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Radiation Protection Guidelines for Mineral Exploration

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NORM Program Guidelines

Exploration crews searching for uranium will receive radiation exposures from uranium and its associated radioactive decay products in the drill core and cuttings. These radiation exposures will normally be quite small. Since the potential for significant radiation exposures is low and because they are working with naturally occurring radioactive material, exploration crews are classified as "incidentally exposed workers" and are regulated provincially. This is in contrast to workers in uranium mines who are usually classified as "nuclear energy workers" and whose radiation exposures are regulated under the federal *Nuclear Safety and Control Act*.

The definitive document on radiation protection requirements for incidentally exposed workers is the *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)* published by Health Canada on the www.hc-sc.gc.ca website (at this link. This document was developed by the Federal Provincial Territorial Radiation Protection Committee and has been endorsed by all provinces and territories as well as the federal government.

The NORM Guidelines define four categories for annual worker radiation exposures in order of increasing radiological concern. The radiation protection requirements for the different annual doses are summarized in Table 1.

Table 1 - Overview of NORM Program Classifications

ANNUAL DOSE (mSv/y)	RADIATION PROTECTION PROGRAM	
Dose < 0.3	**None**	No requirements for dose management
0.3 < Dose < 1.0	**NORM Management**	Radiation Surveys of work areas
1.0 < Dose < 5.0	**Dose Management**	Dose estimates via radiation surveys and worker occupancy times.* Worker dose to be reported to National Dose Registry. Expert advice recommended.
Dose > 5.0	**Radiation Management**	Formal radiation protection program and the use of TLDs for worker dose measurement. Expert advice will be necessary.

*In practice, for the measurement of quarterly and annual gamma radiation exposures, the use of thermo-luminescent dosimeters (TLDs) is an inexpensive and practicable means of assessing worker exposure.

ALARA Principle

The basic principle for worker radiation protection is that worker radiation exposures should be kept "as low as reasonably achievable, social and economic factors being taken into account." ALARA (As Low As Reasonably Achievable) is implicitly assumed throughout Table 1.

It is assumed that for the NORM Management category, a calibrated dose rate meter will be used to assess and minimize worker radiation exposures. The Dose Management and Radiation Management categories will require more sophisticated radiation control measures. Such radiation control measures are beyond the scope of this document.

Sources of Radiation Exposure for Exploration Crews

Exploration crews working with uranium will receive radiation exposures from:

- Gamma radiation emitted from the uranium mineralization
- The inhalation of radon (and the resulting radon progeny decay products) emanating from the core rods and drill cuttings
- The inhalation of radioactive dust
- The ingestion of radioactive dust

The primary source of worker radiation exposure will be from external gamma radiation. The external gamma radiation dose received by exploration crews will depend on:

- The grade of the mineralization
- The amount of time spent by workers close to mineralized drill core and cuttings
- The amount of mineralized drill core and cuttings in the vicinity
- The distance between workers and the drill core and cuttings

Worker radiation exposures from the inhalation or ingestion of radioactive dust (or dirt) should not be a concern provided enclosed areas such as core shacks are suitably ventilated and all work areas are kept clean. Workers should wash their hands after handling radioactive drill core and cuttings and before eating or smoking.

Gamma Radiation

External gamma radiation from the uranium mineralization is the primary source of radiation exposure for exploration crews. For this reason it is a good practice to maximize the distance of workers from mineralized core and to limit the amount of time that workers spend near mineralized drill core. This implies limiting the amount of mineralized core stored in drill and core shacks where possible. Also, drill cuttings should be cleaned up regularly. The use of mineralized core boxes as seats or benches is not recommended.

In order to provide practical advice on the gamma dose rates to be expected from a box of mineralized drill core, the gamma dose rates were measured for single core boxes filled with various grades of uranium mineralization (about 25 kg) at distances ranging from 0.5 to 2 metres. A summary of the results is shown in Table 2.

Table 2 -- Gamma Dose Rates From a Single Core Box

	Hourly Gamma Dose Rates (µSv/h)			
Grade Uranium	at 0.5 m	at 1 m	at 1.5 m	at 2 m
0.1 %	0.2	0.1	0.03	0.02
0.2 %	0.4	0.1	0.06	0.03
1 %	1.8	0.6	0.3	0.2
5 %	9	3	1	0.8
10 %	17	6	3	2
20 %	35	12	6	3

This information can be summarized in a simple formula for the gamma dose rate (GDR) from a single core box at a distance of 1 metre from the midpoint of the box:

GDR (µSv/h) = 0.61 x (% Uranium Grade)

Use of Gamma Dose Rate to Determine Radiation Protection Requirements

Example 1

Consider a drill shack with a core box filled with 1% uranium mineralization at a distance of 1.5 m from the drill crew. From Table 2 we find the GDR to be 0.3 μSv/h.

If we assume a worker spends 500 hours per year working next to this core box, his annual radiation exposure will be: Annual Dose = 0.3 μSv/h x 500 h = 150 μSv/y or 0.15 mSv/y.

According to the NORM Guidelines there are no requirements for radiation protection from this gamma radiation.

Example 2

The gamma dose rates in a workplace will depend on the amount of mineralized core near the workers. If three boxes of 1.0 % drill core are placed one on top of the other, the GDR can be expected to triple. A worker spending 500 hours per year in this workplace would now receive 0.45 mSv/y.

This annual radiation dose would place the worker into the second category of the NORM Guidelines (NORM Management). At this point the company would be required to provide workers with a calibrated dose rate meter to more accurately ascertain the GDR levels and minimize worker exposures. It should also be used to ensure that no workers are receiving more that 1 mSv/y (Dose Management category).

Example 3

Consider a geologist in a core shack who spends 500 hours examining and logging 1% uranium core. The worker's average distance from the core box is likely to be about 0.5 m from the box.

According to Table 2 the GDR at this position will be 1.8 μSv/h. Hence this worker can expect to receive an annual radiation dose of:

Annual Dose = 1.8 μSv/h x 500 h = 900 μSv/y or 0.9 mSv/y

According to Table 1, an annual radiation dose of 0.9 mSv places this worker in the NORM Management category. Once again the employer will be required to provide a calibrated gamma dose rate meter to more accurately assess and minimize worker radiation exposures.

Radon Progeny

Radon gas will emanate from the core samples and drill cuttings. Radon gas and radon progeny are not considered to be a significant source of worker radiation exposure because it is assumed that the drill core is being handled in a well-ventilated area. Wooden or steel core shacks containing significant amounts of mineralized core should be ventilated when workers are inside. Tents are likely to be sufficiently leaky so as not to require ventilation. If large quantities of high-grade material (greater than 5%) are being stored in an enclosed area, periodic measurements of the radon progeny levels would be required.

Radioactive Dust

The radiation dose that workers receive from the inhalation or ingestion of fine radioactive dust will be insignificant if basic preventive measures are taken. That includes good housekeeping to prevent the re-suspension of dust by workers moving about. Cutting of core samples should by a wet process or performed in a separately ventilated enclosure. If the generation of airborne radioactive dust cannot be prevented, the worker should wear a respirator.

Conclusion

The NORM Guidelines specify various radiation protection requirements based on the annual radiation dose incurred by workers.

Uranium exploration workers can expect that their annual radiation exposures will be determined by the external gamma radiation they receive while in close proximity to the mineralized core and drill cuttings.

From the information presented above, it should be evident that exploration crews are unlikely to receive significant radiation exposures as long as the uranium mineralization they are working with is at a grade below 0.05 % uranium.

As a general recommendation, exploration crews encountering significant amounts of drill core at grades greater than 0.05% should have access to a calibrated dose rate meter. This will allow a more accurate evaluation of the annual gamma doses received by workers and a means of minimizing worker radiation exposures.

In addition, TLD badges can be used to ascertain the quarterly and annual dose received by specific workers. These are inexpensive and easy to use.

Doses from the inhalation of radon progeny and radioactive dust are easily controlled and should be insignificant.

Transportation of Mineralized Uranium Core

Federal regulations for the transport on public roads of NORM with a specific activity greater than 70 kBq/kg (about 0.04% Uranium) apply. These are known as the Canadian Nuclear Safety Commission's *Packaging and Transport of Nuclear Substances Regulations,* available at http://www.nuclearsafety.gc.ca.

Further Advice

Additional advice may be obtained from:

Ministry of Energy, Mines and Petroleum Resources
Mining and Minerals Division
PO Box 9320 STN PROV GOVT
Victoria, BC V8W 9N3

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