than $10,000 per person-rem is warranted. This could result in the measure being justified.

Finally, for those situations in which an ALARA factor analysis will be required, one must answer yes or no to the questions that deal with qualitative factors and enter the value of the corresponding weighting factor into either the yes or no box. If, after tallying these weighting factors, the yes total is greater than that for the no answers, the APM should be accepted based on qualitative factors. If the no answer total outweighs that for the yes answers, or if they are equal, the APM should be rejected or accepted based on other factors.

Five operational problems requiring cost-benefit analysis will be evaluated using the methodology described above. The answers to these problems also will be provided.

COST-BENEFIT ANALYSIS WORKSHEETS

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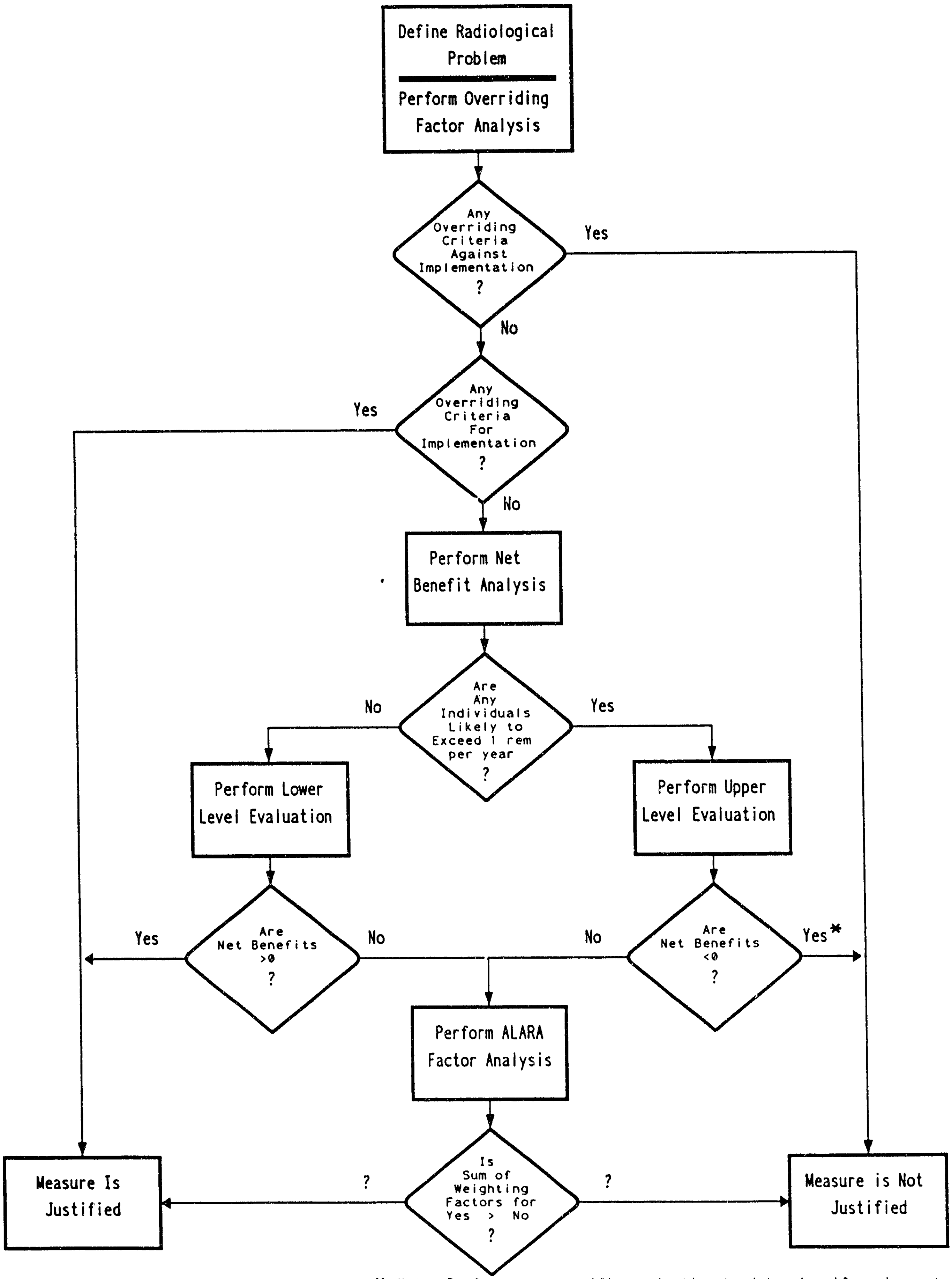
ALARA Protective Measure Analysis - Flow Chart



* Note: Perform case specific evaluation to determine if assignment of radiation detriment cost > 10K per person rem is warranted.

PART A. RADIOLOGICAL PROBLEM DEFINITION

1. Describe the facility, its present radiological conditions, and the radiological activity of concern.

2. Describe the proposed ALARA protective measure (APM).

3. Determine the relevant time frame for estimation of cost elements and exposure impacts.

4. Identify the cost savings associated with the implementation of the APM, e.g., maintenance labor, operations labor, inspection labor, production, processing, salvage, reduced chemicals, reduced consumables, reduced radwaste.

5. Identify the cost elements for implementation of the APM, e.g., design and engineering, equipment procurement, fabrication, installation or construction labor, operation, maintenance, associated training and procedure, additional chemicals, additional consumables, special tools, additional radwaste.

6. Estimate the collective dose without the protective measure, with the protective measure, and to implement the protective measure. Determine, if possible, the maximum individual dose for the present or existing radiological activity.

PART B. OVERRIDING FACTOR ANALYSIS

Overriding Factors	For each question, indicate either YES or NO	
	If Implemented	If Not Implemented
1. Will a DOE order, federal regulation, or state law be violoated?	________	________
2. Will significant quantities of radioactive materials be added to the site?	________	________
3. Will a collective bargaining agreement be violated?	________	________
4. Will the worker administrative dose control level(s) be exceeded?	________	________
5. Will a safety-related activity not be completed because a specially trained, skilled, or certified worker is unavailable?	________	________
6. Other factors (please describe).		
______________________________		
______________________________		
______________________________	________	________
______________________________		
______________________________		
______________________________	________	________

7. Conclusion (Explain how YES answers to the above questions are overriding factors).

____
____
____

8. Discussion (basis and references).

____
____
____
____
____
____
____

PART C. APM BENEFIT CALCULATION

Benefits	Quantity	Unit Cost	Cost	Item(s)
C-1 **Maintenance Labor** Enter the total estimated labor savings for the protective measure. Obtain the estimated total maintenance hours saved. Obtain the appropriate dollar/hour rate for maintenance from the Cost Control Group. Enter the product(s) on line(s) for items C-1.	______ ______ ______	______ ______ ______	______ ______ ______	C-1
C-2 **Operations/Production Labor** Enter the total estimated operation/production labor savings for the protective measure. Obtain the estimated total operation hours saved. Obtain the appropriate dollar/hour rate for operations from the Cost Control Group. Enter the product(s) on line(s) for items C-2.	______ ______ ______	______ ______ ______	______ ______ ______	C-2
C-3 **Inspection/Surveillance Labor** Enter the total estimated inspection/surveillance labor savings for the protective measure. Obtain the estimated total inspection hours saved. Obtain the appropriate dollar/hour rate for inspection from the Cost Control Group. Enter the product(s) on line(s) for items C-3.	______ ______ ______	______ ______ ______	______ ______ ______	C-3
C-4 **Efficiency and/or Reliability Savings** Enter the total estimated savings associated with production or processing improvements provided by the protective measure. Enter the dollar amount of these savings on line(s) for items C-4.	______ ______ ______	______ ______ ______	______ ______ ______	C-4
C-5 **Miscellaneous Savings** Enter estimated savings from miscellaneous items (e.g., salvage value of old equipment, reduced chemical and consumable materials, reduced radwaste). Enter the dollar amount of these savings on line(s) for items C-5.	______ ______ ______	______ ______ ______	______ ______ ______	C-5

TOTAL ECONOMIC BENEFITS
Enter the total estimated benefits of the protective measure. Add all savings from lines for items C-1 through C-5, and enter total into Box C.

Grand Total →

Box C

PART D. APM COST CALCULATION

Costs	Quantity	Unit Cost	Cost	Item(s)
D-1. **Design and Engineering** Enter the total estimated design engineering cost for the protective measure. Obtain the estimated hours to design and engineer the productive measure. Obtain appropriate dollar/hour rate for engineering from the Cost Control Group. Enter the product(s) on line(s) for item(s) D-1.	______ ______ ______	______ ______ ______	______ ______ ______	D-1
D-2. **Capital Equipment, Fabrication, Material** Enter the total estimated capital costs of equipment, fabrication, and materials for the new technique. Include "up front" hidden costs such as R&D, certification, patent rights, etc. Enter product(s) on line(s) for item(s) D-2.	______ ______ ______	______ ______ ______	______ ______ ______	D-2
D-3. **Installation or Construction** Enter the total estimated labor costs to install the protective measure. Obtain the estimated total hours of station and contractor personnel to install. Obtain the appropriate dollar/hour rate for station and contractor labor. Enter the product(s) on line(s) for item(s) D-3.	______ ______ ______	______ ______ ______	______ ______ ______	D-3
D-4. **Implementation: Procedure, Training, Administrative Costs** Enter the estimated costs for training, procedure development, and associated additional O&M protective measure (additional O&M being a negative savings obtained in lines C-1, C-2, and C-3 above from the difference between the existing and the protective technique costs for operations, maintenance, and inspection). Enter the product(s) on line(s) for item(s) D-4.	______ ______ ______	______ ______ ______	______ ______ ______	D-4
D-5 **Operation and Maintenance** Enter the total estimated cost to operate and maintain the protective measure. Obtain the estimated hours to maintain and operate. Obtain the appropriate dollar/hour rate for each work group. Enter the product(s) on line(s) for item(s) D-5.	______ ______ ______	______ ______ ______	______ ______ ______	D-5
D-6 **Miscellaneous Costs** Enter the estimated total costs for miscellaneous items (e.g., chemicals, consumable materials, special tools, additional radwaste). Enter the product(s) on line(s) for item(s) D-6.	______ ______ ______	______ ______ ______	______ ______ ______	D-6

<u>TOTAL ECONOMIC COST</u>
Enter the total estimated costs of the protective measure. Add all the costs from lines for items D-1 through D-6 and enter the total into Box D.

Grand Total → [ ]

Box D

PART E. DOSE ESTIMATE

Description of Radiological Activity	Work Group or Number of Persons	Exp-Hr	Average Dose Rate	Person Rem	Item(s)
E-1. **Existing or Present Radiological Activity**	Enter the existing man-hours to perform activity, maintenance, operate, inspect, process, or produce. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-1.				
____________	______	______	______	______	E-1
____________	______	______	______	______	
____________	______	______	______	______	
____________					
E-2 **Dose with APM Implemented**	Enter the total man-hours with the protection measure for maintenance, operation, inspection, processing, and production. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-2.				
____________	______	______	______	______	E-2
____________	______	______	______	______	
____________	______	______	______	______	
____________					
E-3 **Dose to Implement APM**	Enter the total estimated dose to implement or install the protective measure which will result from it (i.e., negative result from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, inspect new technique) on line(s) for item(s) E-3.				
____________	______	______	______	______	E-3
____________	______	______	______	______	
____________	______	______	______	______	
____________					
____________					

<u>NET DOSE SAVINGS</u>

Enter total estimated dose saved for the protective measure (i.e., positive results from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, maintain, inspect with protective measure plus the dose to implement the APM) in Box E.

E1-E2+E3 = → [ ]

Box E

PART F. LOWER-LEVEL NET BENEFIT EVALUATION

Cost/Benefit	Dollars	Item(s)
F-1 **Estimated Economic Benefits** Enter the results from Box C on line for item F-1.	________	F-1
F-2 **Estimated Economic Costs** Enter the results from Box D on line for item F-2.	________	F-2
F-3 **Net Economic Benefit (Costs)** Estimated benefit on line for item F-1 minus estimated cost on line for item F-2. Enter (F-1) - (F-2) on line F-3.	________	F-3

Net Dose	Person-Rem	Dollars/ Person-Rem	Dollars	Item(s)
F-4 **Net Dose Savings** Enter the result from Box E and multiply by 2,000 S/person-rem. Enter result on line for item F-4.	________	x $2,000 =	________	F-4

<u>Net Benefit</u>
Net benefit on line F-3 plus the dollar value of the net dose savings on line for item F-4, i.e., (F-3) + (F-4).

Box F

<u>Net Benefit Decision Index</u>	Accept	Reject	Indifferent
Depending on the value Net Benefit, circle one of the following:	>0	<0	0

If the net benefit is >0, accept the protective measure.

If the net benefit is ≤0, perform an ALARA Factor Analysis.

PART G. UPPER-LEVEL NET BENEFIT EVALUATION

Cost/Benefit	Dollars	Item(s)
F-1 **Estimated Economic Benefits** Enter the results from Box C on line for item F-1.	________	F-1
F-2 **Estimated Economic Costs** Enter the results from Box D on line for item F-2.	________	F-2
F-3 **Net Economic Benefit (Costs)** Estimated benefit on line for item F-1 minus estimated cost on line for item F-2. Enter (F-1) - (F-2) on line for item F-3.	________	F-3

Net Dose	Person-Rem	Dollars/ Person-Rem	Dollars	Item(s)
F-4 **Net Dose Savings** Enter the result from Box E and multiply by 10,000 \$/person-rem. Enter result on line for item F-4.	______	x \$10,000 =	______	F-4

<u>Net Benefit</u>
Net benefit on line F-3 plus the dollar value of the net dose savings on line F-4, i.e., (F-3) + (F-4).

Box F

Net Benefit Decision Index	Accept	Reject	Indifferent
Depending on the value Net Benefit, circle one of the following:	>0	<0	0

If the net benefit is >0, proceed to Part H and perform the ALARA factor analysis.

If net benefit is ≤0, either reject the protective measure or reevaluate the upper level net benefit using a case-specific value for the radiation detriment instead of \$10,000 per person-rem.

PART H. ALARA FACTOR ANALYSIS CHECKSHEET

Questions on Qualitative Factors	W/F*	Yes	No
1. Will the maximum individual doses for occupational workers exceed 10 mrem for the duration of the relevant time frame?	3		
2. Does the APM maintain or decrease the current level of risk for occupational incidents or accidents?	2		
3. Does the APM decrease the risk of environmental incidents or accidents?	2		
4. Does the APM result in dose savings in the post-operational phase of the facility or activity?	2		
5. Does the APM result in cost savings during the post-operational phase of the facility or activity?	1		
6. Does the APM increase the flexibility of personnel or other resources?	2		
7. Does the APM result in an improved relationship with internal or external organizations?	1		
8. Does the APM decrease or maintain current level of employee exposure to adverse working conditions or extreme discomfort?	3		
9. Does the APM reduce the release of radionuclides to the environment?	3		
10. Does the APM improve or maintain the current level of operability of an activity or a facility?	3		
11. Is the APM impact on the activity schedule minimal?	2		
12. Does the APM contribute to waste minimization?	1		
TOTAL			

*Weighting factor

If the weighted factor total for "Yes" answers is greater than that for "No" answers, the APM should be accepted based on qualitative factors. If the "No" answers outweigh the "Yes" answers, or if they are equal, the APM should be rejected or accepted based on other factors.

Viewgraphs Used for
Cost-Benefit Methodology
Instructional Portion

PURPOSE

To demonstrate a method of how to decide if a protective measure is cost-effective or considered "reasonable."

1

OBJECTIVE

To make net benefit and multi-attribute analyses for an ALARA protective measure, using the data provided.

2

OPTIMIZATION/COST-BENEFIT METHODOLOGIES*

- Cost-Benefit Analysis
- Cost-effectiveness Analysis
- Multi-attribute Utility Analysis
- Multi-criteria Outranking Analysis

*See ICRP-55, Optimization and Decision-making in Radiological Protection, 1989.

3

OPERATIONAL EXERCISE
COST-BENEFIT METHODOLOGY

- Composite from Westinghouse Hanford Company Cost-Benefit Analysis[1] and BNL ALARA Center Detriment Value Range and Cost-Benefit Worksheets[2,3]

[1] Booth, G.F. and D.E. Webb (Westinghouse Hanford Company), A practical method of performing cost-benefit analysis of occupational and environmental protective measures, in Proceedings of the International Workshop on New Developments in Occupational Dose Control and ALARA Implementation at Nuclear Power Plants and Similar Facilities, held at Brookhaven National Laboratory, Upton, NY, September 18-21, 1989, NUREG/CP-0110, February 1990, pp. 153-72.

[2] Baum, J.W. (Brookhaven National Laboratory), Valuation of dose avoided at U.S. nuclear power plants," Nuclear Plant Journal, Vol. 9, No. 2, March-April 1991, pp. 40-46.

[3] Khan, T.A. and J.W. Baum (Brookhaven National Laboratory), Optimization of the Control of Contamination at Nuclear Power Plants, NUREG/CR-5038, May 1988.

4

ASSUMPTIONS FOR THESE EXERCISES

- Time frame of analysis is short
- No escalation of costs
- No carrying charges for capital investments
- No property taxes for capital equipment
- No depreciation for capital equipment
- No allowance for uncertainties in estimates
- Because of these simplifying assumptions and others, the results of these analyses are only approximations, and should, therefore, be used only as screening tools.

NOTE: ALARA Protective Measures which require significant investments should undergo a more rigorous economic engineering analysis to account for the assumptions.

5

DEFINE PROBLEM

- Describe Radiological Problem
- Describe Protective Measure
- Define Timeframe
- Identify Savings
- Identify Costs
- Estimate Collective Dose

6

Viewgraphs Used for
Cost-Benefit Methodology
Instructional Portion

OVERRIDING FACTOR ANALYSIS

1. Will a DOE order, federal regulation, or state law be violated?
2. Will significant quantities of radioactive materials be added to the site?
3. Will a collective bargaining agreement be violated?
4. Will the worker administrative dose control level(s) be exceeded?
5. Will a safety-related activity not be completed because a specially trained, skilled, or certified worker is unavailable?
6. Others (facility specific)

7

POTENTIAL BENEFITS ASSOCIATED WITH AN ALARA PROTECTIVE MEASURE

- Dose Savings
- Maintenance Labor Savings
- Operations Labor Savings
- Inspection/Surveillance Savings
- Efficiency or Reliability Savings
- Miscellaneous Savings (e.g., reduced training and procedures, reduced radwaste, reduced salvage, and reduced use of chemicals or consumable materials)

8

POTENTIAL COSTS ASSOCIATED WITH AN ALARA PROTECTIVE MEASURE

- Dose to Implement
- Design and Engineering
- Capital Equipment, Fabrication, and Material
- Installation or Construction
- Training Procedures and Administrative Costs
- Operating and Maintenance
- Miscellaneous Costs (e.g., chemicals, consumable materials, special tools, and disposal of radwaste)

9

COLLECTIVE DOSE ESTIMATES

- Dose for Existing Radiological Activity, i.e., without Protective Measure
- Dose with ALARA Protective Measure
- Dose to Implement the ALARA Protective Measure
- Annual Dose to Maximum Exposed Individual

10

NOMINAL VALUE FOR DOSE DETRIMENT

$2,000 per person-rem as a lower-level value for dose detriment for low-dose operations, i.e., < 1 rem/yr and typical DOE contractor facility

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EVALUATION OF LOWER-LEVEL NET BENEFIT

1. Estimated Economic Benefits - Estimated Economic Costs = Net Economic Benefit (Cost)
2. Net Dose Saved x $2,000 per Person-rem = Value of Dose Savings
3. Net Economic Benefit + Value of Dose Savings = Net Benefit
4. Evaluate Value of Net Benefit Against Decision Index

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NET-BENEFIT EVALUATION CRITERIA FOR LOWER-LEVEL TEST

Net Benefit (Dollars)	Decision Index		
	Accept	Reject	Indifferent
	>0	<0	0

If net benefit >0, approve protective measure.

If net benefit ≤ 0, perform an ALARA Factor Analysis.

13

UPPER-LEVEL VALUE FOR DOSE DETRIMENT

$10,000 per person-rem as upper-level value for dose detriment involving workers who may equal or exceed 1 rem/yr.

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EVALUATION OF UPPER-LEVEL NET BENEFIT

1. Estimated Economic Benefits - Estimated Economic Costs = Net Economic Benefits (Costs)
2. Net Dose Saved x $10,000 per Person-rem = Value of Dose Savings
3. Net Economic Benefit + Value of Dose Savings = Net Benefit
4. Evaluate Value of Net Benefit Against Decision Index

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NET-BENEFIT EVALUATION CRITERIA FOR UPPER-LEVEL TEST

Net Benefit (Dollars)	Decision Index		
	Accept	Reject	Indifferent
	>0	<0	0

If net benefit >0, perform ALARA factor analysis.

If net benefit ≤0, either reject, or determine a case-specific value for radiation detriment based on the cost of replacement workers, and then re-evaluate.

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ALARA FACTOR ANALYSIS

Consideration is given to qualitative factors. Several of the more common ALARA considerations are assigned weights on a scale of 1 to 3. The ALARA factor analysis provides an additional basis for the decision process for those protective measures which are not cost-effective or are marginal.

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CRITERIA FOR ALARA FACTOR ANALYSIS

- Weighted factor total for "YES" answers > total for "NO" answers -- ACCEPT
- Weighted factor total for "NO" answers > total for "YES" answers -- REJECT or ACCEPT based on other factors
- Weighted factor total for "YES" answers = "NO" answers -- REJECT or ACCEPT based on other factors

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PROBLEMS AND ANSWERS

FOR THE

OPERATIONAL EXERCISES

FOR THE

COST-BENEFIT ANALYSES

C/B ANALYSIS PROBLEM SETS

TABLE OF CONTENTS

EXERCISE NO.	TITLE
1.	ELECTROPOLISHING OF FOUR RAILROAD CARS
2.	MOCKUP OF SPECIAL NUCLEAR MATERIAL STORAGE FACILITY
3.	CLOSE CIRCUIT TELEVISION TO MONITOR THE SPENT FUEL POOL HEAT EXCHANGER ROOM
4.	CLEM-SHIELDING FOR AUTOMATED REFUELING MACHINE
5.	ROBOT FOR HANDLING RADIOACTIVE SOURCES

1. Operational Exercise: Electropolishing of Four Railroad Tank Cars

PART A. RADIOLOGICAL PROBLEM DEFINITION

1. Describe the facility, its present radiological conditions, and the radiological activity of concern.

The facility is involved in nuclear waste storage and environmental remediation. The radiological activities of concern are the Class A inspections, routine surveys, routine operations, and other scheduled inspection of 4 railroad tank cars. These tank cars are used to transport liquid waste between various storage areas on the site. The radiation levels on the empty tank car is 50 mrem/hr and involve about 150 man hrs/yr of various radiological activities.

2. Describe the proposed ALARA protective measure (APM).

The proposed protective measure is to decontaminate internal surfaces of the tank cars using the electropolishing technique. This protective measure is expected to dramatically reduce the dose rates and thereby, reduce the collective dose to perform operations, inspections, and surveys on these railroad cars.

3. Determine the relevant time frame for estimation of cost elements and exposure impacts.

The relevant time frame for the usage of these railroad tank cars is two years. It is not expected that these cars will be in use after this time frame.

4. Identify the cost savings associated with the implementation of the APM, e.g., maintenance labor, operations labor, inspection labor, production, processing, salvage, reduced chemicals, reduced consumables, reduced radwaste.

No cost savings are expected as a result of the reduced dose rates.

5. Identify the cost elements for implementation of the APM, e.g., design and engineering, equipment procurement, fabrication, installation or construction labor, operation, maintenance, associated training and procedure, additional chemicals, additional consumables, special tools, additional radwaste.

The estimated cost to perform the electropolishing decontamination on 4 railroad cars including disposal of the radioactive waste generated onsite is approximately $12,000.

6. Estimate the collective dose without the protective measure, with the protective measure, and to implement the protective measure. Determine, if possible, the maximum individual dose for the present or existing radiological activity.

The exposure impact assuming a DF of about 10 are:
Collective dose w/o protective measure: 12.2 rem
Collective dose with protective measure: 1.4 rem
Collective dose to implement protective measure: 1.4 rem
Maximum annual individual dose: 0.4 rem/yr

OPERATIONAL EXERCISE NO. 1

ELECTROPOLISHING OF FOUR RAILROAD CARS

ANSWER SHEETS

1. Operational Exercise: Electropolishing of Four Railroad Tank Cars

PART B. OVERRIDING FACTOR ANALYSIS

Overriding Factors	For each question, indicate either YES or NO	
	If Implemented	If Not Implemented
1. Will a violation of a DOE order, federal regulation, or state law occur?	No	No
2. Will significant quantities of radioactive materials be added to the site?	No	No
3. Will violation of a collective bargaining agreement occur?	No	No
4. Will worker administrative dose control level(s) be exceeded?	No	No
5. Will a safety-related activity not be completed because of the unavailability of a specially trained, skilled, or certified worker?	No	No
6. Other factors (please describe).	--	--

7. Conclusion (Explain how YES answers to the above questions are overriding factors).

No overriding factors apply to the electropolishing of 4 railroad tank cars.

8. Discussion (basis and references).

Cost-Benefit Analysis Worksheet

1. Operational Exercise: Electropolishing of Four Railroad Tank Cars

PART C. APM BENEFIT CALCULATION

Benefits	Quantity	Unit Cost	Cost	Item(s)
C-1 **Maintenance Labor** Enter the total estimated labor savings for the protective measure. Obtain the estimated total maintenance hours saved. Obtain the appropriate dollar/hour rate for maintenance from the Cost Control Group. Enter the product(s) on line(s) for items C-1.			None	C-1
C-2 **Operations/Production Labor** Enter the total estimated operation/production labor savings for the protective measure. Obtain the estimated total operation hours saved. Obtain the appropriate dollar/hour rate for operations from the Cost Control Group. Enter the product(s) on line(s) for items C-2.			None	C-2
C-3 **Inspection/Surveillance Labor** Enter the total estimated inspection/surveillance labor savings for the protective measure. Obtain the estimated total inspection hours saved. Obtain the appropriate dollar/hour rate for inspection from the Cost Control Group. Enter the product(s) on line(s) for items C-3.			None	C-3
C-4 **Efficiency and/or Reliability Savings** Enter the total estimated savings associated with production or processing improvements provided by the protective measure. Enter the dollar amount of these savings on line(s) for items C-4.			None	C-4
C-5 **Miscellaneous Savings** Enter estimated savings from miscellaneous items (e.g., salvage value of old equipment, reduced chemical and consumable materials, reduced radwaste). Enter the dollar amount of these savings on line(s) for items C-5.			None	C-5

<u>TOTAL ECONOMIC BENEFITS</u>

Enter the total estimated benefits of the protective measure. Add all savings from lines for items C-1 through C-5, and enter total into Box C.

Grand Total → 0

Box C

1. Operational Exercise: Electropolishing of Four Railroad Tank Cars

PART D. APM COST CALCULATION

Costs	Quantity	Unit Cost	Cost	Item(s)
D-1. **Design and Engineering** Enter the total estimated design engineering cost for the protective measure. Obtain the estimated hours to design and engineer the productive measure. Obtain appropriate dollar/hour rate for engineering from the Cost Control Group. Enter the product(s) on line(s) for item(s) D-1.			None	D-1
D-2. **Capital Equipment, Fabrication, Material** Enter the total estimated capital costs of equipment, fabrication, and materials for the new technique. Include "up front" hidden costs such as R&D, certification, patent rights, etc. Enter product(s) on line(s) for item(s) D-2.			None	D-2
D-3. **Installation or Construction** Enter the total estimated labor costs to install the protective measure. Obtain the estimated total hours of station and contractor personnel to install. Obtain the appropriate dollar/hour rate for station and contractor labor. Enter the product(s) on line(s) for item(s) D-3.			$10,000	D-3
D-4. **Implementation: Procedure, Training, Administrative Costs** Enter the estimated costs for training, procedure development, and associated additional O&M protective measure (additional O&M being a negative savings obtained in lines C-1, C-2, and C-3 above from the difference between the existing and the protective technique costs for operations, maintenance, and inspection). Enter the product(s) on line(s) for item(s) D-4.			None	D-4
D-5 **Operation and Maintenance** Enter the total estimated cost to operate and maintain the protective measure. Obtain the estimated hours to maintain and operate. Obtain the appropriate dollar/hour rate for each work group. Enter the product(s) on line(s) for item(s) D-5.			None	D-5
D-6 **Miscellaneous Costs** Enter the estimated total costs for miscellaneous items (e.g., chemicals, consumable materials, special tools, additional radwaste). Enter the product(s) on line(s) for item(s) D-6.			$2000	D-6

TOTAL ECONOMIC COST

Enter the total estimated costs of the protective measure. Add all the costs from lines for items D-1 through D-6 and enter the total into Box D.

Grand Total → $12,000

Box D

Cost-Benefit Analysis Worksheet

1. Operational Exercise: Electropolishing of Four Railroad Tank Cars

PART E. DOSE ESTIMATE

Description of Radiological Activity	Work Group or Number of Persons	Exp-Hr	Average Dose Rate	Person Rem	Item(s)
E-1. **Existing or Present Radiological Activity**	Enter the existing man-hours to perform activity, maintenance, operate, inspect, process, or produce. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-1.				
				12.2	E-1
E-2 **Dose with APM Implemented**	Enter the total man-hours with the protection measure for maintenance, operation, inspection, processing, and production. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-2.				
				1.4	E-2
E-3 **Dose to Implement APM**	Enter the total estimated dose to implement or install the protective measure which will result from it (i.e., negative result from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, inspect new technique) on line(s) for item(s) E-3.				
				1.4	E-3

NET DOSE SAVINGS

Enter total estimated dose saved for the protective measure (i.e., positive results from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, maintain, inspect with protective measure plus the dose to implement the APM) in Box E.

E1-E2+E3 = → 9.4

Box E

PART F. LOWER-LEVEL NET BENEFIT EVALUATION

Cost/Benefit	Dollars	Item(s)
F-1 **Estimated Economic Benefits** Enter the results from Box C on line for item F-1.	0	F-1
F-2 **Estimated Economic Costs** Enter the results from Box D on line for item F-2.	12,000	F-2
F-3 **Net Economic Benefit (Costs)** Estimated benefit on line for item F-1 minus estimated cost on line for item F-2. Enter (F-1) - (F-2) on line F-3.	-12,000	F-3

Net Dose	Person-Rem	Dollars/ Person-Rem	Dollars	Item(s)
F-4 **Net Dose Savings** Enter the result from Box E and multiply by 2,000 \$/person-rem. Enter result on line for item F-4.	9.4	x \$2,000 =	18,800	F-4

<u>**Net Benefit**</u>
Net benefit on line F-3 plus the dollar value of the net dose savings on line for item F-4, i.e., (F-3) + (F-4).

6,800

Box F

<u>**Net Benefit Decision Index**</u>	Accept	Reject	Indifferent
Depending on the value Net Benefit, circle one of the following:	>0	<0	0

If the net benefit is >0, accept the protective measure.

If the net benefit is ≤0, perform an ALARA Factor Analysis.

OPERATIONAL EXERCISE NO. 2

MOCKUP OF SPECIAL NUCLEAR MATERIAL STORAGE FACILTY

ANSWER SHEETS

2. Operational Exercise: Mockup of Special Nuclear Material Storage Facility

PART A. RADIOLOGICAL PROBLEM DEFINITION

1. Describe the facility, its present radiological conditions, and the radiological activity of concern.

The facility is a special nuclear materials storage facility where various tour groups frequently come through to see the unique storage mechanisms designed for the storage of special nuclear material. Approximately 5 tours per year, averaging 12 persons per tour, enter a radiation area for 10 minutes, the security and health physics representatives spend approximately 15 minutes in the radiation area to support each tour. An additional 45 minutes is spent by the HP and Security personnel to support the opening of the area for the tour. The personnel are in a radiation area in which average effective dose equivalent rate is 38 mrem/hr.

2. Describe the proposed ALARA protective measure (APM).

The ALARA Protective Measure is to build a mockup of a storage cabinet that could be used to show touring groups. Additional non quantified benefits of such a mockup is training of operations personnel.

3. Determine the relevant time frame for estimation of cost elements and exposure impacts.

All savings are calculated over a one year period. It is anticipated that because of new security requirements that tours will no longer be allowed after one year.

4. Identify the cost savings associated with the implementation of the APM, e.g., maintenance labor, operations labor, inspection labor, production, processing, salvage, reduced chemicals, reduced consumables, reduced radwaste.

Approximately $80 dollars per tour in labor saved if the tour does not have to enter a secure area where additional escorts are required.

5. Identify the cost elements for implementation of the APM, e.g., design and engineering, equipment procurement, fabrication, installation or construction labor, operation, maintenance, associated training and procedure, additional chemicals, additional consumables, special tools, additional radwaste.

Estimates of $6000 dollars were provided for the mockup of the storage cabinet.

6. Estimate the collective dose without the protective measure, with the protective measure, and to implement the protective measure. Determine, if possible, the maximum individual dose for the present or existing radiological activity.

The exposure impact assuming a one year utilization period are:
Collective dose w/o protection measure: 0.483 rem
Collective dose with protective measure: 0 rem
Collective dose to implement protection measure: 0 rem
Maximum annual individual dose: 0.05 rem/yr

2. Operational Exercise: Mockup of Special Nuclear Material Storage Facility

PART B. OVERRIDING FACTOR ANALYSIS

Overriding Factors	For each question, indicate either YES or NO	
	If Implemented	If Not Implemented
1. Will a violation of a DOE order, federal regulation, or state law occur?	No	No
2. Will significant quantities of radioactive materials be added to the site?	No	No
3. Will violation of a collective bargaining agreement occur?	No	No
4. Will worker administrative dose control level(s) be exceeded?	No	No
5. Will a safety-related activity not be completed because of the unavailability of a specially trained, skilled, or certified worker?	No	No
6. Other factors (please describe).	--	--

7. Conclusion (Explain how YES answers to the above questions are overriding factors).
No overriding factors apply for the use of a mockup SNM facilities during tours.

8. Discussion (basis and references).

Cost-Benefit Analysis Worksheet
2. Operational Exercise: Mockup of Special Nuclear Material Storage Facility

PART C. APM BENEFIT CALCULATION

Benefits	Quantity	Unit Cost	Cost	Item(s)
C-1 Maintenance Labor Enter the total estimated labor savings for the protective measure. Obtain the estimated total maintenance hours saved. Obtain the appropriate dollar/hour rate for maintenance from the Cost Control Group. Enter the product(s) on line(s) for items C-1.	0		None	C-1
C-2 Operations/Production Labor Enter the total estimated operation/production labor savings for the protective measure. Obtain the estimated total operation hours saved. Obtain the appropriate dollar/hour rate for operations from the Cost Control Group. Enter the product(s) on line(s) for items C-2.	5 Tours	$80 1/tour	$400	C-2
C-3 Inspection/Surveillance Labor Enter the total estimated inspection/surveillance labor savings for the protective measure. Obtain the estimated total inspection hours saved. Obtain the appropriate dollar/hour rate for inspection from the Cost Control Group. Enter the product(s) on line(s) for items C-3.	0		None	C-3
C-4 Efficiency and/or Reliability Savings Enter the total estimated savings associated with production or processing improvements provided by the protective measure. Enter the dollar amount of these savings on line(s) for items C-4.	0		None	C-4
C-5 Miscellaneous Savings Enter estimated savings from miscellaneous items (e.g., salvage value of old equipment, reduced chemical and consumable materials, reduced radwaste). Enter the dollar amount of these savings on line(s) for items C-5.	0		None	C-5

TOTAL ECONOMIC BENEFITS
Enter the total estimated benefits of the protective measure. Add all savings from lines for items C-1 through C-5, and enter total into Box C.

Grand Total → 400

Box C

Cost-Benefit Analysis Worksheet

2. Operational Exercise: Mockup of Special Nuclear Material Storage Facility

PART D. APM COST CALCULATION

Costs	Quantity	Unit Cost	Cost	Item(s)
D-1. **Design and Engineering** Enter the total estimated design engineering cost for the protective measure. Obtain the estimated hours to design and engineer the productive measure. Obtain appropriate dollar/hour rate for engineering from the Cost Control Group. Enter the product(s) on line(s) for item(s) D-1.	12 Hr	$40/Hr	$360	D-1
D-2. **Capital Equipment, Fabrication, Material** Enter the total estimated capital costs of equipment, fabrication, and materials for the new technique. Include "up front" hidden costs such as R&D, certification, patent rights, etc. Enter product(s) on line(s) for item(s) D-2.	80 Hr Material	$40/Hr	$3200 1200	D-2
D-3. **Installation or Construction** Enter the total estimated labor costs to install the protective measure. Obtain the estimated total hours of station and contractor personnel to install. Obtain the appropriate dollar/hour rate for station and contractor labor. Enter the product(s) on line(s) for item(s) D-3.	16	$40/Hr	640	D-3
D-4. **Implementation: Procedure, Training, Administrative Costs** Enter the estimated costs for training, procedure development, and associated additional O&M protective measure (additional O&M being a negative savings obtained in lines C-1, C-2, and C-3 above from the difference between the existing and the protective technique costs for operations, maintenance, and inspection). Enter the product(s) on line(s) for item(s) D-4.			None	D-4
D-5 **Operation and Maintenance** Enter the total estimated cost to operate and maintain the protective measure. Obtain the estimated hours to maintain and operate. Obtain the appropriate dollar/hour rate for each work group. Enter the product(s) on line(s) for item(s) D-5.			None	D-5
D-6 **Miscellaneous Costs** Enter the estimated total costs for miscellaneous items (e.g., chemicals, consumable materials, special tools, additional radwaste). Enter the product(s) on line(s) for item(s) D-6.			$600	D-6

TOTAL ECONOMIC COST

Enter the total estimated costs of the protective measure. Add all the costs from lines for items D-1 through D-6 and enter the total into Box D.

Grand Total → 6000

Box D

2. Operational Exercise: Mockup of Special Nuclear Material Storage Facility

PART E. DOSE ESTIMATE

Description of Radiological Activity	Work Group or Number of Persons	Time Exp-Hr	Average Dose Rate	Person Rem	Item(s)
E-1. Existing or Present Radiological Activity	Enter the existing man-hours to perform activity, maintenance, operate, inspect, process, or produce. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-1.				
Note: About 5 tours are conducted ~~each year~~	2	1.25	0.038	0.095	E-1
	12 x 5 yr	0.17	0.038	0.388	
E-2 Dose with APM Implemented	Enter the total man-hours with the protection measure for maintenance, operation, inspection, processing, and production. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-2.				
				0	E-2
E-3 Dose to Implement APM	Enter the total estimated dose to implement or install the protective measure which will result from it (i.e., negative result from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, inspect new technique) on line(s) for item(s) E-3.				
				0	E-3

NET DOSE SAVINGS

Enter total estimated dose saved for the protective measure (i.e., positive results from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, maintain, inspect with protective measure plus the dose to implement the APM) in Box E.

E1-(E2+E3) = → 0.483

Box E

2. Operational Exercise: Mockup of Special Nuclear Material Storage Facility

PART F. LOWER-LEVEL NET BENEFIT EVALUATION

Cost/Benefit	Dollars	Item(s)
F-1 **Estimated Economic Benefits** Enter the results from Box C on line for item F-1.	400	F-1
F-2 **Estimated Economic Costs** Enter the results from Box D on line for item F-2.	6000	F-2
F-3 **Net Economic Benefit (Costs)** Estimated benefit on line for item F-1 minus estimated cost on line for item F-2. Enter (F-1) - (F-2) on line F-3.	-5,600	F-3

Net Dose	Person-Rem	Dollars/ Person-Rem	Dollars	Item(s)
F-4 **Net Dose Savings** Enter the result from Box E and multiply by 2,000 $/person-rem. Enter result on line for item F-4.	0.483	x $2,000 =	966	F-4

Net Benefit
Net benefit on line F-3 plus the dollar value of the net dose savings on line for item F-4, i.e., (F-3) + (F-4).

Box F
-4,634

Net Benefit Decision Index	Accept	Reject	Indifferent
Depending on the value Net Benefit, circle one of the following:	>0	<0	0

If the net benefit is >0, accept the protective measure.

If the net benefit is ≤0, perform an ALARA Factor Analysis.

PART H. ALARA FACTOR ANALYSIS CHECKSHEET

Questions on Qualitative Factors	W/F*	Yes	No
1. Will the maximum individual doses for occupational workers exceed 10 mrem for the duration of the relevant time frame?	3	3	
2. Does the APM maintain or decrease the current level of risk for occupational incidents or accidents?	2	2	
3. Does the APM decrease the risk of environmental incidents or accidents?	2		2
4. Does the APM result in dose savings in the post-operational phase of the facility or activity?	2		2
5. Does the APM result in cost savings during the post-operational phase of the facility or activity?	1		1
6. Does the APM increase the flexibility of personnel or other resources?	2	2	
7. Does the APM result in an improved relationship with internal or external organizations?	1	1	
8. Does the APM decrease or maintain current level of employee exposure to adverse working conditions or extreme discomfort?	3		3
9. Does the APM reduce the release of radionuclides to the environment?	3		3
10. Does the APM improve or maintain the current level of operability of an activity or a facility?	3	3	
11. Is the APM impact on the activity schedule minimal?	2	2	
12. Does the APM contribute to waste minimization?	1		1
TOTAL		13	12

*Weighting factor

If the weighted factor total for "Yes" answers is greater than that for "No" answers, the APM should be accepted based on qualitative factors. If the "No" answers outweigh the "Yes" answers, the APM should be rejected or accepted based on other factors.

OPERATIONAL EXERCISE NO. 3

CLOSED CIRCUIT TELEVISION TO MONITOR THE SPENT FUEL POOL HEAT EXCHANGER ROOM

ANSWER SHEETS

3. Operational Exercise: Closed Circuit Television to Monitor the Spent Fuel Pool Heat Exchanger Room

PART A. RADIOLOGICAL PROBLEM DEFINITION

1. **Describe the facility, its present radiological conditions, and the radiological activity of concern.**

The facility is either a production, research, or test reactor. The radiological activity of concern is the routine inspection by operations of the spent fuel pool heat exchanger cubicle. The purpose of these routine inspections is to monitor for leaks and equipment malfunctions (visually). The radiation levels in the room are on the average 100 mrem/hr with hot spots of 1-10 rem/hr.

2. Describe the proposed ALARA protective measure (APM).

These routine visual inspections could be performed remotely using a commercially available camera with a pan/zoom lens and a trainable (vertical and azimuth) mount and associated monitor/control panel.

3. Determine the relevant time frame for estimation of cost elements and exposure impacts.

The relevant time frame is 10 years based on the expected lifetime of the camera in the environment.

4. Identify the cost savings associated with the implementation of the APM, e.g., maintenance labor, operations labor, inspection labor, production, processing, salvage, reduced chemicals, reduced consumables, reduced radwaste.

Inspection labor savings of 5 min/day or 30 hrs/yr. An operations labor rate, including overhead, is $35.00/hour.

5. Identify the cost elements for implementation of the APM, e.g., design and engineering, equipment procurement, fabrication, installation or construction labor, operation, maintenance, associated training and procedure, additional chemicals, additional consumables, special tools, additional radwaste.

The cost for the camera, stand, and control panel is approximately $5,000. It will require about 100 man hours to install (50 man hours in radiation area and 50 man hours in a non-radiation area). Contractor labor to install and test is billed at a rate of $20.00/hour

6. Estimate the collective dose without the protective measure, with the protective measure, and to implement the protective measure. Determine, if possible, the maximum individual dose for the present or existing radiological activity.

The exposure impacts assuming all exposures associated with inspections are eliminated are:
Collective dose w/o protective measure: 3.000 rem
Collective dose with protective measure: 0 rem
Collective dose to implement protective measure: 5.000 rem
Maximum annual individual dose: 1.5 rem/yr

3. Operational Exercise: Closed Circuit Television to Monitor Spent Fuel Pool Heat Exchanger Room

PART B. OVERRIDING FACTOR ANALYSIS

Overriding Factors	For each question, indicate either YES or NO	
	If Implemented	If Not Implemented
1. Will a violation of a DOE order, federal regulation, or state law occur?	No	No
2. Will significant quantities of radioactive materials be added to the site?	No	No
3. Will violation of a collective bargaining agreement occur?	No	No
4. Will worker administrative dose control level(s) be exceeded?	No	No
5. Will a safety-related activity not be completed because of the unavailability of a specially trained, skilled, or certified worker?	No	No
6. Other factors (please describe).	--	--

7. Conclusion (Explain how YES answers to the above questions are overriding factors).

No overriding factors apply for the use of a remote video monitor in the spent fuel heat exchanger cubicle.

8. Discussion (basis and references).

3. Operational Exercise: Closed Circuit Television to Monitor Spent Fuel Pool Heat Exchanger Room

PART C. APM BENEFIT CALCULATION

Benefits	Quantity	Unit Cost	Cost	Item(s)
C-1 **Maintenance Labor** Enter the total estimated labor savings for the protective measure. Obtain the estimated total maintenance hours saved. Obtain the appropriate dollar/hour rate for maintenance from the Cost Control Group. Enter the product(s) on line(s) for items C-1.			None	C-1
C-2 **Operations/Production Labor** Enter the total estimated operation/production labor savings for the protective measure. Obtain the estimated total operation hours saved. Obtain the appropriate dollar/hour rate for operations from the Cost Control Group. Enter the product(s) on line(s) for items C-2.			None	C-2
C-3 **Inspection/Surveillance Labor** Enter the total estimated inspection/surveillance labor savings for the protective measure. Obtain the estimated total inspection hours saved. Obtain the appropriate dollar/hour rate for inspection from the Cost Control Group. Enter the product(s) on line(s) for items C-3.	30 hrs.	$35.00[1]/hr	$1050 /yr x 10 yr $10,500	C-3
C-4 **Efficiency and/or Reliability Savings** Enter the total estimated savings associated with production or processing improvements provided by the protective measure. Enter the dollar amount of these savings on line(s) for items C-4.			None	C-4
C-5 **Miscellaneous Savings** Enter estimated savings from miscellaneous items (e.g., salvage value of old equipment, reduced chemical and consumable materials, reduced radwaste). Enter the dollar amount of these savings on line(s) for items C-5.			None	C-5

TOTAL ECONOMIC BENEFITS

Enter the total estimated benefits of the protective measure. Add all savings from lines for items C-1 through C-5, and enter total into Box C.

Grand Total → $10,500

Box C

3. Operational Exercise: Closed Circuit Television to Monitor Spent Fuel Pool Heat Exchanger Room

PART D. APM COST CALCULATION

Costs	Quantity	Unit Cost	Cost	Item(s)
D-1. **Design and Engineering** Enter the total estimated design engineering cost for the protective measure. Obtain the estimated hours to design and engineer the productive measure. Obtain appropriate dollar/hour rate for engineering from the Cost Control Group. Enter the product(s) on line(s) for item(s) D-1.			None	D-1
D-2. **Capital Equipment, Fabrication, Material** Enter the total estimated capital costs of equipment, fabrication, and materials for the new technique. Include "up front" hidden costs such as R&D, certification, patent rights, etc. Enter product(s) on line(s) for item(s) D-2.			$5,000	D-2
D-3. **Installation or Construction** Enter the total estimated labor costs to install the protective measure. Obtain the estimated total hours of station and contractor personnel to install. Obtain the appropriate dollar/hour rate for station and contractor labor. Enter the product(s) on line(s) for item(s) D-3.	100 hrs	$20.00[1]/hr	$2,000	D-3
D-4. **Implementation: Procedure, Training, Administrative Costs** Enter the estimated costs for training, procedure development, and associated additional O&M protective measure (additional O&M being a negative savings obtained in lines C-1, C-2, and C-3 above from the difference between the existing and the protective technique costs for operations, maintenance, and inspection). Enter the product(s) on line(s) for item(s) D-4.			None	D-4
D-5 **Operation and Maintenance** Enter the total estimated cost to operate and maintain the protective measure. Obtain the estimated hours to maintain and operate. Obtain the appropriate dollar/hour rate for each work group. Enter the product(s) on line(s) for item(s) D-5.			Negligible	D-5
D-6 **Miscellaneous Costs** Enter the estimated total costs for miscellaneous items (e.g., chemicals, consumable materials, special tools, additional radwaste). Enter the product(s) on line(s) for item(s) D-6.			None	D-6

TOTAL ECONOMIC COST

Enter the total estimated costs of the protective measure. Add all the costs from lines for items D-1 through D-6 and enter the total into Box D.

Grand Total → $7,000

Box D

3. Operational Exercise: Closed Circuit Television to Monitor Spent Fuel Pool Heat Exchanger Room

PART E. DOSE ESTIMATE

Description of Radiological Activity	Work Group or Number of Persons	Exp-Hr	Average Dose Rate	Person Rem	Item(s)
E-1. Existing or Present Radiological Activity	Enter the existing man-hours to perform activity, maintenance, operate, inspect, process, or produce. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-1.				
		30 hr/yr x 10 yr	0.1 Rem/hr	= 30	E-1
E-2 Dose with APM Implemented	Enter the total man-hours with the protection measure for maintenance, operation, inspection, processing, and production. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-2.				
		None	None	0	E-2
E-3 Dose to Implement APM	Enter the total estimated dose to implement or install the protective measure which will result from it (i.e., negative result from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, inspect new technique) on line(s) for item(s) E-3.				
		50	0.1 Rem/hr	5.00	E-3

NET DOSE SAVINGS

Enter total estimated dose saved for the protective measure (i.e., positive results from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, maintain, inspect with protective measure plus the dose to implement the APM) in Box E.

E1-(E2+E3)= → 25

Box E

PART G. UPPER-LEVEL NET BENEFIT EVALUATION

Cost/Benefit	Dollars	Item(s)
F-1 **Estimated Economic Benefits** Enter the results from Box C on line for item F-1.	10,500	F-1
F-2 **Estimated Economic Costs** Enter the results from Box D on line for item F-2.	7000	F-2
F-3 **Net Economic Benefit (Costs)** Estimated benefit on line for item F-1 minus estimated cost on line for item F-2. Enter (F-1) - (F-2) on line for item F-3.	3500	F-3

Net Dose	Person-Rem	Dollars/ Person-Rem	Dollars	Item(s)
F-4 **Net Dose Savings** Enter the result from Box E and multiply by 10,000 $/person-rem. Enter result on line for item F-4.	25	x $10,000 =	$250,000	F-4

<u>Net Benefit</u>
Net benefit on line F-3 plus the dollar value of the net dose savings on line F-4, i.e., (F-3) + (F-4).

$253,500

Box F

<u>Net Benefit Decision Index</u> Depending on the value Net Benefit, circle one of the following:	Accept	Reject	Indifferent
	>0	<0	0

If the net benefit is >0, proceed to Part H and perform the ALARA factor analysis.

If net benefit is ≤0, either reject the protective measure or reevaluate the upper level net benefit using a case-specific value for the radiation detriment instead of $10,000 per person-rem.

OPERATIONAL EXERCISE NO. 4

CLEM - SHIELDING FOR AUTOMATED REFUELING MACHINE

ANSWER SHEETS

4. Operational Exercise: CLEM - Shielding for Automated Refueling Machine

PART A. RADIOLOGICAL PROBLEM DEFINITION

1. **Describe the facility, its present radiological conditions, and the radiological activity of concern.**

An irradiated reactor fuel handling facility has operations personnel who routinely approach and occasionally exceed the facility administrative guide of 2.0 rem/yr. Fuel handling personnel on the average receive 0.98 rem/yr with a maximum individual dose of 2.25, mostly from neutrons. Shielding of the automated refueling machine is needed to reduce dose rates on the operating platform.

2. **Describe the proposed ALARA protective measure (APM).**

Shielding is needed to ensure operator dose is below 1.9 rem so as not to exceed the 2.0 rem administrative guide. Two proposals are under evaluation. One is to rotate operations personnel so that the 1.9 rem target is not exceeded. The second is to add shielding to the handling module in order to reduce dose rates by a factor of two.

3. **Determine the relevant time frame for estimation of cost elements and exposure impacts.**

Due to facility decommissioning, the remaining time frame of 5 years will be assumed.

4. **Identify the cost savings associated with the implementation of the APM, e.g., maintenance labor, operations labor, inspection labor, production, processing, salvage, reduced chemicals, reduced consumables, reduced radwaste.**

It is estimated that annual labor savings from improved operator efficiency resulting from reduced turnover is $26,000 per year. This results in $130,000 labor savings over the 5 year period.

5. **Identify the cost elements for implementation of the APM, e.g., design and engineering, equipment procurement, fabrication, installation or construction labor, operation, maintenance, associated training and procedure, additional chemicals, additional consumables, special tools, additional radwaste.**

The design and engineering costs for the shielding are $157,000. Capital equipment charge is $220,000. Installation cost is $85,000. Additional operating and maintenance costs are expected to be $7,500/yr for 5 years = $37,500.

6. **Estimate the collective dose without the protective measure, with the protective measure, and to implement the protective measure. Determine, if possible, the maximum individual dose for the present or existing radiological activity.**

The dose impacts over the 5 year period using the new shielding which would reduce dose rates by a factor of 2 are:
Collective dose w/o protective measure: 64.8 rem
Collective dose with protective measure: 30.9 rem
Collective dose to implement protective measure: 0 rem
Maximum annual individual dose: 2.25 rem/yr

4. Operational Exercise: CLEM Shielding for Automated Refueling Machine

PART B. OVERRIDING FACTOR ANALYSIS

Overriding Factors	For each question, indicate either YES or NO	
	If Implemented	If Not Implemented
1. Will a violation of a DOE order, federal regulation, or state law occur?	No	No
2. Will significant quantities of radioactive materials be added to the site?	No	No
3. Will violation of a collective bargaining agreement occur?	No	No
4. Will worker administrative dose control level(s) be exceeded?	No	Yes
5. Will a safety related activity not be completed because of the unavailability of a specially trained, skilled, or certified worker?	No	No
6. Other factors (please describe).		

7. Conclusion (Explain how YES answers to the above questions are overriding factors).
Some operators have been allowed to exceed the administrative dose control level. However, this could have been avoided by rotating operations personnel.

8. Discussion (basis and references).

4. Operational Exercise: CLEM Shielding for Automated Refueling Machine

PART C. APM BENEFIT CALCULATION

Benefits	Quantity	Unit Cost	Cost	Item(s)
C-1 **Maintenance Labor** Enter the total estimated labor savings for the protective measure. Obtain the estimated total maintenance hours saved. Obtain the appropriate dollar/hour rate for maintenance from the Cost Control Group. Enter the product(s) on line(s) for items C-1.			None	C-1
C-2 **Operations/Production Labor** Enter the total estimated operation/production labor savings for the protective measure. Obtain the estimated total operation hours saved. Obtain the appropriate dollar/hour rate for operations from the Cost Control Group. Enter the product(s) on line(s) for items C-2.			$130,000	C-2
C-3 **Inspection/Surveillance Labor** Enter the total estimated inspection/surveillance labor savings for the protective measure. Obtain the estimated total inspection hours saved. Obtain the appropriate dollar/hour rate for inspection from the Cost Control Group. Enter the product(s) on line(s) for items C-3.			None	C-3
C-4 **Efficiency and/or Reliability Savings** Enter the total estimated savings associated with production or processing improvements provided by the protective measure. Enter the dollar amount of these savings on line(s) for items C-4.			None	C-4
C-5 **Miscellaneous Savings** Enter estimated savings from miscellaneous items (e.g., salvage value of old equipment, reduced chemical and consumable materials, reduced radwaste). Enter the dollar amount of these savings on line(s) for items C-5.			None	C-5

TOTAL ECONOMIC BENEFITS

Enter the total estimated benefits of the protective measure. Add all savings from lines for items C-1 through C-5, and enter total into Box C.

Grand Total → 130,000

Box C

Cost-Benefit Analysis Worksheet

4. Operational Exercise: CLEM Shielding for Automated Refueling Machine

PART D. APM COST CALCULATION

Costs	Quantity	Unit Cost	Cost	Item(s)
D-1. **Design and Engineering** Enter the total estimated design engineering cost for the protective measure. Obtain the estimated hours to design and engineer the productive measure. Obtain appropriate dollar/hour rate for engineering from the Cost Control Group. Enter the product(s) on line(s) for item(s) D-1.			157,000	D-1
D-2. **Capital Equipment, Fabrication, Material** Enter the total estimated capital costs of equipment, fabrication, and materials for the new technique. Include "up front" hidden costs such as R&D, certification, patent rights, etc. Enter product(s) on line(s) for item(s) D-2.			220,000	D-2
D-3. **Installation or Construction** Enter the total estimated labor costs to install the protective measure. Obtain the estimated total hours of station and contractor personnel to install. Obtain the appropriate dollar/hour rate for station and contractor labor. Enter the product(s) on line(s) for item(s) D-3.			85,000	D-3
D-4. **Implementation: Procedure, Training, Administrative Costs** Enter the estimated costs for training, procedure development, and associated additional O&M protective measure (additional O&M being a negative savings obtained in lines C-1, C-2, and C-3 above from the difference between the existing and the protective technique costs for operations, maintenance, and inspection). Enter the product(s) on line(s) for item(s) D-4.			None	D-4
D-5 **Operation and Maintenance** Enter the total estimated cost to operate and maintain the protective measure. Obtain the estimated hours to maintain and operate. Obtain the appropriate dollar/hour rate for each work group. Enter the product(s) on line(s) for item(s) D-5.			37,500	D-5
D-6 **Miscellaneous Costs** Enter the estimated total costs for miscellaneous items (e.g., chemicals, consumable materials, special tools, additional radwaste). Enter the product(s) on line(s) for item(s) D-6.			None	D-6

TOTAL ECONOMIC COST

Enter the total estimated costs of the protective measure. Add all the costs from lines for items D-1 through D-6 and enter the total into Box D.

Grand Total → $499,500

Box D

4. Operational Exercise: CLEM Shielding for Automated Refueling Machine

PART E. DOSE ESTIMATE

Description of Radiological Activity	Work Group or Number of Persons	Exp-Hr Man Yr	Average Dose Rate mR/Hr	Person Rem	Item(s)
E-1. Existing or Present Radiological Activity	Enter the existing man-hours to perform activity, maintenance, operate, inspect, process, or produce. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-1.				
Fuel Handling	Operators	1800	7.20	12.96	
				x 5 Yr	E-1
				64.8	
E-2 Dose with APM Implemented	Enter the total man-hours with the protection measure for maintenance, operation, inspection, processing, and production. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-2.				
Fuel Handling	Operators	1800	3.43	6.18	
				x 5 Yr	E-2
				30.9	
E-3 Dose to Implement APM	Enter the total estimated dose to implement or install the protective measure which will result from it (i.e., negative result from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, inspect new technique) on line(s) for item(s) E-3.				
Shield to be installed on refuel-				--	
ing module in the machine shop,					E-3
i.e. low dose rate area					

NET DOSE SAVINGS

Enter total estimated dose saved for the protective measure (i.e., positive results from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, maintain, inspect with protective measure plus the dose to implement the APM) in Box E.

E1-(E2+E3) = → 33.9

Box E

PART G. UPPER-LEVEL NET BENEFIT EVALUATION

Cost/Benefit	Dollars	Item(s)
F-1 **Estimated Economic Benefits** Enter the results from Box C on line for item F-1.	130,000	F-1
F-2 **Estimated Economic Costs** Enter the results from Box D on line for item F-2.	499,500	F-2
F-3 **Net Economic Benefit (Costs)** Estimated benefit on line for item F-1 minus estimated cost on line for item F-2. Enter (F-1) - (F-2) on line for item F-3.	-369,500	F-3

Net Dose	Person-Rem	Dollars/ Person-Rem	Dollars	Item(s)
F-4 **Net Dose Savings** Enter the result from Box E and multiply by 10,000 $/person-rem. Enter result on line for item F-4.	33.9	x $10,000 =	339,000	F-4

Net Benefit
Net benefit on line F-3 plus the dollar value of the net dose savings on line F-4, i.e., (F-3) + (F-4).

-30,500

Box F

Net Benefit Decision Index	Accept	Reject	Indifferent
Depending on the value Net Benefit, circle one of the following:	>0	<0	0

If the net benefit is >0, proceed to Part H and perform the ALARA factor analysis.

If net benefit is ≤0, either reject the protective measure or reevaluate the upper level net benefit using a case-specific value for the radiation detriment instead of $10,000 per person-rem.

5. Operational Exercise: Robot for Handling Radioactive Sources

PART A. RADIOLOGICAL PROBLEM DEFINITION

1. Describe the facility, its present radiological conditions, and the radiological activity of concern.

A facility uses and maintains an inventory of sealed radioactive sources (Cf-232, Cs-137, Ir-192) for experimental neutron studies, for calibration, and testing of radiation monitoring instruments, and for non-destructive testing. Technicians transfer and retrieve these radioactive sources from their storage shields using handling tools. They place them on calibration "tracks" or in NDT examination rigs. They are typically 8-10 ft. from the sources, but get closer if a source gets "jammed".

2. Describe the proposed ALARA protective measure (APM).

It has been proposed that a mobile robot be used to perform source handling and recovery operations.

3. Determine the relevant time frame for estimation of cost elements and exposure impacts.

A 5 year life span is expected for this facility due to the federal budget deficit!!!

4. Identify the cost savings associated with the implementation of the APM, e.g., maintenance labor, operations labor, inspection labor, production, processing, salvage, reduced chemicals, reduced consumables, reduced radwaste.

Reduction in maintenance labor of 400 hrs per year are expected as a result of reduction in maintenance and health physics technician time.

5. Identify the cost elements for implementation of the APM, e.g., design and engineering, equipment procurement, fabrication, installation or construction labor, operation, maintenance, associated training and procedure, additional chemicals, additional consumables, special tools, additional radwaste.

The capital cost to procure the robot is $70,000. The design and fabrication of the source handling tool for the robot is $75,000. Annual maintenance cost for the robot and source handling tool is $5,000.

6. Estimate the collective dose without the protective measure, with the protective measure, and to implement the protective measure. Determine, if possible, the maximum individual dose for the present or existing radiological activity.

The collective dose impacts of the robot over the 5 year period are:
Collective dose w/o the protective measure: 57.05 rem
Collective dose with the protective measure: 13.45 rem
Collective dose to implement the protective measure: None
Maximum annual dose for individual: 0.6 rem/yr

OPERATIONAL EXERCISE NO. 5

ROBOT FOR HANDLING RADIOACTIVE SOURCES

ANSWER SHEETS

5. Operational Exercise: Robot for Handling Radioactive Sources

PART B. OVERRIDING FACTOR ANALYSIS

Overriding Factors	For each question, indicate either YES or NO	
	If Implemented	If Not Implemented
1. Will a violation of a DOE order, federal regulation, or state law occur?	No	No
2. Will significant quantities of radioactive materials be added to the site?	No	No
3. Will violation of a collective bargaining agreement occur?	No	No
4. Will worker administrative dose control level(s) be exceeded?	No	No
5. Will a safety-related activity not be completed because of the unavailability of a specially trained, skilled, or certified worker?	No	No
6. Other factors (please describe).		

7. Conclusion (Explain how YES answers to the above questions are overriding factors).

No overriding factors exist with the use or failure to use a robot for radioactive sources handling operations

8. Discussion (basis and references).

5. Operational Exercise: Robot for Handling Radioactive Sources

PART C. APM BENEFIT CALCULATION

Benefits	Quantity	Unit Cost	Cost	Item(s)
C-1 **Maintenance Labor** Enter the total estimated labor savings for the protective measure. Obtain the estimated total maintenance hours saved. Obtain the appropriate dollar/hour rate for maintenance from the Cost Control Group. Enter the product(s) on line(s) for items C-1.	400 Hr	\$36.00[1]/hr	14,400 x 5 Yr 72,000	C-1
C-2 **Operations/Production Labor** Enter the total estimated operation/production labor savings for the protective measure. Obtain the estimated total operation hours saved. Obtain the appropriate dollar/hour rate for operations from the Cost Control Group. Enter the product(s) on line(s) for items C-2.			None	C-2
C-3 **Inspection/Surveillance Labor** Enter the total estimated inspection/surveillance labor savings for the protective measure. Obtain the estimated total inspection hours saved. Obtain the appropriate dollar/hour rate for inspection from the Cost Control Group. Enter the product(s) on line(s) for items C-3.			None	C-3
C-4 **Efficiency and/or Reliability Savings** Enter the total estimated savings associated with production or processing improvements provided by the protective measure. Enter the dollar amount of these savings on line(s) for items C-4.			None	C-4
C-5 **Miscellaneous Savings** Enter estimated savings from miscellaneous items (e.g., salvage value of old equipment, reduced chemical and consumable materials, reduced radwaste). Enter the dollar amount of these savings on line(s) for items C-5.			None	C-5

TOTAL ECONOMIC BENEFITS

Enter the total estimated benefits of the protective measure. Add all savings from lines for items C-1 through C-5, and enter total into Box C.

Grand Total → 72,000

Box C

5. Operational Exercise: Robot for Handling Radioactive Sources

PART D. APM COST CALCULATION

Costs	Quantity	Unit Cost	Cost	Item(s)
D-1. **Design and Engineering** Enter the total estimated design engineering cost for the protective measure. Obtain the estimated hours to design and engineer the productive measure. Obtain appropriate dollar/hour rate for engineering from the Cost Control Group. Enter the product(s) on line(s) for item(s) D-1.			None	D-1
D-2. **Capital Equipment, Fabrication, Material** Enter the total estimated capital costs of equipment, fabrication, and materials for the new technique. Include "up front" hidden costs such as R&D, certification, patent rights, etc. Enter product(s) on line(s) for item(s) D-2.	1 Robot Handling Tool		70,000 75,000	D-2
D-3. **Installation or Construction** Enter the total estimated labor costs to install the protective measure. Obtain the estimated total hours of station and contractor personnel to install. Obtain the appropriate dollar/hour rate for station and contractor labor. Enter the product(s) on line(s) for item(s) D-3.			None	D-3
D-4. **Implementation: Procedure, Training, Administrative Costs** Enter the estimated costs for training, procedure development, and associated additional O&M protective measure (additional O&M being a negative savings obtained in lines C-1, C-2, and C-3 above from the difference between the existing and the protective technique costs for operations, maintenance, and inspection). Enter the product(s) on line(s) for item(s) D-4.			None	D-4
D-5 **Operation and Maintenance** Enter the total estimated cost to operate and maintain the protective measure. Obtain the estimated hours to maintain and operate. Obtain the appropriate dollar/hour rate for each work group. Enter the product(s) on line(s) for item(s) D-5.			5,000 x 5 yr 25,000	D-5
D-6 **Miscellaneous Costs** Enter the estimated total costs for miscellaneous items (e.g., chemicals, consumable materials, special tools, additional radwaste). Enter the product(s) on line(s) for item(s) D-6.			None	D-6

TOTAL ECONOMIC COST

Enter the total estimated costs of the protective measure. Add all the costs from lines for items D-1 through D-6 and enter the total into Box D.

Grand Total → 170,000

Box D

Cost-Benefit Analysis Worksheet

5. Operational Exercise: Robot for Handling Radioactive Sources

PART E. DOSE ESTIMATE

Description of Radiological Activity	Work Group or Number of Persons	Exp-Hr	Average Dose Rate	Person Rem	Item(s)
E-1. Existing or Present Radiological Activity	Enter the existing man-hours to perform activity, maintenance, operate, inspect, process, or produce. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-1.				
Operator - Source handling				57.05	E-1
HP Personnel - Monitoring					
E-2 Dose with APM Implemented	Enter the total man-hours with the protection measure for maintenance, operation, inspection, processing, and production. Enter the average working dose rate for each activity. Enter the product(s) on line(s) for item(s) E-2.				
				13.45	E-2
E-3 Dose to Implement APM	Enter the total estimated dose to implement or install the protective measure which will result from it (i.e., negative result from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, inspect new technique) on line(s) for item(s) E-3.				
				None	E-3

NET DOSE SAVINGS

Enter total estimated dose saved for the protective measure (i.e., positive results from the man-rem to operate, maintain, inspect old technique minus man-rem to operate, maintain, inspect with protective measure plus the dose to implement the APM) in Box E.

E1-E2+E3 = → $\boxed{43.6}$

Box E

PART F. LOWER-LEVEL NET BENEFIT EVALUATION

Cost/Benefit	Dollars	Item(s)
F-1 **Estimated Economic Benefits** Enter the results from Box C on line for item F-1.	72,000	F-1
F-2 **Estimated Economic Costs** Enter the results from Box D on line for item F-2.	170,000	F-2
F-3 **Net Economic Benefit (Costs)** Estimated benefit on line for item F-1 minus estimated cost on line for item F-2. Enter (F-1) - (F-2) on line F-3.	-58,000	F-3

Net Dose	Person-Rem	Dollars/ Person-Rem	Dollars	Item(s)
F-4 **Net Dose Savings** Enter the result from Box E and multiply by 2,000 $/person-rem. . Enter result on line for item F-4.	43.6	x $2,000 =	87,200	F-4

Net Benefit

Net benefit on line F-3 plus the dollar value of the net dose savings on line for item F-4, i.e., (F-3) + (F-4).

-10,800

Box F

Net Benefit Decision Index	Accept	Reject	Indifferent
Depending on the value Net Benefit, circle one of the following:	>0	<0	0

If the net benefit is >0, accept the protective measure.

If the net benefit is ≤0, perform an ALARA Factor Analysis.

OPERATIONAL EXERCISES

ON

ALARA JOB/EXPERIMENT REVIEWS

Workshop Proctors:

Bruce Dionne (BNL)
Timothy Corbett (Rocky Flats)
Tas Khan (BNL)
Steve Laflin (EG&G Idaho)
Steven Masciulli (BNL Consultant)

ALARA JOB/EXPERIMENT REVIEW
INSTRUCTIONAL PORTION

The purpose of this operational exercise is to demonstrate a method to perform and document a systematic review of a radiological activity to ensure that radiological controls are planned and implemented to reduce workers' doses to levels that are as low as reasonably achievable (ALARA). The objective is to successfully perform an ALARA Job/Experiment review for a radiological activity, using the data and worksheets provided. The methodology that will be used is based on the good practice document developed as a part of the BNL study on ALARA programs at DOE contractor facilities. This good practice document, "Example of an ALARA Job/Experiment Review Procedure," appears in Appendix K of the report BNL-47339.

There are three discrete phases of an ALARA job/experiment review:

1. Pre-job planning and dose assessments.
2. Implementation of ALARA controls and dose-tracking.
3. Post-job/experiment review.

A systematic pre-job review of high dose activities is performed to plan, evaluate, and document the reasonable controls to reduce dose and the spread of radioactive materials, i.e., ALARA controls. During the next phase, the job/experiment performance, the ALARA controls are reviewed to ensure that they are being implemented and are effective. In addition, doses being received are periodically compared against their estimates. The last phase involves a systematic post-job review to, in part, ensure that the lessons learned are documented and will be available to optimize future job/experiments.

Several action levels should be established for high radiological risk facilities. This will provide an increasing level of review for activities with higher risk. Examples of criteria for requiring an ALARA job/experiment review are:

- Planned collective dose ≥ 1 person-rem.
- Planned whole-body dose rate ≥ 100 mrem/hr.
- General area contamination levels ≥ 100 times the Surface Radioactivity Guide.
- Airborne concentrations ≥ 1 times the Derived Air Concentrations.

The types of data that will be needed during the pre-planning phase are RWP information, details of work or experiments, survey data, manhour estimates by location and task, collective-dose estimates by task, and any lessons learned from previous or similar activities. The first step is to estimate the time and collective dose to perform each task (see Worksheet B). Next, a meeting with the work supervisor(s) or experimenter(s) is held to plan for those controls that are reasonable to implement. An ALARA checklist can be used to systematically question the applicability of the various controls (see Worksheet C). Those controls that are planned should be documented on either the RWP (see Worksheet A) or the RWP-ALARA Control Record (see Worksheet D) that gets attached to the RWP.

During the job performance phase, information on the planned ALARA controls should be disseminated to the workers via a pre-job briefing or by their reading of the RWP and RWP-ALARA Control Record. Each worker should be required to sign the RWP Sign-In Sheet, acknowledging that he has received a briefing on the ALARA controls or that he has read and understands them. Before starting work and periodically during the job, in-process reviews should be performed and/or radiological control hold points should be checked, to verify the implementation and effectiveness of ALARA controls. Stop work authority should be exercised to enforce the implementation of controls that are found not to be in use. Periodically, during the job or experiment, the actual collective dose totals should be compared against the estimates. If there is a large discrepancy between the actual dose and the estimates, intervention should occur to determine the cause and initiate corrective actions, if needed.

Following the job performance, a post-job review should be performed. Examples of criteria for requiring a post/job experiment review are:

- Actual collective dose > person-rem.
- Actual dose ≥ ± 25% of estimates.
- Work stoppage exercised during job.
- Radiological deficiency occurrence report for job activity.
- Significant lesson learned.
- Collective dose which exceeds pre-established limiting value.

This review can be done after the job by a meeting of the key personnel involved. The type of information to be discussed and documented can include (see Worksheet E):

- Actual and estimated man-hours and man-rem totals for the job.
- Reasons for not achieving ± 25% of person-rem.
- Effectiveness of ALARA controls.
- Deviations from the original job scope.
- Reasons why ALARA exposure controls were not implemented, if applicable.
- Radiological problems encountered and corrective actions.
- Lessons learned that can be incorporated into future work.

It is important to ensure that the next time that the same or similar activity is performed, the experience and lessons learned documented in the ALARA post-job review record are used to optimize the job's radiological performance.

An operational exercise involving an ALARA job/experiment review will be performed as described above. The answer to the radiological problem also will be presented.

ALARA JOB/EXPERIMENT REVIEW

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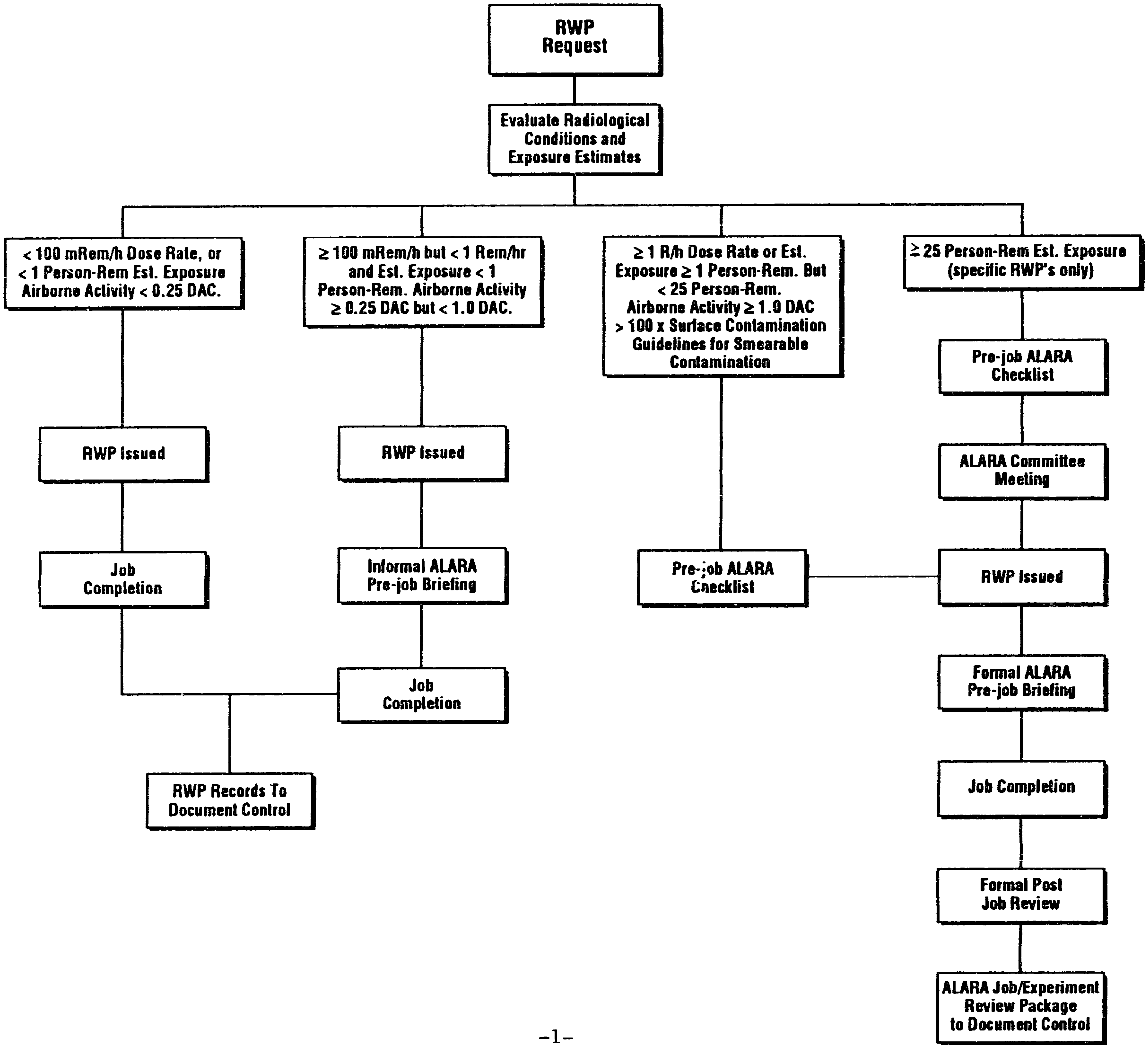
Factoring ALARA Into Jobs/Experiments - Flow Chart



PART A

DOE CONTRACTOR RADIATION WORK PERMIT

- □ Standing RWP
- □ 24-hour RWP

RWP No:	
ALARA Code:	
ALARA Task Code:	

REQUESTOR

Work Description:	Equipment ID Number:
	MR Number (if appropriate):
	Procedure Number (if applicable):
Location (Bldg., room and area. Be specific.):	Location Code:

Estimated person hours in area:	Actual person hours worked:	Requester Name and phone no.:	Date:

RADIOLOGICAL SAFETY PERSONNEL

RADIOLOGICAL INFORMATION

Dose Rate, Contamination Levels and Collective Dose Data	Head/Body Protective Clothing	Hand/Feet Protective Clothing	RESP Protection Equipment	Personnel Monitoring	HP Training/ Coverage
General Area Dose Rate: Date/Time and Survey No.: Job Specific Dose Rate: Date/Time and Survey No.: Contamination Level: Date/Time and Survey No.: Airborne Activity: Date/Time and Survey No.: Estimated person rem: Actual person rem:	□ Cap □ Hood □ Lab Coat □ Coveralls □ Coveralls _ Pr □ Plastic Slip Ons □ Disposable Suit □ Bubble Suit □ Acid Suit □ ______	□ Cotton Gloves □ Surgeon Gloves □ Rubber Gloves □ Acid Guantlets □ Cotton Shoe Cover □ Plastic Shoe Cover □ Rubbers □ Boots □ Acid Boots □ ______	□ Full Face □ Particulate Filter □ Combination Cartridge □ Supplied Air Resp. □ Supplied Air Hood □ Self-Contained Breathing Apparatus □ ______	□ TLD □ Self-Reading Dosimeter □ Hi Range SRFD □ Extremity TLD □ Mult. Badging □ Neutron Dosimeter □ Electronic Dosimeter □ Dose/Rate Alarm □ Breathing Zone Air Sample □ Continuous Air Monitor □ Nasal Smear □ Personnel/ Equipment Frisking □ ______	□ Pre-Job Briefing □ Start of Work □ Intermittent □ Continuous □ Completion of Work □ Survey After Work □ Post-Job Debrief □ Rad Worker I □ Rad Worker II □ Other ______

Additional protection requirements and instructions:

ALARA ENGINEER

ALARA INFORMATION

ALARA Job/Experiment Review Required:	Exposure Controls	Contamination Controls
□ Yes □ No If yes, all work under this RWP must comply with the ALARA controls listed on this form or prescribed on the attached RWP-ALARA Controls Record No. ______.		

APPROVALS

Operational Health Physics Supervisor Approval: ______________________ ____________

Job Supervisor/Foreman Approval: ______________________ ____________ Date / Time

Environment, Safety and Health Manager Approval: ______________________ ____________ Date / Time

Limiting Conditions: ______________________________________

Permit Expires: ______________ Date/Time

GENERAL INSTRUCTIONS

1. Observe all radiological signs, warnings, and postings.
2. No eating, drinking, smoking, or chewing.
3. Obey all written and verbal requirements and instructions from safety personnel.
4. Report any problems with RWP or radiological conditions to HP Technician and/or Supervisor.
5. Maintain your dose and spread of radioactivity ALARA.
6. Monitor tools, equipment, and clothing before leaving radiologically controlled area.

PART B

ALARA JOB/EXPERIMENT REVIEW RECORD

ALARA Code:

Job/Experiment Title:

Task No.	Task Title	Location (be specific)	Estimated Person Hours	Effective Exposure Rate (Rem/hr)	Estimated Exposure (Person-Rem)	ALARA Task Code
	Principal Investigator/Job Planner/Department ALARA Coordinator			Department ALARA Coordinator or Radiological Engineer		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
		Total Job/Experiment Estimates Person Hour		Total Job/Experiment Estimated Person rem		

Prepared by: ______________________ Principal Investigator/Job Planner ______ Date

Received by: ______________________ Department ALARA Coordinator ______ Date

Reviewed by: ______________________ Radiological Engineer ______ Date

Reviewed by: ______________________ ALARA/Radiological Safety Committee Chairman ______ Date

(see back for ALARA Controls Checklist)

PART C

ALARA CHECKLIST

ALARA Code:
ALARA Task Code:

Job Description:

Task Description:

Check Box Yes	No	Items to be considered	Describe each item checked yes
		1. Procedure Preparation	
□	□	1.1 Job procedure prepared	
□	□	1.2 Unnecessary work deleted	
□	□	1.3 Radiation hold points identified	
□	□	1.4 Tool lists developed	
□	□	1.5 Special tools considered	
□	□	1.6 Remote or robotic equipment/tools	
□	□	1.7 Prefabrication considered	
□	□	1.8 Human factors considered	
□	□	1.9 "Lessons-learned" reviewed	
□	□	1.10 Practice repetitive task in lowest dose rate area first	
□	□	1.11 Other	
		2. Set-up Preparation	
□	□	2.1 Access to and exit from work area planned	
		2.2 Services provided:	
□	□	Lighting	
□	□	Breathing Air	
□	□	Welding	
□	□	Staging	
□	□	Instrument/tool air	
□	□	Electric	
□	□	Heating/Cooling	
□	□	Other	
		2.3 Communication provided:	
□	□	Headset	
□	□	Walkie-Talkie	
□	□	TV Camera/Monitor	
□	□	Other	
		3. Worker Preparation	
□	□	3.1 Experienced workers selected	
□	□	3.2 Special training/photos/drawings	
□	□	3.3 Rehearsal	
□	□	3.4 Mock-up training	
□	□	3.5 Workers exposures reviewed	
□	□	3.6 Evaluate fewer workers	
		4. Exposure Controls	
□	□	4.1 Allow for decay following facility shutdown	
□	□	4.2 Decontaminate equipment	
□	□	4.3 Flushing or filling equipment	
□	□	4.4 Move equipment to low dose rate area	
□	□	4.5 Work equipment under water	
□	□	4.6 Temporary shielding of equipment	
□	□	4.7 Temporary shielding of work area	
□	□	4.8 Permanent shielding	
□	□	4.9 Posting of hot spots and low dose rate wait areas	
□	□	4.11 Other	
		5. Contamination Controls	
□	□	5.1 Floor covering (absorbent paper, herculite)	
□	□	5.2 Contamination curbing or kick plate	
□	□	5.3 Fence or "bull-pen"	
□	□	5.4 Glove boxes/tents	
□	□	5.5 Portable ventilation blower	
□	□	5.6 Vacuum cleaner	
□	□	5.7 Decontaminate area/equipment	
□	□	5.8 Other	

Part D

RWP - ALARA CONTROLS RECORD

Attach to RWP or Experiment Logbook		ALARA Control Record No. ________
JOB INFORMATION		
RWP No.:	ALARA Code:	Area/Facility/Location:
Estimated Exposure per Job/Experiment or Task (Person-rem):		Estimated Exposure Per Task (Person-Rem):
Job/Experiment Title:		
ALARA CONTROLS		
EXPOSURE CONTROLS		CONTAMINATION CONTROLS
JOB/EXPERIMENT PERFORMANCE REMARKS (Note Controls not used, reasons for work stoppage, and lessons learned)		

Prepared by: ______________________
Radiological Engineer or
Department ALARA Coordinator

Reviewed by: ______________________ ________
Work Supervisor/Foreman or Principal Investigator   Date

Radiation Protection Manager Concurrence: ______________________ ________
Radiation Protection Manager   Date

PART E

POST-JOB/EXPERIMENT REVIEW RECORD

JOB/EXPERIMENT TITLE: ______________________________

ALARA CODE: ____________ JOB/EXPERIMENT START DATE: ____________ JOB/EXPERIMENT END DATE: ____________

TASK	TASK TITLE/ALARA TASK CODE	ESTIMATED PERSON-HRS	ACTUAL PERSON-HRS	ESTIMATED PERSON-REM	ACTUAL PERSON-REM	PERCENT DIFFERENCE
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
TOTALS						

1. What were the reasons why actual total person-rem was ± 25% different than the estimated total person-rem? ______________________________

2. Evaluate the effectiveness of the radiation exposure and contamination controls that were implemented. List dose savings, dose rate reduction factors, and decontamination factors achieved, if available. ______________________________

3. Describe any changes in scope. List radiation exposure and contamination controls that were not implemented and reasons for not implementing them. ______________________________

4. Describe problems encountered and situations that required the use of stop work/experiment authority. List lessons learned and corrective actions taken to prevent reoccurrence. ______________________________

Viewgraphs Used for
ALARA Job/Experiment Review
Instructional Portion

PURPOSE

- To demonstrate how to perform and document a systematic review of a radiological activity.
- To ensure that radiological controls are planned and implemented to reduce workers' doses to levels that are as low as reasonably achievable.

1

OBJECTIVE

To make an ALARA Job/Experiment Review for a radiological activity, using the information provided.

2

WHAT IS AN ALARA JOB/EXPERIMENT REVIEW?

- A systematic pre-job review of high-dose activities to ensure that ALARA controls are planned, evaluated, implemented, where reasonable, and documented.
- A review during job performance to ensure ALARA controls are implemented and effective, and to ensure that job doses are compared against job estimates, so that intervention is performed if needed.
- A systematic post-job review to ensure that the lessons learned are documented and used to optimize future jobs/experiments.

3

OPERATIONAL EXERCISE METHODOLOGY FOR ALARA JOB/EXPERIMENT REVIEW

- BNL ALARA Study of DOE Contractor ALARA Programs - Good Practice Document in Appendix K, "Example of an ALARA Job/Experiment Review Procedure"[1]

[1] Dionne, B.J., Meinhold, C.B., Khan, T.A., and Baum, J.W. (Brookhaven National Laboratory), Occupational Dose Reduction at Department of Energy Contractor Facilities: Study of ALARA Programs - Good Practice Documents, BNL-47339, March 1992.

4

THREE PHASES OF AN ALARA REVIEW

1. Pre-job planning and dose assessments.
2. Implementation of ALARA controls and dose-tracking during job/experiment.
3. Post-job/experiment review.

5

RADIOLOGICAL ACTION LEVELS FOR AN ALARA JOB/EXPERIMENT REVIEW

Typical trigger points* for pre-planning:

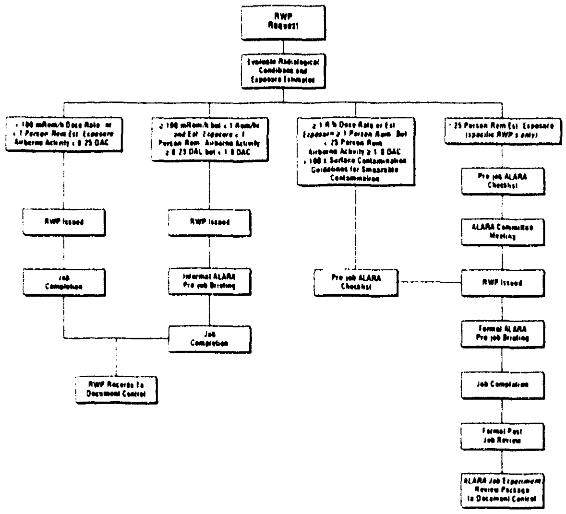
- Planned collective dose ≥ 1 person-rem.
- Planned whole-body dose rate ≥ 100 mrem/hr.
- General area contamination levels ≥ 100 times Surface Radioactivity Guide.
- Airborne concentrations ≥ 1 x Derived Air Concentrations.

*Several sets of action levels should be established for high radiological-risk facilities. This will increase the depth of review for activities with higher risk.

6

Viewgraphs Used for ALARA Job/Experiment Review Instructional Portion

Factoring ALARA Into Jobs/Experiments - Flow Chart



7

DATA AND INFORMATION NEEDED FOR PRE-PLANNING

- RWP Information.
- Details of work/experiment, e.g., work procedures or experimental protocol.
- Surveys for work locations.
- Estimates of personhours by location and workgroup.
- Estimates of collective dose by task.

8

EVALUATE REASONABLE ALARA CONTROLS

- Procedure preparation.
- Services and area preparation.
- Worker preparation.
- Exposure controls.
- Contamination controls.

9

DOCUMENT ALARA CONTROLS

- RWP - Additional Protective Requirements and ALARA Information.
- RWP - ALARA Control Record.
- ALARA Checklist.
- Work Procedures, e.g., Radiation Hold Points.

10

DISSEMINATE ALARA CONTROLS

- RWP sign-in sheet.
- Pre-job briefing.

  a. Scope of work to be performed.
  b. Type and location of dosimeters.
  c. Radiological conditions of the workplace.
  d. Protective clothing requirements.
  e. Degree of RP coverage required.
  f. Radiologically limiting conditions, e.g., contamination or radiation levels which may void the RWP.
  g. Radiation hold point signatures.
  h. ALARA controls.
  i. Any special tools, practices, and/or other controls to be used to reduce dose.
  j. Any precautions and practices to be taken to minimize loose-surface or airborne contamination levels.

- Work procedures.

11

JOB PERFORMANCE

- Implementation of ALARA Controls

  a. In-process reviews
  b. Radiation hold points

- Enforcement

  a. Work supervision and radiological protection technician periodically audit the effectiveness of the RWP requirements and ALARA controls
  b. Stop work authority

- Tracking

  a. Periodically compare total collective dose or projected total to estimates
  b. Intervention

12

CRITERIA FOR POST-JOB/EXPERIMENT REVIEW

Typical trigger points for post-job reviews:

- Actual collective-dose > 5 person-rem.
- Actual dose > ± 25% of estimates.
- Work stoppage exercised during job.
- Radiological deficiency report for job activity.
- Significant lesson learned.
- Collective dose which exceeds pre-established limiting value.

13

DOCUMENT POST-JOB REVIEW

Information to be documented:

- Actual and estimated person-hours and person-rem totals for the job.
- Reasons for not achieving ± 25% of person-rem.
- Effectiveness of ALARA controls.
- Deviations from the original job scope.
- Reasons why ALARA exposure controls were not implemented, if applicable.
- Radiological problems encountered and corrective actions.
- Lessons learned that can be incorporated into future work

14

IMPORTANT

NOTE: Next time the same or similar a job or experiment is performed, use the experience and lessons learned documented in the post-job review to OPTIMIZE the job's radiological performance.

15

PROBLEM AND ANSWER

FOR THE

OPERATIONAL EXERCISE

FOR AN

ALARA JOB/EXPERIMENT REVIEW

Operational Exercise: Repack 26 Plutonium Cans in 2R Containment Vessels into 6-M Shipping Packages and Move to Loading Dock

Purpose: To ship Plutonium buttons back to the processing plant to perform additional processing.

Description of Work: A team of 5 individuals, a radiation protection technician, a pyrochemistry operator, a production control operator, a nuclear material controller and a security guard will repack 26 plutonium cans located in vault into shipping packages and move them to the loading dock in Bldg. 75. The breakdown of tasks, man-hours and effective dose rates are as follows:

1. Locate and survey 2R cans labelled 1-P through 26-P: 15 person-hour and 0.005 rem/hr.

2. Perform physical inspection on 26 2R cans: 3.0 person-hours and 0.2 rem/hr.

3. Hand-carry 26 2R cans, outside of vault: 1.5 person-hours and 0.2 rem/hr.

4. Place 2R cans into 6-M shipping packages: 1.5 person-hours and 0.2 rem/hr.

5. Seal and label 6-M shipping packages: 1.25 person-hours and 0.01 rem/hr.

6. Transport packages on carts to Bldg. 75 loading dock: 1.25 person-hours and 0.01 rem/hr.

Physical Conditions: The special nuclear material storage vault (Rm. 15) is located on the ground floor of Bldg. 75 (see Attachment A). It is a locked 20' x 35' vault with 4 row of stands. The vault is well lighted with fluorescent lights. The aisles are 4' wide, with 13 stands on each row measuring 12" wide by 3' tall. One can fits on each stand. The 2R cans are made of aluminum, hold 3 plutonium buttons, measure 5" in diameter by 10" tall and weight about 10 pounds when full. The 6-M shipping package holds 1 can (see Attachment B). They are transferred on carts; with six 6-M packages to a cart. Only 3 carts are available. The 6-M shipping package is made of lead lined polyethylene, measures 8" in diameter by 14" tall and weights approximately 37 pounds. The covers of the shipping package are hinged, fastened with a single wing nut and then locked. The loading dock also is in building 75 and is on the ground floor approximately 200 ft. from the vault. Three doors must be opened on the way from the vault to the loading dock.

Radiological Conditions:

The radiological conditions outside the vault entrance are:

0.5 - 1.0 mR/hr general area
< 1,000 dpm/100 cm^2.

The radiological conditions inside the vault are:

2-5 mrem/hr in center of aisle at waist level
1-2 rem/hr @ 1 meter from stands
~ 50,000 dpm α/100 cm^2 on floor and walls

The radiological conditions for the 2R cans with 3 plutonium buttons are:

3-5 rem/hr γ plus 0.2-0.7 rem/hr n at contact
1-2 rem/hr γ plus 0.05-0.07 rem/hr n at 1m.

The radiological conditions for the 6-M shipping packages are:

1-2.5 mrem/hr at contact
<0.5 mrem/hr at 1m.

Information on Job Performance:

The breakdown of the actual man-hours and collective dose, which was incurred to perform each task, were as follows:

1. Locate and survey 2R cans labelled 1-P through 26-P: 1.7 person-hours and 0.700 person-rem.

2. Perform physical inspection on 26 2R cans: 2.8 person-hours and 0.780 person-rem.

3. Hand-carry 26 2R cans, outside of vault: 1.5 person-hours and 0.290 person-rem.

4. Place 2R cans into 6-M shipping packages: 1.4 person-hours and 0.265 person-rem.

5. Seal and label 6-M shipping packages: 1.25 person-hours and 0.015 person-rem.

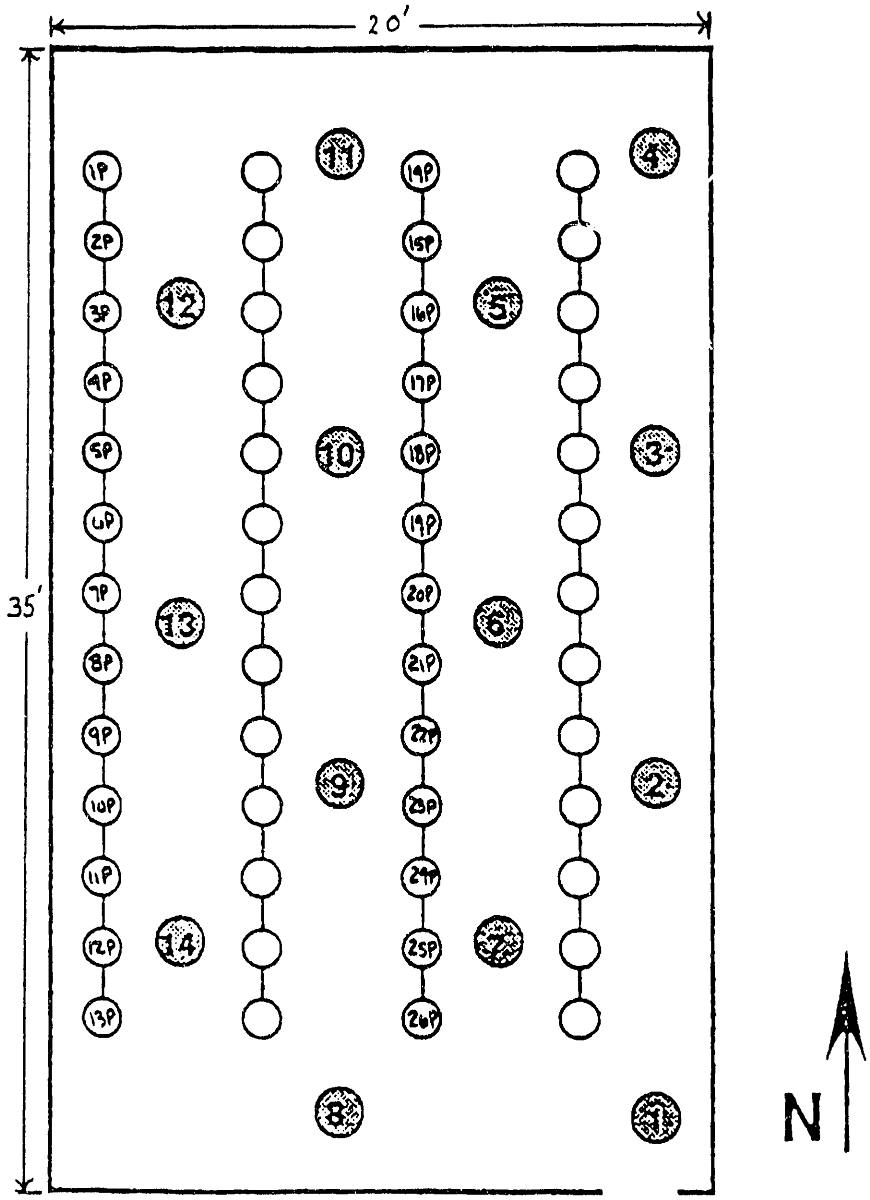
6. Transport packages on carts to Bldg. 75 loading dock: 1.00 person-hours and 0.010 person-rem.

The radiation protection technician received about 450 mrem performing the contact and 1 meter radiation surveys on each 2R can. This resulted in stop work authority being exercised and a meeting to resolve the increase radiation readings. The inspectors in pyrochemistry, production control and nuclear material controllers also received higher than expected doses to perform the inspections. The nuclear material controller received 6.575 rem to his right hand from hand-carrying the 2R cans (despite use of lead gauntlets). A slight delay occurred in closing the 6-M shipping package as a result of one of the survey bolts becoming cross threaded. The results from a test involving placement of a dosimeter on the outside and inside of the apron and gloves indicated that a dose reduction factor of 0.5 was achieved. A change in the job scope occurred in that 3 of the 2R cans were damaged and therefore were not repacked into the shipping packages. The radiation protection technician had heard about a robot that was being tested at Los Alamos. This robot would inspect, survey and transfer plutonium cans in their TA-55 vault. This ALARA suggestion was discussed at the post job meeting. The problem with high extremity dose also was discussed.

GAMMA / NEUTRON SURVEY
ROOM 15
BUILDING 75

WORK TASK: REMOVE 2R CONTAINERS 1P-26P AND PLACE IN DOT-6M SHIPPING CONTAINER. 2 R CONTAINERS ARE 3-5 R γ CONTACT, .2-.7 R n CONTACT, .1-.2 R γ AND .05-.07 n 1 METER

2R CONTAINERS CONTAIN Pu BUTTON SOURCES. 1989 SURVEYS INDICATED 1-3 R γ CONTACT READINGS.

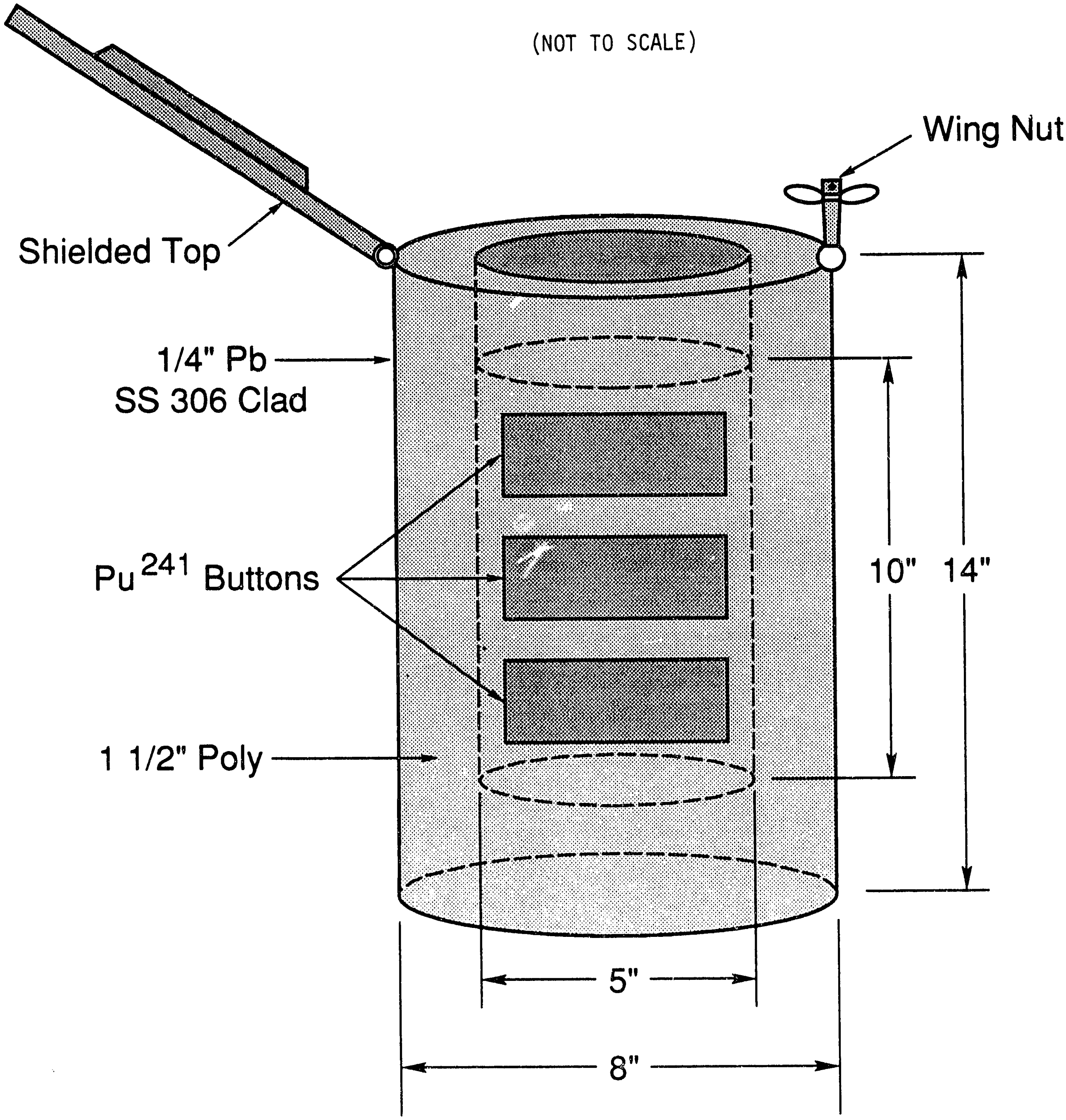


14 Total Survey Points

Attachment B

DOT 6-M Shipping Package

(NOT TO SCALE)



Operational Exercise: Repack Plutonium Buttons

RWP No: #92-0001
ALARA Code:
ALARA Task Code:

☐ Standing RWP
☐ 24-hour RWP

DOE CONTRACTOR
RADIATION WORK PERMIT

REQUESTOR

Work Description: Repack 26 Plutonium cans into 6-M shipping packages and move to loading dock	Equipment ID Number: N/A
	MR Number (if appropriate): N/A
	Procedure Number (if applicable):
Location (Bldg., room and area. Be specific.): Bldg. 75, Room 15 SNM Storage Vault	Location Code: Bldg. 75, Rm. 15 & (Loading Dock

Estimated person hours in area:	Actual person hours worked:	Requester Name and phone no.:	Date:
10		John D. Doe	4/13/92

RADIOLOGICAL INFORMATION

RADIOLOGICAL SAFETY PERSONNEL

Dose Rate, Contamination Levels and Collective Dose Data	Head/Body Protective Clothing	Hand/Feet Protective Clothing	RESP Protection Equipment	Personnel Monitoring	HP Training/ Coverage
General Area Dose Rate: 20-50mR Date/Time and Survey No.: 4/12/92 Job Specific Dose Rate: 1-2 Rγ & 0.05-0.07Rem/hr neut. Date/Time and Survey No.: 4/12/92 Contamination Level: 50,000dpm Date/Time and Survey No.: 4/12/92 Airborne Activity: Date/Time and Survey No.: 4/12/92 Estimated person rem: 1.23 Actual person rem:	☑ Cap ☑ Hood ☐ Lab Coat ☑ Coveralls ☐ Coveralls _ Pr ☐ Plastic Slip Ons ☐ Disposable Suit ☐ Bubble Suit ☐ Acid Suit ☐ ________	☑ Cotton Gloves ☐ Surgeon Gloves ☑ Rubber Gloves ☐ Acid Guantlets ☐ Cotton Shoe Cover ☑ Plastic Shoe Cover ☑ Rubbers ☐ Boots ☐ Acid Boots ☐ ________	☑ Full Face ☑ Particulate Filter ☐ Combination Cartridge ☐ Supplied Air Resp. ☐ Supplied Air Hood ☐ Self-Contained Breathing Apparatus ☐ ________	☑ TLD ☑ Self-Reading Dosimeter ☐ Hi Range SRFD ☑ Extremity TLD ☐ Mult. Badging ☑ Neutron Dosimeter ☑ Electronic Dosimeter ☐ Dose/Rate Alarm ☐ Breathing Zone Air Sample ☐ Continuous Air Monitor ☐ Nasal Smear ☐ Personnel/ Equipment Frisking ☐ ________	☑ Pre-Job Briefing ☑ Start of Work ☐ Intermittent ☐ Continuous ☑ Completion of Work ☐ Survey After Work ☑ Post-Job Debrief ☐ Rad Worker I ☐ Rad Worker II ☐ Other ________

Additional protection requirements and instructions:
HP technician to perform contact reading on each can prior to handling to verify the contact reading on each container.

ALARA ENGINEER

ALARA INFORMATION

ALARA Job/Experiment Review Required:	Exposure Controls	Contamination Controls
☑ Yes ☐ No If yes, all work under this RWP must comply with the ALARA controls listed on this form or prescribed on the attached RWP-ALARA Controls Record No. 1.		

APPROVALS

Operational Health Physics Supervisor Approval: ____________________ ____________

Job Supervisor/Foreman Approval: ____________________ ____________ Date / Time

Environment, Safety and Health Manager Approval: ____________________ ____________ Date / Time

Limiting Conditions: ____________________

Permit Expires: ____________ Date/Time

GENERAL INSTRUCTIONS

1. Observe all radiological signs, warnings, and postings.
2. No eating, drinking, smoking, or chewing.
3. Obey all written and verbal requirements and instructions from safety personnel.
4. Report any problems with RWP or radiological conditions to HP Technician and/or Supervisor.
5. Maintain your dose and spread of radioactivity ALARA.
6. Monitor tools, equipment, and clothing before leaving radiologically controlled area.

Operational Exercise: Repack Plutonium Buttons

ALARA JOB/EXPERIMENT REVIEW RECORD

ALARA Code:

Job/Experiment Title: Repack 26 Plutonium cans 2R containment vessels into 6-M shipping packages

	Principal Investigator/Job Planner/Department ALARA Coordinator			Department ALARA Coordinator or Radiological Engineer		
Task No.	Task Title	Location (be specific)	Estimated Person Hours	Effective Exposure Rate (Rem/hr)	Estimated Exposure (Person-Rem)	ALARA Task Code
1	Locate 2R cans and survey	See survey form	15.0	0.05	0.750	
2	Inspect cans	Inside Rm. 15 vault	3.0	0.200	0.600	
3	Transport to location of 6-M shipping packages	Inside Rm. 15 vault	1.5	0.200	0.300	
4	Place into 6-M shipping packages	Outside Rm. 15 vault	1.5	0.200	0.300	
5	Seal 6-M shipping packages	Outside Rm. 15 vault	1.25	0.010	0.012	
6	Transport to Bldg. 75 Loading dock	Bldg. 75 Loading	1.25	0.010	0.012	
7		Dock				
8						
9						
10						
		Total Job/Experiment Estimates Person Hour	23.50	Total Job/Experiment Estimated Person rem	1.974	

Prepared by: ______________ Principal Investigator/Job Planner ______ Date

Received by: ______________ Department ALARA Coordinator ______ Date

Reviewed by: ______________ Radiological Engineer ______ Date

Reviewed by: ______________ ALARA/Radiological Safety Committee Chairman ______ Date

(see back for ALARA Controls Checklist)

Operational Exercise: Repack Plutonium Buttons

ALARA CHECKLIST

ALARA Code:	
ALARA Task Code:	

Job Description: Repack 26 Plutonium cans into 6-M shipping packages

Task Description:

Check Box Yes	Check Box No	Items to be considered	Describe each item checked yes
		1. Procedure Preparation	
✓		1.1 Job procedure prepared	TIP 75PC-91-35 "Inspection, Control and Transfer of SNM"
✓		1.2 Unnecessary work deleted	Yes.
✓		1.3 Radiation hold points identified	Yes-following contact reading on cont.
	✓	1.4 Tool lists developed	
✓		1.5 Special tools considered	Tongs and pliers
	✓	1.6 Remote or robotic equipment/tools	
✓		1.7 Prefabrication considered	Shielding of transport cans
✓		1.8 Human factors considered	Heat stress
✓		1.9 "Lessons-learned" reviewed	Use of tools in damaging containers
✓		1.10 Practice repetitive task in lowest dose rate area first	Loading in can containers
		1.11 Other	
		2. Set-up Preparation	
✓		2.1 Access to and exit from work area planned	Dismantle and exit to vault
		2.2 Services provided:	
✓		Lighting	Overhead lighting
	✓	Breathing Air	
	✓	Welding	
	✓	Staging	
	✓	Instrument/tool air	
	✓	Electric	
	✓	Heating/Cooling	
	✓	Other	
		2.3 Communication provided:	
	✓	Headset	
	✓	Walkie-Talkie	
	✓	TV Camera/Monitor	
	✓	Other	
		3. Worker Preparation	
✓		3.1 Experienced workers selected	Workers familiar with vault and containers
✓		3.2 Special training/photos/drawings	Vault photo and drawing
✓		3.3 Rehearsal	Break down on job and route
	✓	3.4 Mock-up training	
✓		3.5 Workers exposures reviewed	Previous and estimated dose
✓		3.6 Evaluate fewer workers	Eliminated unnecessary support
		4. Exposure Controls	
	N/A	4.1 Allow for decay following facility shutdown	
	✓	4.2 Decontaminate equipment	
	✓	4.3 Flushing or filling equipment	
✓		4.4 Move equipment to low dose rate area	Repack cans outside of vault
	N/A	4.5 Work equipment under water	
✓		4.6 Temporary shielding of equipment	Temporary shielding of transport carts
	✓	4.7 Temporary shielding of work area	
	✓	4.8 Permanent shielding	
✓		4.9 Posting of hot spots and low dose rate wait areas	Convenience and exit to vault
✓		4.11 Other	Workers to wear lead apron and gloves
		5. Contamination Controls	
✓		5.1 Floor covering (absorbent paper, herculite)	Tape on wheels of carts & cover/floor
	✓	5.2 Contamination curbing or kick plate	
✓		5.3 ~~Fence or~~ "bull-pen"	outside of vault
	✓	5.4 Glove boxes/tents	
	✓	5.5 Portable ventilation blower	
	✓	5.6 Vacuum cleaner	
	✓	5.7 Decontaminate area/equipment	
	✓	5.8 Other	

RWP - ALARA CONTROLS RECORD

Attach to RWP or Experiment Logbook	ALARA Control Record No. ______

JOB INFORMATION

RWP No.: 92-0001	ALARA Code:	Area/Facility/Location: Bldg. 75, Room 15

Estimated Exposure per Job/Experiment or Task (Person-rem): 1.23	Estimated Exposure Per Task (Person-Rem): 1.23

Job/Experiment Title: Repack 26 Plutonium Cans into 6-M Shipping Packages and Move to Loading Dock

ALARA CONTROLS

EXPOSURE CONTROLS	CONTAMINATION CONTROLS
o Use tongs and pliers whenever possible	o Tape over wheels on carts
o Apply additional shielding on transfer carts	o Frisk after exiting vault
o Mockup training for nuclear material controller on placing 2R cans into 6-M shipping packages	o Establish bullpen outside vault
o Repack shipping packages in a low dose rate area	o Floor covering inside vault and inside bullpen
o Use lead aprons and lead impregnated gauntlets	

JOB/EXPERIMENT PERFORMANCE REMARKS (Note Controls not used, reasons for work stoppage, and lessons learned)

Prepared by: ______________________
Radiological Engineer or
Department ALARA Coordinator

Reviewed by: ______________________ ______
Work Supervisor/Foreman or
Principal Investigator
Date

Radiation Protection Manager Concurrence: ______________________ ______
Radiation Protection Manager
Date

Operational Exercise: Repack Plutonium Buttons

POST-JOB/EXPERIMENT REVIEW RECORD

JOB/EXPERIMENT TITLE: Repack 26 Plutonium cans into DOT 6-M shipping Packages

ALARA CODE: ______ JOB/EXPERIMENT START DATE: 1992 JOB/EXPERIMENT END DATE: 1992

TASK	TASK TITLE/ALARA TASK CODE	ESTIMATED PERSON-HRS	ACTUAL PERSON-HRS	ESTIMATED PERSON-REM	ACTUAL PERSON-REM	PERCENT DIFFERENCE
1	Locate 2R containers	15.0	1.7	0.750	0.700	- 7%
2	Inspect containers	3.0	2.8	0.600	0.780	+ 30%
3	Transport to 6-M location	1.5	1.5	0.300	0.290	- 3%
4	Place in 6-M Packages	1.5	1.4	0.300	0.265	- 12%
5	Seal 6-M Packages	1.25	1.25	0.012	0.015	+ 25%
6	Transport to loading dock	1.25	1.00	0.012	0.010	- 16%
7						
8						
9						
10						
	TOTALS	23.50	9.65	1.974	2.060	

1. What were the reasons why actual total person-rem was ± 25% different than the estimated total person-rem? The dose to locate and survey cans was exceeded due to the higher than expected dose rates to surveyor. In addition, the dose to inspect container was exceeded again due to higher than expected dose rates to inspect. The sealing of one of the containers was hampered by a cross threaded swing bolt.

2. Evaluate the effectiveness of the radiation exposure and contamination controls that were implemented. List dose savings, dose rate reduction factors, and decontamination factors achieved, if available. Lead aprons and gloves provided effective exposure protection. Secondary dosimetry was worn under clothing to evaluate factor. A DRF = 0.5 was achieved for the apron dose reduction

3. Describe any changes in scope. List radiation exposure and contamination controls that were not implemented and reasons for not implementing them. Some containers that were scheduled for removal were damaged and had to remain in vault.

Describe problems encountered and situations that required the use of stop work/experiment authority. List lessons learned and corrective actions taken to prevent reoccurrence. Contact readings were higher than estimated. Stop work was initiated by RP Techs. to re-evaluate exposure controls. It is suggested that the use of a robot similar to that at LASL's TA-55 vault be evaluated.

ALARA PROGRAM IMPROVEMENTS: DOE CONTRACTOR FACILITIES

Chairperson:

R. Desmarais (Department of Energy - BNL)

DOE ALARA WORKSHOP
BROOKHAVEN NATIONAL LABORATORY
UPTON, NY 11973

Comments from the Participants

ALARA PROGRAM IMPROVEMENTS AT VARIOUS DOE CONTRACTOR FACILITIES

To improve the ALARA program at the Uranium Mill Tailing Remedial Action Project (UMTRAP) the ALARA Plan was recently rewritten. The plan was revised using the DOE ALARA implementation guides. Under the new plan, the ALARA committee has assumed a more active role in the implementation and review of all aspects of the project. The Radiation Worker Training program has also been revised to provide a greater emphasis on ALARA. - ***Ron Jacobs, CWMFES, UMTRAP.***

Our company (EG&G Idaho) is organized without a centralized Health and Safety Organization; therefore, getting each Department (there are twelve) to understand and implement ALARA principles is difficult. We have chosen to place most emphasis on the Department that accumulates the highest collective dose and then work down through the next highest and the next, and so on. We have been successful in forming ALARA committees in four Departments now and progress in reducing doses is being made. The other Departments are now paying much more attention to their ALARA exposure goals and to individuals' doses. As more people become involved in ALARA process, thus becoming aware of the ALARA mission, we will find greater support and associated reductions in exposure. - ***N.G. Reece, EG&G Idaho.***

The Power Reactors Program Hot Cell Facility processes radioisotopes and prepares them for shipment to various customers. These isotopes are transferred to the Hot Cell Facility in a shielded cask. A long rod is used to push the isotopes from the cask into the hot cell. Radiation beams of several hundred rads have been detected in the vicinity of the rod as it penetrates the shield. Each manipulation of the rod has resulted in the hands of facility personnel receiving several hundred millirem exposure. By actively involving the facility personnel, several ideas were generated to shield the beam and still allow manipulation of the rod. A temporary design for shielding was tried on two occasions. The first attempt reduced the beam to less than 10 rads. The second attempt eliminated the beam. Total extremity exposure was less than 50 millirem following the installation of the second shield. - ***Christine Baccus, Power Reactor Programs, EG&G, Idaho.***

The air pulsars located in the Westinghouse Chemical Processing Plant, Building 601 Preventive Maintenance area have been a source of radioactive contamination for some time. They require continual deconning by operations personnel. The surrounding areas have been known to become contaminated on numerous occasions. During plant operations this area is entered to read gauges. Operational Health Physics Technicians were required to perform radiological job surveillance for every decon effort. We developed a plexi-glass box to fit over the poppet valves which periodically leak. We were able to contain the contamination and reduce the contaminated area from 100 square feet to 1 square foot. In addition, workers are now required to wear gloves whenever reaching into the contamination control box to manipulative valves. In the past, full anti-contamination protection was required with the valve containment devices. This approach has resulted in fewer incidents of skin contamination and reduced external dose. - ***Ron Reavis, WINCO-Westinghouse-Idaho, Nuclear Company, Inc.***

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Comments from the Participants

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The Waste Isolation Plant (WIP) ALARA program is being improved by providing more separation in authority between those responsible for executing program requirements (Operational Health Physics and Radiological Engineering) and those recently responsible for stewardship and implementation of the ALARA program as a focused entity (Safety Analysis and Review). A major effort in this process is the pooling of representatives from affected or interested sections to develop a procedures manual for the ALARA program. The scope of this manual, however, extends beyond radiation protection and also encompasses protection from hazardous chemical agents. - ***Don Mayfield, Westinghouse, WIP***

At Argonne National Laboratory-East, we have made the following improvements:

- Criteria established for participation: > 0.5 person-rem/yr, and/or operation of major radiological facility.
- Divisional ALARA coordinators appointed in participating divisions. ALARA coordinators constitute ALARA committee.
- ALARA policy statement signed by Laboratory Director.
- ALARA program document developed and issued.
- Periodic "Safety Alert" notices sent to all employees on topics such as radiation risk, and contamination control.
- Specific inclusion of ALARA in all phases of radiation safety training (general employee, radiation worker, HP technician).
- ALARA goals established for collective dose, maximum individual external dose, maximum individual internal dose (effective dose equivalent and organ dose equivalent), and maximum off-site dose from radiological emissions.
- Semi-annual dose report and ALARA goal memo distributed to ALARA coordinators, line management, and Health Physics.
- Credit taken for pre-existing operations, such as building retention tank monitoring.
- Incorporated specific ALARA guidance into ES&H manual.
- Added ALARA Checklist to RWP form, with graded levels of review depending on anticipated exposure. - ***Richard E. Toohey, Argonne National Laboratory - East***

DOE ALARA Workshop
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5/24/93