Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

REGULATORY
GUIDE

Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable (ALARA)"

G-129, REVISION 1

October 2004

Canada

REGULATORY DOCUMENTS

The legal framework within which the Canadian Nuclear Safety Commission (CNSC) operates includes the *Nuclear Safety and Control Act* (*Act*), its Regulations and other legal instruments such as licences, certificates and orders. The legal framework is supported by regulatory documents issued by the CNSC, the main classes of which are

Regulatory Policy (P): a document that describes the philosophy, principles or fundamental factors that underlie the CNSC's approach to its regulatory mission. It provides direction to CNSC staff and information to stakeholders.

Regulatory Standard (S): a document that describes CNSC requirements. It imposes obligations on the regulated party, once it is referenced in a licence or other legally enforceable instrument.

Regulatory Guide (G): a document that indicates acceptable ways of meeting CNSC requirements, as expressed in the *Act*, Regulations, regulatory standard or other legally-enforceable instrument. It provides guidance to licensees and other stakeholders.

Regulatory Notice (N): a document that provides licensees and other stakeholders with information about significant matters that warrant timely action.

REGULATORY GUIDE

G-129, Revision 1

KEEPING RADIATION EXPOSURES AND DOSES "AS LOW AS REASONABLY ACHIEVABLE (ALARA)"

Published by the
Canadian Nuclear Safety Commission
October 2004

Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable (ALARA)"

Regulatory Guide G-129, Revision 1

Published by the Canadian Nuclear Safety Commission

Catalogue number: CC173-3/2-129-1E
ISBN 0-662-38407-5

Ce document est également disponible en français sous le titre Maintenir les expositions et les doses au «niveau le plus bas qu'il soit raisonnablement possible d'atteindre (ALARA)».

Document availability

The document can be viewed on the CNSC Internet website at www.nuclearsafety.gc.ca. Copies may be ordered in English or French using the contact information below:

Communications and Information Management Directorate
Canadian Nuclear Safety Commission
P.O. Box 1046, Station B
280 Slater Street
Ottawa, Ontario, K1P 5S9

Telephone: (613) 995-5894 or 1 800 668-5284 (Canada only)
Facsimile: (613) 992-2915
E-mail: publications@cnsc-ccsn.gc.ca

TABLE OF CONTENTS

KEEPING RADIATION EXPOSURES AND DOSES "AS LOW AS REASONABLY ACHIEVABLE (ALARA)"

1.0 PURPOSE

This Regulatory Guide helps persons regulated by the Canadian Nuclear Safety Commission (CNSC), when implementing a radiation protection program, to keep the amount of exposure to radon progeny and the effective dose and equivalent dose received by and committed to persons as low as reasonably achievable, social and economic factors being taken into account (ALARA).

2.0 SCOPE

This document describes measures that regulated persons can take for the purpose of keeping the amount of exposure to radon progeny and the effective dose and equivalent dose received by and committed to persons as low as reasonably achievable, social and economic factors being taken into account (ALARA).

This Regulatory Guide G-129, Rev.1, Keeping Radiation Exposures and Doses “As Low as Reasonably Achievable (ALARA)” supersedes the Regulatory Guide G-129, Guidelines on How to Meet the Requirement to Keep All Exposures As Low As Reasonably Achievable published in September 1997.

3.0 RELEVANT LEGISLATION

The following provisions of the regulations made under the *Nuclear Safety and Control Act* are relevant to this guide:

1. Paragraph 4(a) of the *Radiation Protection Regulations* requires every licensee, as part of a radiation protection program, to “keep the amount of exposure to radon progeny and the effective dose and equivalent dose received by and committed to persons as low as is reasonably achievable, social and economic factors being taken into account, through the implementation of

   (i) management control over work practices,

   (ii) personnel qualification and training,

   (iii) control of occupational and public exposure to radiation, and

   (iv) planning for unusual situations….”

2. Subsection 18(1), of the *Packaging and Transport of Nuclear Substances Regulations* obliges every consignor, carrier, and consignee of radioactive material to “implement a radiation protection program,” and, as part of that program to

"(a) keep the amount of exposure to radon progeny and the effective dose and equivalent dose received by and committed to persons as low as is reasonably achievable, social and economic factors being taken into account, through the implementation of

(i) management control over work practices,

(ii) personnel qualification and training,

(iii) control of occupational and public exposure to radiation, and

(iv) planning for unusual situations;

(b) prevent persons from receiving doses of radiation higher than the dose limits prescribed by the *Radiation Protection Regulations*; and

(c) train persons referred to in the program on the application of the program."

4.0 INTRODUCTION

The *Radiation Protection Regulations* require licensees to implement measures to keep doses received by workers and members of the public from exposure to sources of radiation ALARA. It is insufficient for a licensee to simply respect the appropriate dose limits; efforts must be made to further reduce doses. The senior management of a licensee is expected to be committed to the concept of maintaining doses ALARA and to take appropriate measures to reduce doses where practical.

The ALARA concept is not new. It has been incorporated into the recommendations of the International Commission on Radiological Protection for a number of years. The *Radiation Protection Regulations* extend this requirement to all licensees, and the CNSC seeks explicit demonstration of compliance.

This document guides licensees on the type of action that aims to effectively control and minimize doses. It outlines the importance of an explicit commitment by senior management to limit doses to magnitudes that are ALARA, the need for suitable programs to achieve this objective, and the value of reviewing work-related doses periodically to ensure that they continue to be adequately controlled.

The CNSC, among other things, looks at the processes adopted by licensees to maintain doses ALARA as evidence of compliance with paragraph 4(a) of the *Radiation Protection Regulations*. Accordingly, licensees may be required to identify the process by which they maintain doses ALARA. CNSC staff verify the licensee's adherence to this process from time to time. The CNSC believes that the application of sound radiation protection principles by well-trained employees will be, in most instances, all that is required to maintain doses ALARA.

This document includes information that pertains to all phases of an operation's life cycle, from site selection through to decommissioning. The transportation of radioactive materials also falls within the scope of this document; those responsible for such

transportation can review this document to determine which elements pertain to their particular situation. Detailed descriptions of the measures that may be necessary to comply with the regulations are beyond the scope of this document.

5.0 SOCIAL AND ECONOMIC FACTORS

The ALARA concept takes into consideration relevant social and economic factors. These could include, for example, the financial impact of protection measures as balanced against the benefit obtained. The views of the public are also relevant.

6.0 ALARA: MAGNITUDE OF EFFORT AND DOSE LEVELS

ALARA incorporates the notion that the magnitude of effort that should be applied to control doses depends on the magnitude of projected or historical doses. Managers should review dose levels on a continuous basis to ensure they are ALARA.

Licensees are expected to reduce doses where this can be done without significant expenditures. To minimize the commitment of resources that are likely to have a poor return in safety improvement, the CNSC may consider that an ALARA assessment, beyond the initial analysis, is not required in the following circumstances:

1. individual occupational doses are unlikely to exceed 1 mSv per year,
2. dose to individual members of the public is unlikely to exceed 50 μSv per year, and
3. the annual collective dose (both occupational and public) is unlikely to exceed 1 person-Sv.

Considering doses to members of the public addresses situations where a limited number of people may receive significant fractions of the individual dose limit even if the collective dose is low (i.e., less than 1 person-Sv). In such situations, additional radiation protection measures may still be required.

In some situations, a decision is required on whether it is economically justifiable to take action to reduce dose levels. Safety literature widely discusses expenditures that can be justified economically. A discussion of the monetary value of the unit collective dose can be found in the IAEA Safety Reports Series No. 21, *Optimization of Radiation Protection in the Control of Occupational Exposure,* which provides guidance when such decisions must be made.

7.0 APPROACH TO ALARA

7.1 Management Control over Work Practices

Organizational and management practices that bear upon the effectiveness of radiation protection include commitment, oversight of the radiation program, selection, training, and organization of personnel, including the delegation of responsibilities and authorities.

7.1.1 Commitment

It is essential that all levels of management, in particular the senior level of the organization, commit to a policy of safety and good radiation protection in order to keep all doses ALARA. This commitment may be made manifest through written policy statements from the highest level of management, and through clear and demonstrable support for those persons with direct responsibility for radiation protection in the workplace and in the environment.

To translate this commitment into effective action, senior management may identify appropriate organizational arrangements and assign clear responsibilities and authorities to put these actions into effect. Senior management may also establish a safety culture within which all those in the organization recognize the importance of restricting doses from exposure to ionizing radiation.

7.1.2 Oversight of the Radiation Protection Program

Management should periodically inspect the workplace to observe, first-hand, workers' adherence to the established radiation protection and conventional safety practices. Senior management should receive, on a regular basis, summary reviews of the effectiveness of the radiation protection program and practices being implemented in the workplace.

7.2 Personnel Qualification and Training

7.2.1 Commitment

It is essential that workers commit to radiation safety. This commitment should be demonstrated by adherence to radiation protection practices and procedures derived from the written policy statements. In this way, workers will protect themselves, their fellow workers, the public, and the environment. Management can provide mechanisms by which workers furnish advice on the effectiveness of radiation protection practices to ensure that doses continue to be adequately controlled.

7.2.2 Training

Relevant and adequate training programs for all personnel in the organization, including management, enable all concerned to contribute to the reduction and control of doses. Sufficient instruction and training enable workers to understand the risk from exposure to radiation and the methods of controlling doses. Workers need specific working procedures that take into account existing and potential radiological hazards. Training should, among other things, make workers aware of the simple actions they can take to minimize their doses and the doses received by others.

7.3 Control of Occupational and Public Exposure to Radiation

7.3.1 Resources

Management's provision of appropriate resources, such as staff, equipment and facilities, contribute to the adequate control of doses. Equipment and facilities may include, but are not limited to, items such as radiation field and contamination monitoring instrumentation, personal dosimetry equipment, protective clothing; and as appropriate, ventilation controlling devices such as fans, fume hoods and glove boxes. In addition, decontamination facilities, such as showers and washbasins, may limit the spread of radioactive contamination. Similarly, resources for monitoring the environment beyond the workplace that is affected by operations should be identified and provided.

7.3.2 Operational Reviews

The regular review of dose records and other appropriate indicators, such as the frequency of contamination incidents or results of environmental monitoring, form a critical part of ensuring that doses are ALARA. These reviews identify trends that enable the evaluation of the effectiveness of dose reduction efforts.

While the dose to some workers or work groups will be higher than the licensee's average dose, the dose may already be ALARA, making further dose reduction efforts impractical. Dose reduction efforts should not be directed solely at those workers with the highest dose. Practical means to reduce dose may be found for other workers whose doses are not the highest.

Increases in dose levels would not normally be expected if the type and frequency of radiation work do not change. Justification is required for any proposal involving a predicted increase in worker doses.

As well as reviewing doses and other appropriate statistics, the licensee demonstrates good radiation protection practices by regularly reviewing information on new technologies and procedures that might affect radiation protection. Technological advances in protective equipment and instrumentation should be monitored to identify improved methods of dose reduction.

7.3.3 Environmental Monitoring

In the interest of ensuring that the use of nuclear materials poses no undue risk to the public, management should receive summary reviews of the results of environmental monitoring and should ensure that radionuclide emissions to the environment are kept ALARA.

7.3.4 Overall Health and Safety

For some organizations, an integrated health and safety approach (i.e., one in which the resources allocated to reduce radiological and non-radiological risks are considered together) would be advantageous. This approach prevents introducing dose reduction at the expense of controlling conventional risks that may have greater impact on health and safety.

7.4 Planning for Unusual Situations

The potential for high doses exists in some operations where routine doses are low. For such operations, major radiation protection efforts should be directed to reducing, to the extent possible, the probability of occurrence of events that can result in high doses.

7.4.1 Radiological Work Plans

For work projects in areas where the existing or potential radiation hazards may result in workers accumulating significant doses, detailed work plans should be developed. The radiation protection component of work plans should include the following, but not necessarily be limited to:

1. radiological surveys of the hazards present in advance of carrying out the project,
2. estimates of optimum time to be spent by workers in radiation fields,
3. an estimate of doses to the workers involved,
4. identification of protective equipment and clothing to be used, and
5. actions, e.g. back-out, to be taken should the anticipated dose or dose rate be exceeded.

The review of work plans by management, radiation protection staff, and those conducting the work prior to and following execution of the work also contribute to keeping the doses ALARA. Reviews done following the completion of a project enables the experience gained to be used when planning future jobs of a similar nature with a view to further reducing worker doses where possible. Approval of work plans should involve a level of management higher than the level that is directly supervising the job.

7.5 Other Measures

Licensees are encouraged to consider the following additional measures for applicability to their operation as ways to control radiation doses to workers and the public. It should be noted that this list of measures is not intended to be comprehensive.

7.5.1 Documentation

Documentation of all aspects of the licensee's radiation protection program should be clear and include the identification of responsible individuals and their authority, and the means by which the licensee maintains doses ALARA. Existing radiation protection program documentation may suffice. Documents, such as policies, principles, operating procedures, and internal memoranda, that make obvious the licensee's commitment to maintaining doses ALARA should be readily available for inspection purposes.

Other documentation used to indicate compliance with the ALARA principle may include records such as dose statistics, analysis of dose trends, reports of "unusual" events and environmental monitoring results, and follow-up corrective actions.

7.5.2 Radiological Performance Targets

Setting radiological performance targets and determining which targets are met enable management and workers to focus their efforts on those areas of radiation protection that require improvement. A target may be defined in terms of a statistic such as average dose or collective dose during a specified period or frequency of contamination incidents, not necessarily in terms of individual dose. The specified period is the time interval that has been chosen for monitoring performance (e.g., each quarter, semi-annually). A review of the performance in meeting these targets may also suggest that the licensee set more stringent targets for subsequent periods.

8.0 JUDGEMENT OF REASONABLENESS

In implementing the ALARA principle, it must be determined whether the efforts to reduce doses are worthwhile. Some problems may be resolved using cost-benefit analysis or other quantitative techniques. However, it may be inappropriate to solely consider quantitative arguments in judging reasonableness.

8.1 Source

The judgement of reasonableness is inherent in the ALARA process. Understanding, good practice and feasibility help judge the reasonableness of an action.

8.1.1 Understanding

Understanding is based on experience, knowledge and the exercise of professional judgement (e.g., a very low-cost, practical change that reduces dose should be made even if doses are already low).

8.1.2 Good Practice

Good practice considers the radiation safety practices and performance of other, similar operations.

8.1.3 Feasibility

Feasibility includes approaching improvements in radiation protection pragmatically (i.e., weighing cost versus benefits of implementing changes in accordance with their practical significance).

8.2 Substantiation

In order to substantiate decisions regarding what is reasonably achievable, licensees should document the rationale for the judgement. This could include the following, among other considerations:

1. options considered for siting, design, construction, decommissioning or site closure, and the rationale for choices made;
2. rationale for proposed operating, maintenance and administrative programs and procedures, including a discussion of those options that were considered and rejected;
3. analyses of the radiation protection program effectiveness based on records of doses to workers and to the public, radiation protection inspection findings, radioactive effluent releases, timeliness and relevance of training, instrument maintenance, incident and non-conformance reports and subsequent actions taken;
4. analyses of trends of doses to workers and to the public;
5. analyses of trends of radioactive effluent releases and environmental monitoring results; and
6. findings of internal audits and peer reviews.

REFERENCES

Related Publications

1. International Atomic Energy Agency (IAEA)

Optimization of Radiation Protection in the Control of Occupational Exposure, Safety Series No. 21, Vienna, 2002.

Recommendations for the Safe Use of Radiation Sources in Industry, Medicine, Research and Teaching, Safety Series No. 102, Vienna, 1990.

Provision of Operational Radiation Protection Services at Nuclear Power Plants, Safety Reports Series No. 103, Vienna, 1990.

2. International Commission on Radiological Protection (ICRP)

Cost-Benefit Analysis in the Optimization of Radiation Protection, Annals of the ICRP, ICRP 37, Pergamon Press, 1983.

Optimization and Decision-Making in Radiological Protection, Annals of the ICRP, ICRP 55, Pergamon Press, 1989.

1990 Recommendations of the ICRP, Annals of the ICRP, ICRP 60, Pergamon Press, 1991.