A Radiation Protection Training Program with a Focus on Communicating Risk

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ABSTRACT

Radiation protection training is generally provided to promote a radiologically safe work environment, and to help ensure that doses are kept as low as reasonably achievable. In many cases, this reason makes good sense. Radiological risk can often be a significant concern when working with radioactive materials or radiation-emitting devices. However, in conducting the work of the Low-Level Radioactive Waste Management Office, it is often the case that the perception of radiological risk is of greater concern than the radiological risk itself. In this case, radiation protection training can serve another equally important purpose. It can be used to convey, in a balanced manner, the actual radiological risks associated with the work, and to put those risks in perspective. For individuals who are not familiar with radiation safety, effective radiation protection training that focuses on risk communication can reduce the level of concern surrounding work to be performed. This, in turn, can have an overall positive impact on the efficiency of the work, on goodwill within the community where the work is taking place, and even on the overall safety of those conducting the work. The radiation protection training program developed and implemented by the Low-Level Radioactive Waste Management Office is described in the context of other, more traditional radiation protection training programs.

1. INTRODUCTION

Why provide radiation protection training? Often, the answer to this question is to promote a radiologically safe work environment, and to help ensure that doses are kept as low as reasonably achievable (ALARA). More simply, the answer is to minimize risk. In many cases, this reasoning is sufficient. Radiological risk can often be a significant concern when working with radioactive materials or radiation-emitting devices.

Many individuals who receive radiation protection (RP) training work in an environment where there is a potential to receive doses approaching or exceeding regulatory limits. Under these conditions, it is important that a RP training program address this potential, to help ensure that limits are not exceeded and that doses are kept ALARA. For example, in the introduction to the “Training and Qualification” section of the US DOE Standard for Radiological Control [1], the primary objective of the RP training program is stated to be to “ensure that individuals are trained to work safely … and to maintain their individual radiation exposure and the radiation exposures of others ALARA.”

Sometimes, when working with mildly radioactive material, the perception of risk can be a greater concern than the risk itself. In this case, RP training can serve a different primary purpose. It can be used to convey, in a balanced manner, the actual radiological risks associated with the work, and to put those risks in perspective. For individuals who are not familiar with radiation safety, effective RP training that focuses on risk communication can reduce the level of concern surrounding work to be performed. This, in turn, can have an overall positive impact on the efficiency of the work, on goodwill within the community where the work is taking place, as well as on the overall safety of those conducting the work.

1.1 Low-Level Radioactive Waste Management Office (LLRWMO)

The Low-Level Radioactive Waste Management Office (LLRWMO) was established in 1982 to carry out the responsibilities of the federal government for low-level radioactive waste management in Canada. The mandate of the LLRWMO is to:

- resolve historic waste problems that are a federal responsibility;
- establish, as required, a user-pay service for the disposal of low-level radioactive waste produced on an ongoing basis; and,
- address public information needs about low-level radioactive wastes.

The LLRWMO is operated by Atomic Energy of Canada Limited (AECL) through a cost-recovery agreement with Natural Resources Canada, the federal department that provides the funding and establishes national policy for low-level radioactive waste management.

The Historic Wastes Program is one of three broad programs under which the activities of the LLRWMO are carried out, the others being the Ongoing Wastes Program and the Information Program.

Historic wastes are low-level radioactive wastes for which the original owner can no longer be held responsible. The federal government has assumed responsibility for historic waste in Canada through the LLRWMO.

The focus of the Historic Wastes Program is to perform cleanup and interim remedial work at historic waste sites, and to construct and operate any necessary waste storage facilities to protect human health and the environment before the waste can be moved to permanent waste disposal facilities.

Environmental remediation work involving site characterization, removal of contaminated soil and other wastes, and decontamination of structures is carried out by LLRWMO staff and contractors. Operation of waste storage facilities and receipt and use of instruments and artifacts with radioactive components is also part of the work of the LLRWMO staff. Physical work conducted under the Historic Wastes program is normally carried out by local contractors with little or no prior first-hand experience in handling radioactive materials. This paper addresses the RP training program developed by the LLRWMO for these contractors.

1.2 Atomic Energy of Canada Limited (AECL)

AECL was incorporated in 1952 and is wholly-owned by the Government of Canada. AECL is a world-leading supplier of full-scope nuclear power capabilities. It develops and markets CANDU® power reactors and MAPLE research reactors, supplies power and research reactor support services, and also offers MACSTOR™ waste storage facilities and waste management expertise. AECL supports its CANDU business with comprehensive research and product development programs that range from underlying research, to applied research, to design, and through to the product itself.

2. THE AECL RADIATION PROTECTION TRAINING PROGRAM

The purpose of AECL's standardized RP training program is to ensure a consistent level of proficiency in radiation protection between sites, between facilities at sites, and between occupations to the extent appropriate.

2.1 AECL’s Radiation Protection Policy and Objectives

The following policy statement and objectives are the guiding principles that have shaped the development of both the AECL-wide RP training program, and the LLRWMO RP training program.

AECL’s policy with respect to radiation protection is as follows:
“AECL shall maintain an effective, comprehensive, and responsive RP Program that ensures that radiation doses to employees and members of the public, due to AECL’s activities, are significantly below relevant regulatory levels, and as low as reasonably achievable, social and economic effects being taken into account.”

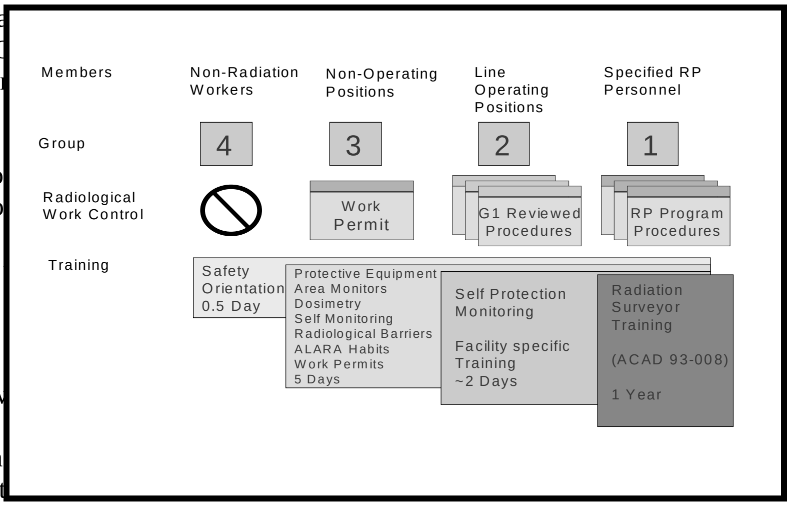
The objectives of the AECL RP program are to:

- limit the doses to less than the regulatory limits;
- limit detrimental stochastic health effects in employees and members of the public to levels as low as reasonably achievable, social and economic factors being taken into account (ALARA principle); and,
- prevent detrimental non-stochastic (deterministic) health effects caused in employees and members of the public by the AECL use of radiation.

2.2 AECL's Radiation Protection Training

The primary focus of ... environment, and to help ensure t...

Figure 1
AECL Radiation Protection Employee Groups



AECL's RP Program ca... Group Designation specifies ... corresponding RP training requi... defined by two factors:

- the degree of radiological wo...
- the types and extents of radio...

Based on these factors, ... perform radiation work.

- Group 4 employees do not ... temporarily under stringent w... for a higher Group.
- Group 3 employees only han... valid Work Permit, in which t... a Group 1 employee. Of app...
- Group 2 employees normally work with radioactive materials or radiation-emitting devices within a defined routine envelope, and in accordance with detailed procedures and protocols that have been reviewed and approved by a Group 1 employee. Approximately 600 AECL employees have Group 2 designation.
- Group 1 employees shall be only those who are trained and qualified as RP specialists reporting to the responsible RP Program Manager. Group 1 employees are the only employees who can provide authoritative advice on the appropriate protection for any radiation work to other AECL employees or non-AECL employees. Approximately 50 AECL employees have Group 1 designation.

2.2.1 Group 4 Training

Group 4 Training consists of industry standard "general employee" RP training. The course, which lasts approximately 3 hours, informs trainees as to the risks and hazards associated with ionizing radiation and provides them with a basic understanding of the AECL RP Program. Specifically, the topics covered are, at a minimum:

- Basic radiation theory;
- Understanding of radiation risks and hazards;
- Radiation protection techniques; and,
- Radiation protection aspects of Unplanned Event and Emergency response

2.2.2 Group 3 Training

Group 3 Training is the basic level of training required by all persons who perform work with radioactive materials or radiation emitting devices. The course, which typically lasts approximately 5 days, provides trainees with the required knowledge and skill to safely perform radiation work while working under the provisions of a work permit. Group 3 Training must address all types of radiological hazards that may be encountered at the site during routine operations and while controlling unplanned events and emergencies.

The Group 3 training course is delivered in several modules, each focusing on one or more hazard or topic area. Group 3 employees must complete all of the modules that apply to their site.

The course begins with an introductory module covering basic nuclear and radiation theory, dose quantities and units, risks and hazards of ionizing radiation, and RP fundamentals to a depth required to support the practical knowledge presented in the following modules.

The introductory module is followed by a series of hazard specific modules. The site RP Program

Manager determines which of the modules are required. The full list of modules considered for inclusion is as follows:

- Introductory Module (required);
- External Gamma Radiation Hazards;
- External Beta Radiation Hazards;
- External Neutron Radiation Hazards;
- Internal Radiation Hazards from Common alpha, beta and gamma Emitting Contaminants;
- Internal Radiation Hazards from Common alpha Emitting Contaminants;
- Internal Radiation Hazards from Tritium Oxide;
- Internal Radiation Hazards for Radioiodine

For each module, there is a set of training objectives. These objectives, which are the same for each module, are to achieve the required level of skill and knowledge in the following areas:

- Use of protective equipment;
- Appraising external radiation exposure;
- Self monitoring for surface contamination;
- Complying with barriers;
- Appraising working environment to ensure that doses are ALARA;
- Responding to radiological hazard monitors;
- Adhering to the internal dosimetry program;
- Conforming to all material transfer restrictions and regulations; and,
- Compliance with all work restrictions documented in a work permit or as given by group 1 personnel.

2.2.3 Group 2 Training

Group 2 Training is specifically designed for personnel in line operating positions in listed (licensed) facilities and radionuclide laboratories. This training prepares employees to perform routine, approved and authorized work that involves handling radioactive material and radiation emitting devices independently. Group 2 qualification is facility specific - outside of their own facilities, employees are considered Group 3 qualified only.

Group 2 Training varies in duration from two to several days, depending on the complexity of the facilities involved and the number of special RP responsibilities assigned.

Group 2 Training addresses the following for each facility to which the employee is assigned:

- Group 2 responsibilities under the Radiation Protection Program;
- Performance of the following Self Protection Tests:
  - measurement of gross alpha, beta and gamma emitting contamination (fixed and loose) and comparison against documented criteria using radiation meters specified in work procedures or protocols;
  - measurement of gross alpha-emitting contamination (fixed and loose) and comparison against documented criteria using radiation meters specified in work procedures or protocols; and,
  - measurement of gamma radiation dose rates and comparison against documented criteria using specified meters, as specified in work procedures or protocols;
- Facility specific radiological hazard orientation; and,
- Facility RP program and procedures.

2.2.4 Group 1 Training

Group 1 Training provides employees with the theoretical knowledge and skills required to perform Radiation Safety Assessments and to provide authoritative advice on occupational RP to other employees. It is intended for RP staff at each site, including Radiation Surveyors, Radiation Safety Supervisors, and Health Physicists. The duration of this training normally ranges from approximately 17 to 52 weeks, depending on the number and complexity of the facilities for which the individual requires qualification.

3. LLRWMO HISTORIC WASTE PROJECTS

The LLRWMO conducts cleanup and interim remedial work projects at historic waste sites across Canada. These projects also include the construction and operation of any necessary waste storage facilities to protect human health and the environment before the waste can be moved to permanent waste disposal facilities.

3.1 Historic Wastes in Canada

Historic low-level radioactive wastes date back to 1933 in Canada, when a radium refinery began operation in Port Hope, Ontario. Ores were mined at Port Radium on Great Bear Lake in the Northwest Territories and transported 5,000 km to the refinery. Refining of uranium began at this site in 1942. The problem of contaminated buildings and soils in the community surrounding the plant site resulted from accepted practices in the early years of radium and uranium production. Off-site contamination was only recognized in the mid-1970s. Immediately a radiation reduction program was initiated in Port Hope and extended to the mining communities of Elliot Lake and Bancroft in Ontario, and Uranium City, Saskatchewan.

Additional historic waste sites have subsequently been identified at other communities in Canada including: Surrey, British Columbia; Scarborough, Ontario; Fort McMurray, Alberta; and, along the water transportation route from the original mine sites in the Northwest Territories. This contamination has been found in buildings or soils where spills of ores or concentrates have occurred during transport, or where processing residues have been spilled or dumped, where salvaged refinery plant materials have been used as building materials in private homes, or where radium paints or other products have been manufactured, used, stored or disposed. It was common for processing residues and other contaminated wastes from the refinery to be used either as fill materials during construction, or to be sent to early landfill sites. Contamination was further spread by wind and water transport from these sites.

In Canada, “low-level radioactive wastes” are defined as all radioactive wastes other than nuclear fuel wastes and uranium mill tailings. The forecast amount of all low-level radioactive wastes to the year 2025 is in the range of 1.6 to 1.8 million cubic meters. “Historic wastes” are those low-level radioactive wastes for which the original producer can no longer reasonably be held responsible, which are managed in a manner no longer considered acceptable, and which are accepted as a federal responsibility. The only increases expected to add to the volume of historic low-level radioactive waste will come from discovery of new sites or improved delineation and characterization of present sites. There are approximately 1,000,000 m^3 of historic low-level radioactive waste in Canada, mostly located in the Port Hope area. Over 600,000 m^3 is in licensed storage facilities. Slightly over 200,000 m^3 is found in large and small-scale sites in the Town of Port Hope. Under 100,000 m^3 is thought to be at all other historic waste sites in Canada. For comparison, the current annual production rate of low-level radioactive waste in Canada from the nuclear fuel cycle, the production of electricity by nuclear reactors and the use of radioisotopes is about 6,000 m^3.

There are substantive differences in radiological, chemical and physical characteristics between historic wastes and low-level radioactive waste produced today from nuclear power production and radioisotope use. The contaminants in historic wastes are natural uranium and other radionuclides and heavy metals present in the original ores. Arsenic is the most significant of the heavy metals in terms of amount, mobility and toxicity. At many of the old sites, for every cubic meter of waste that was originally produced, there is now about 10 m^3 of contaminated soil, which has become part of the overall problem.

3.2 LLRWMO Projects

LLRWMO projects are generally small- to medium-scale earth moving or building decontamination operations. Because of the national mandate, and the economic advantages of using local contractors to conduct much of the physical work, contracted construction firms are normally not familiar with radiological risks.

A few examples of typical LLRWMO projects include:

- The excavation, transportation and disposal at a commercial facility of approximately 4500 m^3 of thorium contaminated material (with an average thorium concentration of approximately 200 ppm) from an industrial property in Surrey, British Columbia. Local contractors were hired to carry out the physical work. Specialized radiological characterization and RP services were provided by LLRWMO staff.

- The excavation of approximately 8,500 m^3 of radium contaminated material from a residential neighborhood in Scarborough, Ontario. Most of this material was placed in a temporary storage facility on previously vacant land in a nearby industrial/commercial area. Approximately 50 m^3 of material requiring a license for possession from the AECB were transported to a LLRWMO facility. Local contractors were hired to carry out the physical work. Specialized radiological characterization and RP services were provided jointly by contractors and LLRWMO staff.

- The excavation, transportation, and storage at a LLRWMO facility of small volumes (totalling 22 m^3 from four locations) of uranium contaminated material from several sites along the former northern transportation route in the Northwest Territories. This material exceeded concentrations requiring a license for possession from the AECB (i.e. > 500 ppm uranium). This 2100 km transportation route was used to haul uranium ore and concentrates from the Port Radium mine to the rail head in Fort McMurray, Alberta. Local contractors were generally hired to carry out the physical work. Radiological characterization and RP services are provided by LLRWMO staff or specialized contractors working under the direction of the LLRWMO.

- The removal of uranium and radium contaminated soil and building materials from hundreds of private residential properties in Port Hope, Ontario. Local contractors are generally hired to carry out the physical work. Specialized radiological characterization and RP services are provided by LLRWMO staff.

3.3 Worker Doses and Risks

Before any work is conducted by the LLRWMO, estimates of potential doses to workers and the public resulting from the work are developed. These doses tend to range from 1 µSv for a one-day project, to approximately 100 µSv for projects lasting one to two months. These estimated potential doses are based on conservative assumptions and are considered prudently conservative upper bounds of the expected doses. Experience on LLRWMO historic waste projects has shown that the actual (measured) dose tends to be five to ten times lower than the potential dose estimated before the work is carried out. The purpose of estimating potential doses is to determine appropriate requirements for work control to minimize risk to the project workers and to the public. Making use of a prudently conservative potential dose instead of a best estimate predicted dose adds an additional level of radiation safety, and ensures that the appropriate control are in place for circumstances that may differ from what is expected before the work is carried out.

Worker doses on LLRWMO projects tend to be a small fraction of the annual limit for members of the general public, and the radiological risks are generally significantly outweighed by conventional construction risks (i.e. slips and falls, vehicular accidents, etc.).

A typical gamma radiation dose rate experienced on an LLRWMO project might be 0.1 uSv per hour when averaged over the duration of a project. Using the ICRP-60 nominal probability coefficient for fatal cancer in adult workers of $4x10^{-2}$ Sv^{-1} [2], this is equivalent to a fatal cancer risk of $4x10^{-9}$ (4 in a billion) per hour.

The risk of a fatal industrial accident can be estimated from statistics for 1998 published by the United States Department of Labor Bureau of Labor Statistics [3]. A risk of $7x10^{-8}$ (70 in a billion) fatalities per hour worked was derived using the number of fatalities for the year in the construction industry, divided by the number of people employed in that industry during the year, divided by 2000 hours per work year.

Using this simple comparison, the risk of a fatality from an industrial accident outweighs the risk of fatal cancer by about a factor of 20 on a typical LLRWMO project.

4. THE LLRWMO RADIATION PROTECTION TRAINING PROGRAM

As part of AECL, the LLRWMO RP Program is governed by AECL's RP Program. The same policy and overall objectives apply. LLRWMO staff participates in the standard RP program delivered across AECL. They are classified into employee groups as described under the AECL RP training program, and receive the same basic classroom training offered to other AECL employees in those groups. The only difference in the formal RP training is a job specific module, which covers procedures and instrumentation used by the LLRWMO.

Contractors who work on LLRWMO projects do not normally receive the standard AECL RP training. They are classified into employee groups (normally as RP Group 3 Employees), and the RP training they receive meets the standard set by AECL for employees in those groups. However, the RP training program for these contractors was developed specifically to meet the needs of the LLRWMO.

The LLRWMO RP program is a subset of the AECL-wide RP program, and as such it has an entirely different scale. The LLRWMO has one Group 1 employee, six Group 2 employees, and one Group 3 employee, in comparison to AECL's approximately 50 Group 1 employees, 600 Group 2 employees, and 1200 Group 3 employees. The relatively low number of Group 3 employees within the LLRWMO is because of the way the work is structured. AECL primarily maintains facilities, while the LLRWMO primarily conducts remedial work projects. AECL must maintain a continuing Group 3 staff, while the LLRWMO hires contractors to perform most Group 3 work on a project-by-project basis. The LLRWMO has provided Group 3 equivalent project-specific RP training or briefings to approximately 50 contractor staff since formal implementation of the group designation system within the LLRWMO in 1998.

4.1 Objectives of the LLRWMO Contractor RP Training

A primary objective of the LLRWMO program for contractors is to communicate, in a balanced manner, the radiological risks associated with the work to be conducted. This objective is equal in importance to ensuring that doses are maintained ALARA. This is because the concern that contractors have with respect to working with radioactive materials is a more significant issue than the relatively small potential doses that may be received during the work. There has never been an instance where a contractor working on an LLRWMO project received a dose even approaching regulatory limits. To mitigate any concerns relating to the discomfort of contractor staff with respect to radiological safety, training sessions and information sheets are provided before work begins. These concerns could have a significant impact on the progress of the work, on goodwill within the community where the work is taking place, and even on the safety of those conducting the work.

4.2 Description of LLRWMO Contractor RP Training

Contractors working on LLRWMO projects are generally considered equivalent to AECL Group 3 employees for radiation protection purposes. This means that they are able to work with radioactive materials under very controlled conditions, which must include some level of supervision by radiation protection specialists.

Three levels of RP training are provided to contractors working on LLRWMO projects. The level of training required depends on three factors:

- the maximum individual potential dose;
- the duration of the work; and,
- the level of RP supervision provided.

For projects where the maximum individual potential dose does not exceed 50 µSv, the duration of the work does not exceed 10 working days, and all work is fully supervised by a radiation protection specialist, the minimum level of training is required. This level of training is referred to as a RP Briefing. It generally lasts no more than one hour.

For projects where the maximum individual potential dose exceeds 500 µSv, the duration of the work exceed six months, or the level of radiation protection supervision is very low, contractors are required to take the full AECL Group 3 training program. As discussed above, this generally takes five days.

For projects in between the two descriptions above, an intermediate level of RP training is provided. This "Project Specific Group 3 Equivalent RP Training" generally takes one-half to one day to complete. All three levels of project and required RP training are outlined in Table 1.

Table 1
Levels of LLRWMO Contractor Radiation Protection Training

Project Description	**Training Required**
LEVEL 1 All of the following: - short duration (up to 10 days); - 100% radiation protection supervision; and - doses < 5% of the annual limit (< 50 µSv).	Radiation Protection Briefing (approx. 1-2 hours)
LEVEL 2 Exceeds any of the conditions listed above, but none of the conditions listed below.	Project Specific Group 3 Equivalent Radiation Protection Training (approx. ½-1 day)
LEVEL 3 Any of the following: - long-term projects (> 6 months); - Minimal radiation protection supervision; or, - Doses > 50% of the annual limit (> 500 µSv).	Full AECL Group 3 Training (approx. 1 week)

Both the RP Briefing and the Project Specific Group 3 Equivalent RP training follow the objectives of the contractor RP training described in Section 4.1. In both cases, the primary focus is on the communication of risk.

4.2.1 Radiation Protection Briefing

This level of RP training is only given when the estimated potential doses are very low, and all work with radioactive materials is fully supervised. As a result, the RP training can be short and relatively informal. Even so, all contractor staff receive a short handout that covers radiological risks in perspective, and a description of general good practices for working with radioactive material. The oral presentation is normally given by the radiation protection specialist who will be supervising the work. It covers the following topics:

- a review of the estimated radiological risk (dose) of the work to be performed, including a discussion which puts those risks into perspective;
- a brief discussion of the potential radiological hazards specific to the project including:
  - the location of potential radiological hazards,
  - how the worker can be protected from the hazards,
  - how dose is monitored and reported, and
  - how to recognize and react to an emergency situation;
- a review of the health and safety plan applicable to the project; and,
- a practical demonstration of the use of all personal protective equipment and dosimetry devices required or made available to the worker for the project.

Although risk communication is an important objective of the RP Briefing, it is difficult to go into a detailed discussion of relative risks in the time allowed. This is overcome by simply comparing the potential doses estimated for the work to other doses of radiation. Comparisons to doses received during airplane flights, and occupational doses received by various professions tend to be well received.

4.2.2 Project Specific Group 3 Equivalent RP Training

This is the most comprehensive RP training developed specifically for contractors on LLRWMO projects. The topics covered are:

- a brief review of the basic principles of radioactivity and radiation hazards including:
  - the structure of matter (the atom),
  - radioactive decay and the applicable types of radiation (i.e. alpha, beta and gamma),
  - activity and specific activity,
  - exposure rate,
  - biological damage, effective dose and dose rate,
  - stochastic effects and risk in perspective, including a discussion of the radiological risks (dose) of the

work to be performed,
  - modes of exposure (internal vs. external),
  - dose limits, and
  - the AECL radiation protection program;
- a review of both contamination and radiation hazards including:
  - the types of radiation/contamination that might be encountered,
  - why radiation/contamination can be hazardous,
  - where the radiological hazards are likely to be found,
  - how the radiological hazard level is quantified,
  - how to identify the radiological conditions in the work area,
  - radiation protection measures,
  - how dose is measured and reported,
  - how to avoid unnecessary exposure, and
  - how to recognize and react to an emergency situation;
- a detailed review of the health and safety plan applicable to the project;
- hands-on experience using of all personal protective equipment and dosimetry devices required or made available for the project; and
- hands-on experience with self-monitoring for surface contamination.

At the beginning of the training session, the first overhead to be displayed (after introductions) provides an overview of the objectives of the session in two simple bullets: “Understand the risks” and “Minimize the risks”. This sets the stage for the rest of the session. It is made clear that the first goal is risk communication, and the second is risk reduction, and that both are important.

The training session is divided into four main modules: an introductory module, a risk module, a radiation hazards module, and a contamination hazards module.

4.2.2.1 The Introductory Module

The purpose of the introductory module is to build a foundation of basic radiation physics and radiation protection. This foundation is necessary to help support the later material on radiological risks. This foundation includes a discussion, in simple terms, of the basic principles of radioactivity, mechanisms of radiation-induced damage, and the development of risk estimates and their associated uncertainties.

4.2.2.2 The Risks Module

It is the risk module, presented after the introductory module, that is the primary focus of the session. Because the potential doses associated with the work to be carried out are generally very small, and the concern over working with radioactive materials can be large, it is important that the potential risks are properly understood. It is also very important to present a balanced view of the risks, so that the trainees make their own judgement with respect to their comfort level with the work. It is not effective to simply tell them that the work is “safe”. What is considered “safe” by one individual may not be considered “safe” by another.

Potential doses estimated for the upcoming work are discussed in the context of doses from other activities. This includes occupational doses for some professions, doses from air travel, and doses from natural background radiation. Risk calculations are also performed based on the estimated potential doses. However, before calculating risks, some of the problems with risk calculations for very low doses are reviewed. One of the most useful tools for this discussion is a graph of risk vs. dose. “Data points” can be added, all well away from the origin, to show the region in which reliable human data exist. A small box near the origin can be drawn to show the region of interest. Several different curves can be drawn to show the various theories including linear-no-threshold, linear with threshold, hormesis, and superlinearity.

Once there is some understanding as to the uncertainty of the risk calculations, calculated radiological risks are compared to risks from other, more familiar, sources. A list of activities that cause a one-in-a-million risk of death from that activity is useful, as is a list of activities with their corresponding “lost life expectancy”. Perhaps the most useful risk comparison is one to the standard construction hazards associated with the work to be conducted. As discussed in Section 3.3, the risk of a fatality during standard construction work is perhaps twenty or more times greater than the conservatively calculated risk of fatal cancer as a result of the radiation exposure. Another potentially useful comparison is to look at the average death rate from cancer (about 20-25%)

versus the calculated additional risk of fatal cancer due to the work (it is usually approximately one-in-a-million).

The overall goal is to enable the workers to understand (and believe) the radiological risks of the project, put them in perspective, and establish their own comfort level with respect to the risks of the work to be performed.

4.2.2.3 The Radiation Hazards and Contamination Hazards Module

The last two modules, the radiation hazards module and the contamination hazards module, focus on methods for reducing external and internal exposure. These modules differ little from industry standard training material on this subject. One downside to focusing primarily on risks (when the risks are so small) is that some trainees treat these last two modules less seriously than desired. Some are convinced that the radiological risks are so small as to be inconsequential, in which case there is little point in further reducing doses. If this is apparent, supplementary discussions on the ALARA concept and simple "good practice" are introduced into the session.

The material is primarily presented lecture style, with practical demonstrations whenever possible to help convey concepts and to keep the attention of the trainees. Perhaps the best demonstrations make use of sources of alpha, beta and gamma radiation, along with a pancake Geiger. Various shielding materials, ranging from a piece of paper or latex glove, to a sheet of steel are used to demonstrate the differing penetrating abilities of alpha, beta and gamma radiation. It is used to demonstrate, qualitatively, the shielding properties of air for alpha and beta radiation, and the inverse square law for gamma radiation. It is used to discuss the difference between dose and dose rate (the number of clicks heard is the dose, the rate of the clicks is the dose rate). It is even used to enhance the discussion of the basic radiation protection concepts of "time, distance and shielding".

4.2.2.4 Evaluation

Following the lectures and demonstrations, a written, multiple-choice format test is administered. Perhaps the most important reason to include a test is to ensure that all required material was adequately covered and understood. If many trainees cannot answer a question, it is likely because that material was not well covered. Other reasons to include a test are to give an opportunity for trainees to think for themselves about the material covered, to ensure that all trainees have attained some level of understanding, and as a permanent record of their attendance and level of understanding.

Training and evaluation do not end at the end of the formal training session. Practical experience with tasks such as self-monitoring for contamination is provided and evaluated in the field. The work begins with a RP specialist performing all monitoring. As the contractors become more familiar with the process, they will perform it themselves under supervision, and finally without supervision when the RP specialist is comfort with their ability.

5. SUMMARY AND CONCLUSIONS

Ensuring that doses are kept as low as reasonably achievable is the primary focus of many radiation protection training programs. This focus is in response to the primary concern addressed by the program: radiological risk.

A primary focus of the LLRWMO radiation protection training program for contractors is on communicating radiological risks. This objective is equal in importance to ensuring that doses are maintained ALARA. This focus is a result of a differing primary concern: perceived radiological risk.

The change from a more conventional contractor radiation protection training program to one that focuses more on risk communication has been successful. The primary focus of the training now addresses the primary concern, and radiological safety issues raised by contractor staff on LLRWMO projects have decreased.

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