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Pacific Northwest Laboratory Plan to Maintain Radiation Exposure As Low As Reasonable Achievable (ALARA)

D. P. Higby
J. T. Denovan

December 1982

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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PNL-4560

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Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

NTIS Price Codes
Microfiche A01

Printed Copy

Pages	Price Codes
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
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251-275	A012
276-300	A013

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PACIFIC NORTHWEST LABORATORY PLAN TO MAINTAIN RADIATION EXPOSURE AS LOW AS REASONABLY ACHIEVABLE (ALARA)

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Richland, Washington 99352

SUMMARY

This document describes the radiation safety program at the Pacific Northwest Laboratory (PNL). The practices and administrative policies of this program support the principles of ALARA (to maintain radiation exposure as low as reasonably achievable). This document also describes a program to establish safety goals at PNL to help ensure that operations are conducted according to ALARA principles.

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PACIFIC NORTHWEST LABORATORY PLAN TO MAINTAIN RADIATION EXPOSURE AS LOW AS REASONABLY ACHIEVABLE (ALARA)

1.0 INTRODUCTION

This document describes the radiation safety program at the Pacific Northwest Laboratory (PNL). This program is founded on the philosophy that radiation exposure be maintained "as low as reasonably achievable" (ALARA). PNL has always been committed to the principle that personnel and environmental radiation exposures shall be kept to the lowest levels commensurate with sound economics and operating practices. It has been PNL policy and practice to base its overall radiation safety program on the ALARA principle. Those practices and the administrative policies supporting them are described herein, along with safety goals and objectives established by PNL. Because of the dynamic nature of PNL's operations and programs, the PNL radiation safety program is a living program subject to update, revision, and improvement to maintain PNL staff exposure to ionizing radiation ALARA.

2.0 BACKGROUND

The concept of maintaining radiation exposure "as low as possible" (ALAP) was formally introduced by the National Committee on Radiation Protection (NCRP) in 1954. Since that time, the major energy contractors have integrated the ALAP (later ALARA) philosophy into their overall radiation safety programs. The ALARA philosophy has been an integral part of the PNL radiation program for many years. Requirements for limiting radiation exposures to as low as practicable were introduced in the U. S. Energy Research and Development Administration (ERDA) Manual Chapter 0524 in 1975. In 1980, the U. S. Department of Energy published "A Guide to Reducing Radiation Exposure to As Low as Reasonably Achievable (ALARA)," (DOE/EV/1830-T5). This guide was prepared by PNL staff and is primarily a description of the current PNL radiation safety program.

3.0 MAJOR COMPONENTS OF THE PNL RADIATION SAFETY PROGRAM

The PNL radiation safety program has five major components: management, facilities, training, equipment and quality assurance. Management includes such items as organization, policies, procedures, manuals, management oversight, communications, and evaluations. Facilities include buildings; internal structures such as walls, containment, and shielding; and integral equipment such as utilities, HVAC systems, and effluent control systems. Equipment includes all portable, mobile, and detachable items. Training includes qualification and training of those who perform and supervise radiation work or provide support functions for radiation work. Quality assurance includes the application of appropriate elements of the QA program such as documentation, audits, and design reviews.

4.0 MANAGEMENT

The establishment and administration of the PNL radiation safety program draws upon many information sources, including: DOE Order 5480.1, Chapter XI, Chg. 6; the DOE ALARA Guide; publications of the NCRP and ICRP; reports of experiences from other nuclear energy contractors; and technical publications of radiation protection professionals. The administrative policy for the program is contained in PNL Management Guide 11.4., which states:

> *Human exposure to ionizing radiation from both internal and external sources shall be kept as low as practicable through application of the best protective equipment, methods, and designs technically and economically feasible.*

The application of the ALARA policy to the PNL radiation safety program is stated in PNL-MA-6, Radiation Protection Procedures:

> *The basic radiation protection policy of Battelle is designed to maintain radiation exposures of personnel and the environment to the lowest levels practicable, commensurate with sound economics and good operating practices. The "as low as reasonably achievable" (ALARA) concept should be interpreted as an intent to implement practices that minimize total personnel exposures to radiation from all Battelle operations. The procedures and practices presented in this manual are intended to achieve this objective.*

PNL management at all levels is firmly committed to maintaining and supporting a sound and effective general safety program. The foundation of PNL's radiation safety program lies in the strong support provided by the Directors and upper PNL management. Upper-level management is closely involved in the review and approval process for many aspects of the radiation safety program. Department managers are responsible for ensuring the adequacy of audit and appraisal responses.

The Director of Laboratory Support reviews and approves manuals pertaining to radiation safety. The cognizant Research Director is responsible for determining the need for Operational Readiness Reviews (ORRs), appointing the ORR Board (if one is required), obtaining final approval for project start-up after completion of the ORR, approval of safety goals developed by line management, and evaluation of the implementation of safety goals. This type of involvement on the part of the upper PNL management demonstrates their commitment to maintaining a strong radiation safety program and to the philosophy of ALARA. Past experience and an excellent safety record (including maintaining radiation exposure ALARA) demonstrate the success of the PNL approach to safety.

Primary responsibility for ensuring that personnel radiation exposures at PNL are ALARA rests with line management. Line management is responsible for designating staff members as radiation zone (RZ) workers or non-RZ workers, ensuring that each RZ-worker is provided with the proper radiation dosimeter(s), assigning RZ-workers to an appropriate internal dosimetry evaluation schedule, ensuring that each RZ-worker receives proper and adequate radiation safety training, and ensuring that the radiation work carried out at PNL is performed to limit radiation exposure to levels that are ALARA. Line management approval is required on all new Radiation Work Procedures (RWPs) and line management is responsible for ensuring the adequacy of responses to audit and appraisal findings. In addition, line management is responsible for developing and implementing appropriate safety goals on an annual basis. Of these goals, at least one per year is required to apply to radiation safety in applicable facilities. The Laboratory Safety Department works closely with line management to develop appropriate radiation control practices and goals for day-to-day operations at PNL, and to ensure that the ALARA principle is successfully implemented. Feedback on efforts to maintain radiation exposure ALARA is provided to line management through monthly personnel exposure reports that summarize employee exposures for the preceeding month.

The Director of Laboratory Support is responsible for ensuring the protection of the health and safety of PNL staff, and for ensuring that the radiological impact of PNL operations on the general public and the environment is limited to levels that are ALARA. Responsibility for the establishment of the overall radiation safety, radiation monitoring, and industrial health and safety programs is delegated to the Laboratory Safety Department. The Laboratory Safety Department was recently created through reorganization of some components of the Occupational and Environmental Protection Department and the Industrial Health and Safety Office. The reorganization effectively separated the responsibility for PNL safety programs from the site-wide radiation protection services, such as personnel dosimetry, environmental evaluation, and instrument calibrations. Organizational independence from the research operations is ensured by the fact that the manager of Laboratory Safety Department reports directly to the Director of Laboratory Support. The radiation safety function is thus independent of operations to the Director level within PNL.

Specific responsibility for the establishment of the PNL radiation safety program rests with the manager of the Radiation and Nuclear Safety Section (RNS) of the Laboratory Safety Department. RNS, in addition to establishing radiation safety practices, provides technical assistance, support and guidance to operations to ensure the adequacy of the PNL radiation safety program. In this respect, the manager of RNS fulfills all of the responsibilities of an "ALARA Coordinator" as described in the ALARA guide. RNS serves as a technical resource to PNL staff at all levels and as an independent review agency to verify and evaluate the successful implementation of the ALARA policy in the radiation safety program. RNS is also responsible for publication and timely review of all safety manuals pertaining to radiation work. This includes PNL-MA-3, Radiological Design Criteria; PNL-MA-6, Radiation Protection Procedures and PNL-MA-8, Waste Management. All of these manuals provide radiation safety guidance based on the ALARA policy to operations management and staff.

5.0 FACILITIES

All new facility designs and modifications to older facilities are reviewed by Laboratory Safety Department to ensure that they meet the environmental and radiological criteria in the DOE Orders. Laboratory Safety Department provides written recommendations to line management on the application of the ALARA principle in design.

Gloveboxes, hot cells, and fume hoods are containment structures designed to limit the exposure of personnel to hazardous materials. PNL-MA-3 places conservative limits on the quantities of radioactive materials which may be handled outside containment. Appropriate graded limitations are provided for each level of containment.

All integral building equipment, such as utilities, HVAC systems and effluent systems, are designed to provide a high degree of protection to both facility occupants and the environment. For example, backflow prevention is provided in utility lines where there is a potential for backflow of radioactive materials. HVAC systems have one or more high efficiency filters in both air recirculation and exhaust portions of the system. The number, size, and type of filters are carefully determined to ensure minimal exposures to both facility personnel and the environment. Filter systems are always designed to provide more filtration capacity than is anticipated to be required in order to protect against unexpected releases of radioactivity.

Building release points (i.e., stacks and radioactive sewers) are either instrumented or continuously sampled to provide warnings of unexpected releases. Releases from PNL facilities have typically been a small fraction of the applicable DOE guidelines.

PNL facilities having materials or operations with a significant potential for personnel contamination have change rooms where protective clothing may be obtained. Contamination survey instruments are provided in, or near, the change rooms to provide prompt detection of personnel contamination, in order to minimize contamination spread.

Personnel decontamination equipment and supplies are provided in these facilities, in or adjacent to the change rooms. The necessary supplies are maintained by the facility administrator and Radiation Monitoring (RM). There is a continuing effort to train and remind employees of contamination control techniques and avoidance of personnel contamination.

Skin contamination receives special consideration by Laboratory Safety Department. Although the incidence of skin contamination at PNL has typically been quite low, it is recognized that reduction of skin contamination may be particularly amenable to the principle of ALARA. RM maintains detailed documentation on each case of skin contamination. RM supervision continually examines skin contamination records for possible improvements to control radioactive materials and contamination. RM also generates a monthly skin contamination report for review by RNS.

Areas within PNL facilities with a significant potential for internal or external radiation exposure (>2 mrem/hr or any removable surface contamination) are designated as radiation zones according to the criteria in PNL-MA-6. Each radiation zone is provided with one or more Radiation Work Procedures (RWPs) which define the appropriate radiological controls to maintain radiation exposures ALARA. RWPs are reviewed and updated annually or as required by RM and line management.

The RWP system is presently being revised in order to provide more uniform and consistent specifications for controlling radioactivity and to keep personnel radiation exposure ALARA. The revised system will be known as a Radiation Control Specification (RCS). The RCS will provide general specifications for all radiation work. Separate Radiation Work Specifications (RWSs) will be posted in radiation zones and will delineate specific controls for those zones. The controls specified in each RWS will be supported by a technical evaluation which demonstrates that work tasks covered by the RWS can be performed with radiation exposures maintained ALARA. These

technical evaluations will be entitled Radiation Control Protocols (RCPs) and will receive appropriate reviews by qualified and responsible staff. Radiation work will be divided into six RCS classes, based on the type of work performed (e.g., fume hood, glove box, and hot cell) and the associated potential for radiation exposure.

Evaluation of the impact of PNL operations on the local environment is performed by the Environmental Evaluations Section (EES) of the Occupational and Environmental Protection Department, as specified by the Hanford Site Services Handbook. EES conducts an extensive program of surface and groundwater monitoring in and around the Hanford site. A yearly summary of these activities and their results are published for release to the public. The data have shown that PNL operations have resulted in essentially no additional exposure of the public to ionizing radiation.

PNL policy on emergency preparedness is to provide for personal safety primarily by preventing emergencies. If an emergency does occur, PNL policy is to carry out emergency measures so as to minimize the effects of the emergency on personnel and property. If the emergency involves radioactive material, the primary objective is to limit all exposures to less than the radiation protection standards. To achieve these objectives, PNL maintains PNL-MA-11, Emergency Preparedness, which describes appropriate PNL emergency response action. This manual was developed after detailed analyses of plausible emergency scenarios in PNL facilities. PNL also maintains extensive emergency response facilities and equipment in cooperation with other Hanford contractors. Sufficient high-level radiation monitoring equipment is available to permit rapid assessment of emergency conditions. Emergency drills are conducted for all PNL facilities on a regular basis, according to specific emergency plans developed for each facility.

6.0 TRAINING AND EDUCATION

The primary goal of PNL's radiation safety training program is to provide staff members with the knowledge and skill to perform their job assignments safely. This program is designed to instill the philosophy of ALARA while training PNL staff to perform their assigned tasks in an expeditious and efficient manner. In addition, this radiation safety training familiarizes workers with the fundamentals of health physics and proper procedures for radiation work, thereby reducing personnel exposures and preventing accidental over-exposures.

Four levels of radiation safety training are provided at PNL. (1) A brief, general radiation safety orientation is provided to each new staff member the day employment begins. This orientation covers emergency signals and appropriate actions, biological effects of ionizing radiation, and general rules for radiation safety. (2) Staff members assigned to radiation zone worker status receive general RZ-worker training which is provided by Laboratory Safety Department. This training covers self-survey techniques, ALARA philosophy, prenatal exposures, protective clothing, radiation zone rules and, where appropriate, respiratory protection training. (3) Line management provides job-specific, on-the-job training to individuals according to criteria developed by line management and approved by Laboratory Safety Department. (4) Finally, general radiation safety retraining is provided biennially by Laboratory Safety Department.

Laboratory Safety Department is responsible for reviewing the training criteria developed by line management, periodically auditing the training documentation, and providing general and specific radiation safety training as required by line management. All radiation safety training is evaluated as to its effectiveness by demonstration, oral examination, or written examination. An annual audit of all radiation safety training and training records is performed on each nuclear facility by qualified staff from Laboratory Safety Department as part of the Audit/Appraisal program. One Laboratory Safety staff member is assigned to the area of radiation

safety training on a full time basis. This staff member is a certified teacher who, in addition to professional qualifications in education, has operational experience as a radiation monitor.

Several approaches to radiation safety training are used, including the traditional centralized classroom technique, decentralized training demonstrations, and individual instruction. Materials used in PNL's radiation training include: visual aids, audio-visual equipment, chalkboard, and job-specific equipment (e.g., glove boxes, protective clothing, and radiation detection instruments).

The Laboratory Safety Department is staffed by a group of highly qualified engineers, specialists, supervisors and radiation monitors. A large proportion of this staff acquired their expertise in radiation safety through many years of operational experience at Hanford. In addition, the Laboratory Safety staff includes two Certified Health Physicists, as well as several acknowledged experts in criticality and nuclear safety, hazardous material transportation, and radioactive waste management. Several of the radiation monitors are certified by the National Registry of Radiation Protection Technologists (NRRPT). All non-NRRPT certified radiation monitors are actively encouraged to obtain certification.

7.0 EQUIPMENT

The Laboratory Safety Department works closely with line and facility management to ensure that radiation safety-related equipment used at PNL provides the highest level of performance attainable within budget constraints.

A continuing effort is under way to upgrade and improve radiation detection and personnel dosimetry equipment. PNL is constantly reviewing manufacturer specifications on new instruments and equipment in order to maintain equipment at state-of-the-art. Whenever practicable, instrument capabilities will be upgraded by purchase or development of new equipment. Every effort is made in purchasing new radiation detection equipment to ensure that the equipment complies with applicable criteria developed by the American National Standards Institute (ANSI) and similar standards and guides. Upon delivery, every new instrument is subjected to rigorous performance testing by the Instrument Calibration and Evaluation (IC&E) Section of the Occupational and Environmental Protection Department.

As required by the Hanford Site Services Handbook, all radiation detection instrument calibrations are performed by IC&E. Instrument calibrations are performed in accordance with the applicable criteria developed by ANSI, and are generally traceable to the National Bureau of Standards. IC&E is currently in the process of upgrading its instrument calibration record-keeping system to a computerized database system. This system will provide enhanced instrument history-tracing capability, as well as to facilitate instrument performance evaluations.

Portable radiation detection instruments used at PNL include thin window beta-gamma (G-M) detectors, portable alpha meters, ion-chamber survey instruments, and compensated BF_3 instruments for neutron dose equivalent measurements. All portable instruments are placed on a conservative calibration schedule to ensure the validity of survey

measurements. Semiportable instruments used in PNL include beta-gamma and alpha detecting continuous air monitors, bench-top survey instruments and tritium monitoring instruments. These instruments are also rotated on a regular schedule through IC&E for maintenance and calibration.

Fixed radiation detection instruments used in PNL include hand and foot monitors, water diverting instruments used to divert building effluents to retention systems in the event of accidental releases to building sewers, and radiation area monitors. PNL has nearly completed a program to replace all older scintillation-type hand and foot monitors with more sensitive and reliable gas-proportional instruments.

PNL personnel who work in radiation zones are provided with a Hanford multipurpose dosimeter. These dosimeters utilize thermo-luminescent dosimeters (TLDs) to monitor personnel exposure to penetrating, nonpenetrating and neutron radiation. Additional TLD finger ring or pocket ion-chamber dosimeters are provided as needed for monitoring extremity exposure. The PNL personnel dosimetry program meets all of the major criteria in the ALARA guide. Recent modifications to the personnel dosimetry record-keeping system provide the opportunity for extraction and summarization of exposure data that will facilitate trend analysis for evaluating the implementation of the ALARA policy.

Exhaust stacks and/or ducts of all major PNL facilities are continuously monitored for airborne beta-gamma and alpha-emitting radionuclides. In some cases, continuous air monitors with preset alarm levels are installed. Central air sampling vacuum systems are provided in most PNL facilities for sampling laboratory air. Portable air sampling equipment is available to supplement the central systems. PNL maintains an air sample analysis laboratory with state-of-the-art equipment, much of which has been designed and built at PNL.

Detection limits for this equipment are typically several orders of magnitude below the administrative control limits for airborne concentrations established by PNL. Air sample data is fed into a computer data-base system that allows rapid summarization as well as graphical representations of the data. This greatly facilitates trend analysis of air sample data.

8.0 QUALITY ASSURANCE

PNL conducts a comprehensive quality assurance (QA) program that covers all aspects of both safety and research operations. Major radiation safety programs such as air sampling, radiation monitoring, personnel dosimetry, instrument calibrations, radiation records, and environmental monitoring are covered by specific QA plans developed by the responsible staff members in cooperation with the PNL QA Office. The QA Office conducts periodic independent audits of the records associated with these programs to ensure adequate and traceable documentation.

The personnel dosimetry and environmental evaluations programs make use of the services of an independent laboratory for analysis of bioassay and environmental samples and for read-out of dosimeters. These programs make use of replicate and duplicate sample collection and blind analysis to verify the accuracy and consistency of the results obtained from the independent laboratory.

In addition to the above QA programs, the Laboratory Safety Department is responsible for conducting comprehensive audits and appraisals of all PNL safety programs. Implementation of the PNL radiation safety program is evaluated with respect to established safety criteria through the following programs:

1. In-depth appraisals of principal nuclear facilities and other PNL facilities having moderate or high hazard potential. These appraisals require significant planning, in-depth discussion with operations staff and examination of records, inspection of the facility, and a comprehensive report on the safety status of the facility. Nuclear facilities are appraised jointly by RNS and the Industrial Health and Safety Section of the Laboratory Safety Department.
2. The audit/inspection is a specialized field check of a facility for compliance with applicable requirements, standards, and

identification of any conditions which the audit team feels require the attention of line management.

All audit and appraisal results are reported to both the cognizant line manager, the cognizant department manager, and the manager of the Laboratory Safety Department. Significant findings are followed up by the audit or appraisal team leader and line management to ensure a satisfactory resolution.

Radiation safety documentation includes formal policy statements and procedures; training records; historical files including copies of all editions of procedural manuals; purchase specifications; radiation survey records and reports; air sampling data and results; dosimetry records; calibration documents; audit checklists and finding reports; records; calibration documents; audit checklists and finding reports; appraisals; and facility historical files, including contamination clean-up operations, modifications, and occurrence reports.

Early planning for new facilities involves review and input from Laboratory Safety, Crafts and Operations Services, Facilities Planning and Engineering, and research operations staff. The Laboratory Safety Department independently reviews the following design and safety documentation:

- functional design criteria
- ALARA design criteria
- conceptual design
- Title I - preliminary design
- preliminary Safety Analysis Report or Safety Assessment Document
- Title II - detailed design
- final Safety Analysis Report or Safety Assessment Document
- construction
- documented Operational Safety Requirements.

In addition, Laboratory Safety Department performs the following functions when existing facilities are modified:

1. evaluation of modification designs to maintain dose equivalents ALARA during modification
2. evaluation of the impact of modifications on existing safety systems
3. review the design of any structures intended for radioactive material containment (e.g., greenhouses and special waste containers)
4. coordination or review of the revised or supplemental safety analysis and the Operational Safety Requirements
5. upgrade of safety systems to current standards.

Approval by Laboratory Safety Department is required on all new facility designs or modifications of existing facilities.

9.0 GOALS

Upper PNL management has determined that successful safety program evaluation requires the establishment of specific safety goals by line management. Defining specific goals will aid the program evaluation because these goals are easily individualized, are usually measurable, and can emphasize current safety program needs. Because of the integrated safety approach adopted by PNL, specific radiation safety (or ALARA) goals will be developed by line management as part of a program of general safety goal development and implementation.

Line management, with assistance from Laboratory Safety, will be responsible for developing safety goals that address current safety needs or deficiences. Goals will be assigned and implemented on a calendar year basis. Goals for the upcoming calendar year will be developed in a timely manner to ensure a continuing program of safety evaluation. Each safety goal will have a discrete, measurable characteristic that can be used to confirm that the goal has been achieved. Each goal will also include a specific end-point description to facilitate the evaluation of goal achievement.

Upper PNL management will be responsible for final approval of safety goals and for evaluating the attainment of these safety goals. The Laboratory Safety Department will provide significant input and assistance to upper management in the evaluation process.

PNL line management is currently in the process of developing the safety goals for the 1983 calendar year.

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