Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

REGULATORY GUIDE

Ascertaining and Recording Radiation Doses to Individuals

G-91

June 2003

Canada

REGULATORY DOCUMENTS

The Canadian Nuclear Safety Commission (CNSC) operates within a legal framework that includes law and supporting regulatory documents. Law includes such legally enforceable instruments as acts, regulations, licences and orders. Regulatory documents such as policies, standards, guides, notices, procedures and information documents support and provide further information on these legally enforceable instruments. Together, law and regulatory documents form the framework for the regulatory activities of the CNSC.

The main classes of regulatory documents developed by the CNSC are:

Regulatory policy: a document that describes the philosophy, principles and fundamental factors used by the CNSC in its regulatory program.

Regulatory standard: a document that is suitable for use in compliance assessment and describes rules, characteristics or practices which the CNSC accepts as meeting the regulatory requirements.

Regulatory guide: a document that provides guidance or describes characteristics or practices that the CNSC recommends for meeting regulatory requirements or improving administrative effectiveness.

Regulatory notice: a document that provides case-specific guidance or information to alert licensees and others about significant health, safety or compliance issues that should be acted upon in a timely manner.

Regulatory procedure: a document that describes work processes that the CNSC follows to administer the regulatory requirements for which it is responsible.

Document types such as regulatory policies, standards, guides, notices and procedures do not create legally enforceable requirements. They support regulatory requirements found in regulations, licences and other legally enforceable instruments. However, where appropriate, a regulatory document may be made into a legally enforceable requirement by incorporation in a CNSC regulation, a licence or other legally enforceable instrument made pursuant to the *Nuclear Safety and Control Act*.

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

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

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ASCERTAINING AND RECORDING RADIATION DOSES TO INDIVIDUALS

1.0 PURPOSE

This Regulatory Guide is intended to help an applicant for a Canadian Nuclear Safety Commission (CNSC) licence, or a holder of a CNSC licence, to develop a program to ascertain and record radiation exposures and doses in accordance with section 27 of the *Nuclear Safety and Control (NSC) Act*, section 3 of the *General Nuclear Safety and Control Regulations,* and sections 5, 7 and 8 of the *Radiation Protection Regulations*.

2.0 SCOPE

This document describes approaches that may be used by a CNSC licensee to ascertain and record radiation exposures and doses under the *NSC Act* and regulations. It discusses related requirements, including the obligations on the licensee to use a licensed dosimetry service, and to make information on radiation doses available to workers.

3.0 DEFINITIONS

Within this document, the meanings of the terms "nuclear energy worker", "nuclear substance", "nuclear facility", and "prescribed" are as defined in section 2 of the *NSC Act.* These definitions are repeated below for the convenience of readers:

- "nuclear energy worker" means a person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation than is greater than the prescribed limit for the general public.

- "nuclear substance" means
  (a) deuterium, thorium, uranium or an element with an atomic number greater than 92;
  (b) a derivative or compound of deuterium, thorium, uranium or of an element with an atomic number greater than 92;
  (c) a radioactive nuclide;
  (d) a substance that is prescribed as being capable of releasing nuclear energy or as being required for the production or use of nuclear energy;
  (e) a radioactive by-product of the development, production or use of nuclear energy; and
  (f) a radioactive substance or radioactive thing that was used for the development or production, or in connection with the use, of nuclear energy.

- "nuclear facility" means any of the following facilities, namely,
  (a) a nuclear fission or fusion reactor or sub critical nuclear assembly,
  (b) a particle accelerator,
  (c) a uranium or thorium mine or mill,
  (d) a plant for the processing, reprocessing or separation of an isotope of uranium, thorium or plutonium,
  (e) a plant for the manufacture of a product from uranium, thorium or plutonium,
  (f) a plant for the processing or use, in a quantity greater than 10^{15} Bq per calendar year, of nuclear substances other than uranium, thorium or plutonium,
  (g) a facility for the disposal of a nuclear substance generated at another nuclear facility,

(h) a vehicle that is equipped with a nuclear reactor, and
(i) any other facility that is prescribed for the development, production or use of nuclear energy or the production, possession or use of a nuclear substance, prescribed equipment or prescribed information, and includes, where applicable, the land on which the facility is located, a building that forms part of, or equipment used in conjunction with, the facility and any system for the management, storage or disposal of a nuclear substance.

- "prescribed" means prescribed by regulation of the Commission.

4.0 BACKGROUND

4.1 Regulatory framework

The Canadian Nuclear Safety Commission is the federal agency that regulates the use of nuclear energy and materials to protect health, safety, security and the environment, and to respect Canada's international commitments on the peaceful use of nuclear energy.

The *NSC Act* requires persons or organizations to be licensed by the CNSC for carrying out the activities referred to in section 26 of the Act, unless otherwise exempted. The associated regulations stipulate prerequisites for CNSC licensing, and the obligations of licensees and workers.

4.2 Licensing process

The CNSC typically applies a phased process to its licensing of nuclear facilities and activities. For major facilities, this process begins with a consideration of the environmental impacts of the proposed project, and proceeds progressively through site preparation, construction, operation, decommissioning and abandonment phases.

The *Nuclear Safety and Control Act* and regulations require licence applicants to provide certain information at each licensing stage. The type and level of detail of this information will vary to accommodate the licensing stage and specific circumstances.

At all licensing stages, applications may incorporate (directly, or by reference) new or previously submitted information, in accordance with legislated requirements and the best judgment of the applicant. An application that is submitted at one licensing stage can become a building block for the next stage.

Upon receipt of an application that is complete, the CNSC reviews it to determine whether the applicant is qualified to carry on the proposed activity, and has made adequate provision for the protection of the environment, the health and safety of persons, and the maintenance of national security and measures required to implement international obligations to which Canada has agreed. If satisfied, the CNSC may issue, renew, amend or replace a licence that contains relevant conditions. Typically, this licence will incorporate the applicant's undertakings, and will contain other conditions that the CNSC considers necessary.

4.3 Legislative basis for this document

Section 27 of the *NSC Act,* section 3 of the *General Nuclear Safety and Control Regulations* and sections 5, 7 and 8 of the *Radiation Protection Regulations* are relevant to the ascertaining and recording of radiation exposures and doses and to an understanding of this guide.

Section 27 of the *Act* states:

"Every licensee and every prescribed person shall
(a) keep the prescribed records, including a record of the dose of radiation received by or committed to each person who performs duties in connection with any activity that is authorized by this Act or who is present at a place where that activity is carried on, retain those records for the prescribed time and disclose them under the prescribed circumstances; and
(b) make the prescribed reports and file them in the prescribed manner, including a report on
  (i) any theft or loss of a nuclear substance, prescribed equipment or prescribed information that is used in carrying on any activity that is authorized by this Act, and
  (ii) any contravention of this Act in relation to an activity that is authorized by this Act and any measure that has been taken in respect of the contravention."

Section 2 of the *NSC Act* defines the term "prescribed" to mean "prescribed by regulation of the Commission". Accordingly, to understand the related obligations of licensees pursuant to section 27 of the *Act,* refer to sections 5, 7, and 8 of the *Radiation Protection Regulations.* These sections contain requirements that pertain directly or indirectly to the ascertaining and recording of radiation exposures and doses. These requirements are:

- "5. (1) For the purpose of keeping a record of doses of radiation in accordance with section 27 of the Act, every licensee shall ascertain and record the amount of exposure to radon progeny of each person referred to in that section, as well as the effective dose and equivalent dose received by and committed to that person. (2) A licensee shall ascertain the amount of exposure to radon progeny and the effective dose and equivalent dose (a) by direct measurement as a result of monitoring; or (b) if the time and resources required for direct measurement as a result of monitoring outweigh the usefulness of ascertaining the amount and doses using that method, by estimating them."
- "7.(1)(d) Every licensee shall inform each nuclear energy worker, in writing, of the worker's radiation dose levels."
- "8. Every licensee shall use a licensed dosimetry service to measure and monitor the doses of radiation received by and committed to nuclear energy workers who have a reasonable probability of receiving an effective dose greater than 5 mSv in a one-year dosimetry period."

The *Radiation Protection Regulation*s do not tell CNSC licensees how to meet the above requirements, nor how they should make the corresponding determinations that are necessary. In particular, the regulations do not describe:

- how licensees are to determine when the time and resources for monitoring exposures and doses outweigh the usefulness of monitoring;
- how licensees are to "ascertain" exposures and doses by "direct measurement as a result of monitoring" or by "estimating" them; nor
- how licensees are to determine when nuclear energy workers have "a reasonable probability" of receiving an effective dose greater than 5 mSv in a one-year dosimetry period.

Paragraph 3(1)(e) of the *General Nuclear Safety and Control Regulations* stipulates that an application for a CNSC licence shall contain the proposed measures to ensure compliance with the *Radiation Protection Regulations*. Accordingly, any application for a CNSC licence must include a description of how the applicant proposes to meet the above requirements to ascertain and record exposures and doses, including making or arriving at any associated determinations. If these proposals are accepted by the CNSC and incorporated into a corresponding licence, the licensee will be required to meet the resulting obligations.

Thus, license applicants, whether renewing a CNSC license or applying for the licence for the first time, should address the above requirements in their respective applications.

5.0 ASCERTAINING EXPOSURES AND DOSES

5.1 Methods to measure exposures and doses directly

A radiation exposure or dose can be ascertained by direct measurement as a result of monitoring. A direct measurement typically involves the use or application of personal monitoring equipment and techniques. In each situation involving direct measurement as a result of monitoring, the choice of the most appropriate equipment and techniques will depend upon case-specific factors. Such factors include whether the source of the radiation that is to be measured is external to the subject's body, or whether it could be incorporated into the body (e.g., by inhalation or ingestion).

For example, a personal monitoring device that is worn or carried on a person's body (e.g., a thermo luminescent dosimeter) can be used to directly measure the person's exposure to radiation from sources that remain outside the body. Or, alternatively, a person's exposure to radiation from an internal source may be ascertained by direct measurements on the body (e.g., in vivo measurements), or by direct measurements on material that is excreted, exhaled or otherwise sampled from the body (i.e., in vitro measurements).

Typically, a radiation dose that is ascertained by direct measurement as a result of monitoring is reasonably representative of the actual dose received from radon progeny and other sources.

5.2 Methods to estimate exposures and doses

An exposure or dose may be estimated, pursuant to section 5 of the *Radiation Protection Regulations* by indirect methods that take into account non-personal monitoring results, and other relevant data.

For example, if a person occupies an area that has a known concentration of airborne radioactivity or a known radiation field for a known period of time, this knowledge can be used, in conjunction with other information, to estimate the person's radiation exposure during that occupancy. This approach is often used where an airborne radioactive substance is the source of exposure. In such instances, the concentration in air of radon progeny or other radionuclides in an area might be measured by air sampling or another method, and the time spent in the area by a person or persons recorded. The measured concentrations of airborne radioactivity, the recorded period of occupancy, representative metabolic data, and air-inhalation rates could then be used to estimate the exposures of the person or persons to airborne radiation.

In some situations, it may be possible to estimate exposures or doses by applying statistical methods to representative data for a comparable situation.

5.3 Direct measurement versus the estimating of exposures and doses

If an application under the *NSC Act* and regulations for a CNSC licence:

- demonstrates to the satisfaction of CNSC that the time and resources required to ascertain nuclear energy worker exposures and doses by "direct measurement as a result of monitoring" will outweigh the usefulness of the results thus obtained, and
- proposes an acceptable method of estimating those exposures and doses,

the CNSC will typically incorporate the proposed estimation approach in the licence that it issues in response to the application. Upon incorporation of the proposed approach, implementation will become a licence requirement.

When deciding whether to measure, or to estimate, a radiation exposure or dose from an activity to be licensed by the CNSC, the licence applicant should take into account the advice of radiation safety experts, and any other relevant factors. The relevant factors could include such considerations as the number of workers involved; the nature of the work activity and its processes; the nature, number, activity and size of the associated radiation sources; the magnitude, distribution and range of the anticipated radiation exposures or doses; and the techniques and equipment that are available and suitable for measuring and monitoring the exposure or dose.

For situations that could involve radiation exposures or doses from multiple sources or via different pathways, the licence applicant should determine, for each contributing component, whether direct measurement as a result of monitoring, or estimation, of the associated exposures or doses is warranted.

Accordingly, any proposal to estimate a radiation exposure or doses, instead of measuring it directly with personal monitoring equipment, should be well-founded, and adequately explained and substantiated. The proposed estimation approach should be consistent with good practices and accepted techniques.

The decision to estimate should be justified on the basis of the time and resources that would otherwise be required for direct measurement as a result of monitoring, and the anticipated usefulness of the results that would be obtained from such measurement. For example, in some cases, the resulting radiation exposures and doses could be so demonstrably small that direct measurement as a result of monitoring would not yield meaningful results.

6.0 REQUIREMENT TO USE A LICENSED DOSIMETRY SERVICE

Under section 8 of the *Radiation Protection Regulations,* every CNSC licensee is required to use a licensed dosimetry service to measure and monitor the doses of radiation received by and committed to nuclear energy workers who have a reasonable probability of receiving an effective dose greater than 5 mSv in a one-year dosimetry period.

Since the *NSC Act* and its regulations do not define what constitutes "reasonable probability", the use of the term in section 8 of the *Radiation Protection Regulations* creates a need for decisions by licence applicants and licensees as to when the use of a licensed dosimetry service is required or not required. Accordingly, under the *Act* and new regulations, licence applicants will be

responsible for determining and proposing what, if anything constitutes evidence of "reasonable probability" for the purposes of their planned operations and section 8 of the *Radiation Protection Regulations*.

Licensees, when deciding whether to use a licensed dosimetry service to measure and monitor radiation doses to workers, should take relevant case-specific factors into account. These factors include the number of workers involved, the nature of the work and the associated work processes, the types and inventory of radionuclides to be encountered, the potential magnitude, distribution and range of the anticipated doses, and the sensitivities and practical limitations of dosimeters and dosimetric methods. These judgments should involve professional input from an expert, such as a radiation safety officer or a member of a radiation safety committee.

7.0 EXAMPLES OF EXPOSURE SCENARIOS AND MONITORING RESPONSES

The following examples illustrate some possible monitoring responses to postulated radiation - exposure scenarios, taking into account the typical sensitivities and limitations of dosimeters and dosimetric methods. The examples are not meant to constrain licence applicants from proposing, or to deter licensees from implementing, radiation protection programs that provide for other approaches that meet the related requirements in the *Radiation Protection Regulations*.

Exposure Scenario	**Possible Response**
(a) A reasonable probability that the effective dose to a nuclear energy worker, from a single contributing component, will exceed 5 mSv/a.	(a) Use a licensed dosimetry service to ascertain the effective dose from the component by direct measurement as a result of monitoring.
(b) A reasonable probability that the effective dose to a nuclear energy worker, from more than one contributing component, will exceed 5 mSv/a.	(b) Use a licensed dosimetry service to ascertain, by direct measurement as a result of monitoring, the dose from each component that is likely to contribute more than 1mSv/a; estimate the respective doses from the other contributing components.
(c) The effective dose to a nuclear energy worker is likely to be less than 5 mSv/a, but more than 1 mSv/a.	(c) Ascertain the effective dose from each contributing component by direct measurement as a result of monitoring; or if the costs of direct measurement outweigh the benefits, by estimation.
(d) The effective dose to a nuclear energy worker is likely to be less than 1 mSv/a.	(d) Ascertain the dose by estimation.

8.0 RECORDING RADIATION DOSES

Under paragraph 27(a) of the *NSC Act*, every licensee is required to keep any records prescribed by the regulations under the *Act*, as well as a record of the dose received by or committed to each person who performs duties in connection with any activity that is authorized by the *Act* or who is present at a place where that activity is conducted. Accordingly, CNSC licensees should keep the following dose-related records to satisfy regulatory requirements, or to facilitate regulatory review:

- a record of the name and job category of each Nuclear Energy Worker, as defined in section 2 of the *NSC Act* [Section 24 of the *Radiation Protection Regulations*];

- a record of the effective dose received by or committed to each person who performs duties in connection with any activity that is authorized by the *NSC Act* or who is present at a place where that activity is carried on [Paragraph 27(a) of *NSC Act*];
- a record of the time period over which the above dose was accumulated;
- a description of the dosimetric model that was used to obtain the dose from measured data; and
- any other dosimetry record or information required by a condition of the licence, the *NSC Act*, or the CNSC pursuant to paragraphs 3(1)(n) and 3(1)(m) of the *General Nuclear Safety and Control Regulations*.

9.0 HANDLING RADIATION DOSE RECORDS

Under paragraph 7(1)(d) of the *Radiation Protection* Regulations, every CNSC licensee is required to inform each nuclear energy worker, in writing, of the worker's radiation dose levels.

Section 19 of the *Radiation Protection Regulations* requires licensed dosimetry services to file assigned doses and related information for nuclear energy workers with the National Dose Registry (NDR) maintained by Health Canada in a format that meets the registry's needs. The information required by the NDR is described in Appendix D of Regulatory Standard, S-106, "Technical and Quality Assurance Requirements for Dosimetry Services in Canada".

In practice, a CNSC licensee may choose to voluntarily measure the radiation doses received by its staff or workers, even when such monitoring is not required by law. For example, a licensee might include in its monitoring program those staff who have little probability of being exposed to radiation or radioactive materials, in order to confirm or demonstrate that these persons have not received significant exposures. If voluntarily submitted to the NDR, the results of such non-obligatory monitoring programs will add to the NDR data base on radiation exposures of Canadian workers. Such data could subsequently prove useful to resolve related enquiries, compensation claims or litigation.