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The Canada Science and Technology Museum Corporation (CSTMC), which includes the collections of the Science and Technology Museum, the Aviation Museum and the Agriculture Museum, has housed artifacts containing radioactive material since its creation in 1967. Efforts have been made in the past 15 years to properly label and store this material, most recently a collection of approximately 1200 radium dial instruments. Since this required staff involvement, many of whom had no previous experience with or knowledge of radioactive materials, guidelines specific to Canada were developed internally to clearly explain the regulations and risks, and to provide practical methods of mitigating those risks. The article describes the occurrence of radiation in the collection and the Luminous Dial Re-housing Project, and contains summary information including a glossary, guidelines for personal protection, and handling guidelines specific to Canada. It is always advisable to contact the regulatory bodies prior to working with this material.

Depuis sa fondation en 1967, la société du Musée des sciences et de la technologie du Canada (SMSTC), qui comprend le Musée des sciences et de la technologie du Canada, le Musée de l'Aviation ainsi que le Musée de l'Agriculture, détient dans ses collections certains objets faits en partie de matière radioactive. Depuis les 15 dernières années, plusieurs initiatives ont eu lieu afin de bien identifier ces matériaux et les mettre en réserve de façon sécuritaire. Le plus récent projet dans cette veine concerne une collection d'environ 1200 instruments à cadran phosphorescent au radium. Puisque du personnel n'ayant que peu de connaissances et d'expérience avec des matières radioactives devait être impliqué, des lignes directrices suivant les normes canadiennes ont été rédigées pour usage interne afin d'expliquer clairement les règles et les risques concernant les matières radioactives, ainsi que les méthodes pratiques pouvant être mises en œuvre pour contrer ces risques. Cet article fait le point sur la présence de matières radioactives dans la collection et décrit le projet de relocalisation des cadrans phosphorescents au radium. L'article contient aussi un glossaire ainsi que des lignes directrices sur les mesures de protection corporelle et sur les mesures de manipulation des matières radioactives basées sur les normes canadiennes. Il est recommandé de contacter les autorités en matière de radiation avant de manipuler des matières radioactives.

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Introduction

Radiation is by no means a new problem for museums. While this paper deals with collections of industrial technology, transportation and scientific instruments, radioactive material can be present in collections of natural history, social history and decorative arts. Regardless of the type of artifact, the guidelines for handling and storing remain the same. The challenge for those who are the guardians of this material is to protect it and the staff required to work with it.

An excellent article by John Ashton, "Radiation Hazards in Museum Aircraft",[1] describes the risks and technology of radium dials in some detail. The McMaster University *Radiation Surveys of Cockpits of Aircraft at Canadian Warplane Heritage Museum*[2] provides an extremely valuable reference for radiation hazards in Museum aircraft. Canada Science and Technology Museum Corporation (CSTMC) is currently conducting a similar survey of the cockpits of aircraft in the collection.

This article describes the occurrence of radiation in the collection of the CSTMC[3] and in particular the re-housing of the radium dial collection. Since this project required staff involvement, many of whom had no previous experience with or knowledge of radioactive materials, guidelines specific to Canada were developed internally to clearly explain the regulations and risks, and to provide practical methods of mitigating those risks. The summary information prepared for this project, including a glossary of terms and guidelines for personal protection and artifact handling are also presented.

Radioactive Objects in the Collection

The Science and Technology Museum campus has a moderate number of radioactive artifacts. A representative sample of objects is shown in **Figure 1**. By far the largest quantity and the most hazardous materials belong to the Aviation Museum collection where they include radium luminous devices, as well as depleted uranium ballasts and tritium emergency exit signs.

While CSTMC has collected artifacts containing radioactive material since the Museums were created in 1967, it was not until 1995 that it acquired a license to store them. At this time a concerted effort was made to relocate specific radioactive artifacts to a secure area, and to restrict access to that space. The radium dial collection was not addressed at that time other than to gather them together in the same storage room at the Aviation Museum site. At the time it was decided that the radiation hazard had been sufficiently contained and controlled through consolidation and signage. Radon gas was not considered.

Figure 1. Representative sample of artifacts containing radioactive material in the collection of CSTMC. Note that many of the objects are bagged in polyethylene, which serves to contain any friable radium luminous paint. Units are in micro-Sieverts per hour (µSv/hr), as defined in Appendix 1. Photographs © and courtesy of the Canada Science & Technology Museum Corporation.

Figure 1a. Spectrophotofluorimeter; Cat. # 1988.0672; Radiation level at 25 cm: 80 µSv/hr; Annual limit: 12.5 hr/yr.

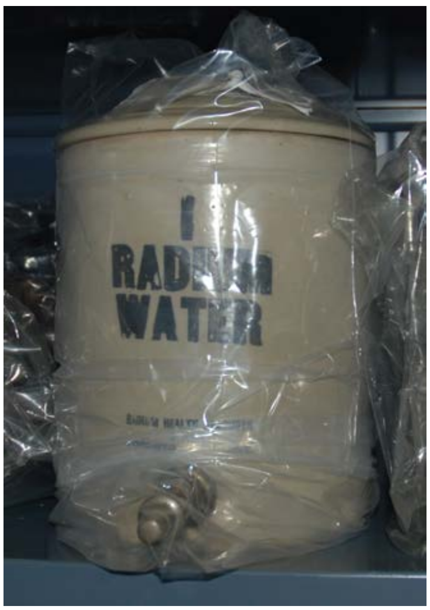

Figure 1b. Radium water jar: Cat. # 2002.0538; Radiation level at 25 cm: 60 µSv/hr; Annual limit: 16.67 hr/yr.

Figure 1c. Wind speed & direction indicator: Cat. # 1987.0783; Radiation level at 25 cm: 120 µSv/hr; Annual limit: 8.3 hr/yr.

Figure 1d. Ship's telegraph: Cat. # 1971.0688; Radiation level at 25 cm: 75 µSv/hr; Annual limit: 13.3 hr/yr.

Figure 1e. Altimeter: Cat. # 1970.0809; Radiation level at 25 cm: 90 µSv/hr; Annual limit: 11.1 hr/yr.

Figure 1f. Aviation magnetic compass: Cat. # 1970.0662; Radiation level at 25 cm: 300 µSv/hr; Annual limit: 3.3 hr/yr.

Figure 1g. Analytical balance: Cat. # 1969.1002; Radiation level at 25 cm: 120 µSv/hr; Annual limit: 8.3 hr/yr.

Figure 1h. Bomarc missile: Cat. # 1973.0009; Radiation level at 8 m. distance (visitor barrier): 500 µSv/hr; Annual limit: 2 hr/yr.

Historically, radioactive material has been used for different reasons. Prior to 1970, when other radioactive elements posing lower risks were introduced to replace it, Radium 226 was the source of radiation for luminous paints. It was mixed with a luminescent crystalline powder such as zinc sulphide, in a medium of linseed oil or similar binder. The decay products of radium include alpha, beta and gamma rays; of which the alpha and beta are crucial in the "activation" of the luminescent crystals. Instruments with critical readings such as flight controls and navigation devices were generally treated with a higher radium concentration paint; less critical items such as switches and handles needed less concentrated paints. Over time these dials lose their luminescence and appear dull and discoloured. This is not due to a reduction in radioactivity (since the half life of Radium 226 is 1,600 years), but rather to the chemical degradation of the zinc sulphate luminescent crystals as a result of damage from the radioactive particles. Since the binder used in the paint formula acted as interference between the alpha particles and the luminescent powder, it was generally kept to a minimum.[4]

Empirical evidence at CSTMC, has shown that radium paint becomes very friable over time, largely due to the loss of binder and subsequent loss of adhesion of the crystalline components. This is most problematic in instruments or panels that have broken covers or no covers at all.

Depleted uranium (DU) has civilian uses in medical technology as shielding for radiation therapy but is most often used in military applications. Its extremely high density makes it useful for counterweights in aircraft, defensive armour plating, and also for armour piercing projectiles. It is often used in ordnance due to its ability to spontaneously ignite similarly to magnesium. While the collection of CSTMC does not contain any ordnance with depleted uranium, the incidence of DU as ballast is widespread on military aircraft and rockets dating from the 1950s onward.

Luminous Dial Re-housing Project

In 2008, a major project was initiated at the Aviation Museum, to consolidate and safely store the collection of over 1,200 radium dial instruments. The need for this was identified following an inspection of the Bomarc Missile (**Figure 1h**) currently on display at the Aviation Museum. Health Canada was contracted to measure radiation levels in response to correspondence in 2007 from the Smithsonian Institute, describing the presence of radioactive ballast in these missiles. They had done a radiation survey on their own collection, and followed up by notifying other public institutions known to house Bomarc missiles. Health Canada personnel completed an inspection of the display area and also undertook an assessment of the storage rooms: taking both radiation measurements and radon gas measurements.[5] While radiation levels had been previously monitored and were within acceptable levels for a storage area, radon gas had never been measured. Radon gas is a radioactive noble gas produced from the natural decay of radium. It comprises a large part of an individuals' background radiation exposure, as it is present at varying concentrations in ground rock. It is heavier than air and can accumulate in the lower levels of buildings, posing a serious health threat.[6]

The result of the radon readings in the storage space was 410 Becquerel per cubic meter (Bq/m^3). The Canadian guidelines for radon in dwellings, as stated in the Canadian Mortgage and Housing Corporation document "Radon, a Guide for Canadian Homeowners" has recently been lowered from 800 to 200 Bq/m^3.[6] The Canadian Labour Code for radon concentrations in workplaces under federal jurisdiction still specifies a limit of 800 Bq/m^3, but this is under review, and it is therefore prudent to undertake radon mitigation for any concentrations above 200 Bq/m^3. A work station was present in the storage area, and as a result of these measurements, the staff member was re-located and a plan developed to move all of the devices to a secure, vented storage area.

The dials were previously stored on open shelving in a general storage room. Some were loose, and some were in cardboard boxes. Many had not been inspected in years, and few were catalogued or identified. The first stage of the project was to sort all dials by type and size, and identify them as much as possible. Work was isolated to one area of the storage room, to contain any hazard and to restrict access to the area. This facilitated clean-up of the contaminated space once the project was complete.

The broken dials were bagged, as sealing items in polyester film (Mylar) was recommended by Health Canada Dosimetry section.[7] Due to the cost and lack of equipment to make this number of custom Mylar enclosures, collections staff opted to use thick polyethylene bags such as commercially available freezer bags (Ziploc). According to Health Canada, while not as efficient at preventing the diffusion of radon, they still serve the two purposes as intended: to contain any friable paint during storage and handling, and to reduce the diffusion of radon. The disadvantage of sealing in plastic according to Health Canada, is that this could concentrate deposits of longer-lived decay products of radon and pose more of a threat in the future when the bags are opened.[7]

All dials were placed in compartmentalized Coroplast boxes for easy transportation and storage. These were copied from a Parks Canada design for storing separate archaeological specimens, but served well to isolate the dials and provide for an easy location designation within the new storage room. Transportation between sites was carried out in accordance with Federal Government regulations.[8] The task of cataloguing the dials has not yet been undertaken, though they were photographed (in their bags) for identification and to minimize the future need for handling.

The dials as well as an assortment of small artifacts are currently stored in two small secure concrete-wall rooms, vented to the outside. These rooms were pre-existing and previously housed building services equipment. Inside the room are seven cabinets in which the Coroplast boxes are stored, and two open shelving units for larger objects. Metal cabinets substantially reduce levels of radiation within the storage room; for instance, a radium dial measured at 20 cm, with a reading of 300 µSv/hr, measured only 180 µSv/hr at the same distance through the cabinet door.

The Canadian Nuclear Safety Commission, in a pamphlet entitled "Radium Luminous Devices: Tips for your Safety"[9] recommends that the number of devices stored in one location be kept to a minimum. Consideration was given to this, but it was decided that the benefits of having all radioactive materials together, isolated and secure, outweighed the risks of concentrating the radiation in one location.

Radiation Safety for Museum Staff

Radiation is one of the most worrying hazards in any collection, as it is not something that can be easily identified or avoided. Our modern world has imbued radiation with an almost mythical characteristic of danger, so that there is often resistance from staff to working with these materials. This, of course, is entirely valid unless precautions are taken to minimize risk to workers, and to reduce exposure to as low as reasonably achievable (ALARA).

As the work on the luminous dial re-housing project was labour-intensive and time-consuming: only critical staff members were involved. Each was provided with a personal monitoring device for long term radiation exposure, and these devices were sent to Health Canada for analysis monthly. All relevant staff were made aware of and provided with safety equipment. Additional staff who were not involved as extensively were provided with different dosimeters which measured single doses. There were two of these monitors that were shared between other staff with a log-book to be signed if the monitor was in use. These were also downloaded monthly. These single dose dosimeters had alarms that identified high risk objects. None of the dosimeters monitored showed exposure above allowable limits of 1 mSv per year.[5,10,11]

Initially the re-housing project at the Aviation Museum was undertaken without providing staff with the information they felt they needed. This is not to say that the information was not available, only that it was not disseminated in a way that addressed staff concerns: the comprehensive ten page document from Health Canada[5] used terminology not familiar to some CSTMC staff.

In response to staff concerns, summary documents, included here in **Appendix 1** and **2**, were written by the author, and edited by one of the consultants from Health Canada, Bliss Tracy, in October 2008. They are intended as a means of communicating a better understanding of the hazards and how they can be minimized.

Even with this information and proper safety equipment, there are instances where it is unsafe for conservation staff, or any staff, to be working in close proximity to radioactive materials. For instance, in the case of luminous placards in the nose of the Comet Aircraft (**Figure 2**), a reading in excess of 400 µSv/hr, at 15 cm distance means that the annual exposure limit for staff would be reached within two hours. Since access to the cockpits is often requested by veterans or researchers or required by staff, this is important information to be able to share and to use to proscribe or sanction access.

Conclusion

The luminous dial project at the Aviation Museum was completed in early 2009. All stages of this project were undertaken in consultation with Health Canada, and the Canadian Nuclear Safety Commission. The summary documents developed for this project gave staff the clear information and guidance they needed to feel safe working with this hazardous material. All handling and transportation was carried out in accordance with written documentation from the regulatory bodies.[8,12] Much information on radiation risks is available as printed material or on the internet;[6,8-12] nevertheless, it is always advisable to contact the regulatory bodies prior to working with radioactive materials in collections.

Acknowledgements

Many thanks to the staff of the Collections and Conservation Divisions, for their work with this material. My special thanks to Pat Montero for her help with the research, and to Bliss Tracy for editing the document before circulation to staff.

Materials

Coroplast boxes: "Parks Canada divided container" die# 45579, lid die# 45580, and dividers die# 45581A, Coroplast Division of Great Pacific Enterprises Inc., 700 Vadnais St., Granby, Quebec, J2L 1A7.

Mylar: Carr McLean, 461 Horner Avenue, Toronto, Ont. M8W 4X2. Tel: 1-800-268-2123; www.carrmclean.ca.

Equipment

Geiger Counter:
Dosimeter Corporation Model 3007A, portable battery-powered transistorized survey meter with a permanently attached gamma probe, which can measure from 5 to 500 µSv/hr. The probe is a Model 3073 probe, permanently attached, which consists of a nickel plated brass housing with a beta window.

Dosimeters:
Thermo Electron Corporation EPD Mk2 personal dosimeter, with audible alarm. They were provided through National Dosimetry Services of Health Canada.

- Three dose alarm flags indicate when a dose has exceeded the alarm threshold; two dose alarms for Hp10 and a single alarm for Hp07. "Alarms are acknowledged by pressing the button which extinguishes the alarm whereupon appropriate response action should be taken."

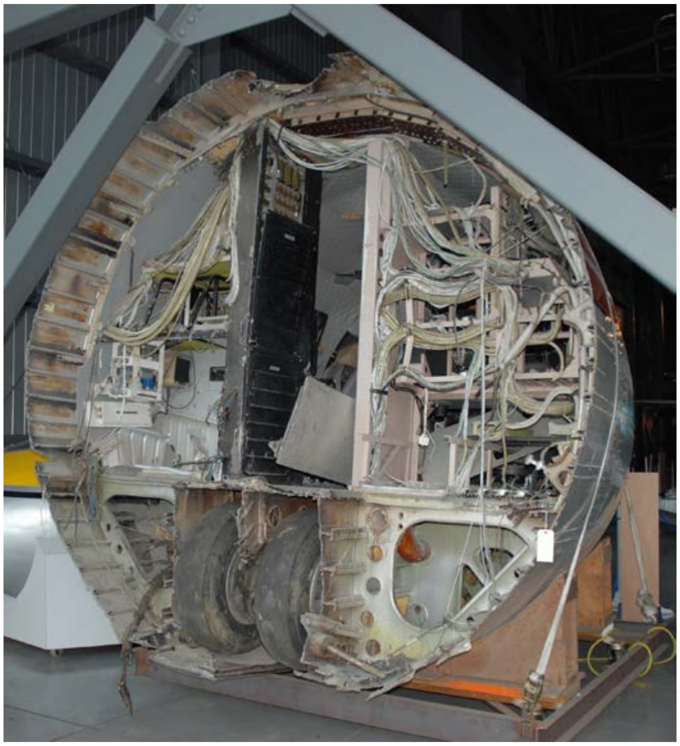

Figure 2. Luminous placards in nose section of Comet Aircraft which give readings over 400 µSv/hr at 15 cm from the surface. Moving to 30 cm reduces the readings to 100 µSv/hr. Photograph © and courtesy of the Canada Science & Technology Museum Corporation.

Notes and References

1. Ashton, John, “Radiation Hazards in Museum Aircraft,” in: *Saving the Twentieth Century: The Conservation of Modern Materials*, edited by David W. Grattan (Ottawa: Canadian Conservation Institute, 1993), pp. 287-300.

2. *Radiation Surveys of Cockpits of Aircraft at Canadian Warplane Heritage Museum* (Hamilton, Ontario: McMaster University, February 2009). Unpublished data.

3. For further information on this and other hazards in the CSTMC, see: Warren, Sue, “Hazards in industrial collections of the Canada Science and Technology Museum Corporation Ottawa, Canada,” in: *Incredible Industry: Preserving the evidence of industrial society*, Conference Proceedings of the Nordic Association of Conservators, 25-27 May 2009, edited by Morten Ryhl-Svendsen, Karen Borchersen and Winnie Odder (Denmark: Nordic Association of Conservators, 2009), pp. 225-231, <http://www.nkf-dk.dk/Bulletin/NKF-Incredible-industry09.pdf>. Accessed March 2010.

4. Frame, Paul, “Radioluminescent Paint,” in: *Oak Ridge Associated Universities Website*, <www.orau.org/ptp/collection/radioluminescent/radioluminescentinfo.htm>. Accessed March 2010.

5. Tracy, Bliss, Bill Walker, and Renato Falcomer, *Radiation Survey of the Canadian Aviation Museum* (Ottawa: Radiation Protection Bureau of Health Canada, March 2007). Unpublished report.

6. CMHC: *Radon: A Guide for Canadian Homeowners* (Ottawa, Canada Mortgage and Housing Corporation and Health Canada, 2007), <www.cmhc-schl.gc.ca/odpub/pdf/61945.pdf?lang=en>. Accessed March 2010.

7. Gaulke, Brian (Head of Dosimetry Section, National Dosimetry Services, Health Canada), personal communication, December 2007. See also notes under “Containment of Radioactive Materials” in Appendix 2.

8. *Regulations for the Safe Transport of Radioactive Material*, IAEA Safety Standards Series No. TS-R-1 (Vienna: International Atomic Energy Association, 2009). <http://www-pub.iaea.org/MTCD/publications/PDF/Pub1384_web.pdf>. Accessed March 2010.

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10. “Health Concerns: Can you give details about radiation exposures?”in: *Health Canada Website*,<http://www.hc-sc.gc.ca/hc-ps/ed-ud/event-incident/radiolog/info/details-eng.php>. Accessed March 2010.

11. “Radiation Dose Limit” in: *McGill University Services Environmental Health and Safety Website*, <http://www.mcgill.ca/ehs/radiation/manual/3/>. Accessed March 2010.

12. *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)* (Ottawa: Health Canada, 2000),<http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/norm-mrn/00ehd245.pdf>. Accessed March 2010.

Appendix 1: Glossary of Terms and Useful Facts prepared for CSTMC staff for work on the Luminous Dial Re-housing Project

Radium: Radioactive element with a half life of 1600 years. Decays into radon 222. Present on some luminous paint surfaces. Most dangerous when friable and exposed to air where it can become airborne. It also releases external radiation (alpha, beta and gamma).

Radon: The only radioactive gas generated during natural radioactive decay. The decay products of radon attach themselves to airborne dust particles that can be easily inhaled.
Units of measure: **Becquerel (Bq)**: an SI unit of *Radioactivity* used as a measure of the quantity of a radionuclide (amount of radioactive element). Equals the number of nuclear transformations that occur in a quantity of material per unit of time i.e. 1 Bq = 1 disintegration per second. Usually used to measure radon concentration in air.
Dose limits: The new Canadian radon guideline limit is 200 Bq/m^3. Dose is calculated as Working Level Month (WLM). The dose in WLM is converted to mSv (milli-Sievert) by multiplying by 5.
At CSTMC: Currently there is no in-house means of measuring staff exposure to radon gas, though radon readings have been taken in working and display areas. Staff working at the Aviation Museum are provided with long-term exposure dosimeters for routine work in aircraft.

Radiation:

Alpha radiation: A particle consisting of 2 protons and 2 neutrons that is dangerous if ingested. Most are stopped by barriers. Particle is heavy and slow moving and most are completely absorbed by a few centimeters of air. The decay of alpha particles in radium results in transformation to radon.
Beta radiation: The range of Beta radiation or particles in air may be more than a meter, and they can penetrate several millimeters of aluminum or plastic. More high energy (faster) than alpha particles.
Gamma radiation: Formed as a secondary process following alpha and beta decay. Highly penetrating and most dangerous. Can penetrate several centimeters of lead.

Units of measure:
Old Units
- rad: a historical (cgs) unit for *Absorbed Dose*. Replaced by the Gray (Gy) in the SI system (100 rad = 1 Gy).
- Roentgen (R): old unit of exposure to ionizing radiation (x-rays, gamma rays), now measured in Coulomb per kilogram in SI units.
- µR/h (micro-Roentgen per hour), mR/h (milli-Roentgen per hour): units commonly used in the past to measure exposure levels to gamma radiation.
- rem (acronym for 'Roentgen equivalent in man'): old unit for measuring the radiation dose equivalent. Has been superseded by the SI unit the Sievert.

Current Units
- **Gray (Gy)**: SI unit of *Absorbed Radiation Dose* to humans, = 1 joule of radiation energy per kg of material (1 Gy = 1 J/kg). It replaces the cgs unit the rad (1 Gy = 100 rad).
- **Sievert (Sv)**: SI unit of measure of the *Biological Dose Equivalent* (for human exposure), used for legal, engineering and administrative purposes. It is "the SI unit of *Absorbed Radiation Dose* in living organisms modified by radiation type and tissue weighting factors". (E.g. 1 Sv = 1 Gy only for certain types of radiation and on certain tissues.) It replaces the classical radiation unit the rem.
- **mSv/h** (milli-Sievert per hour), **µSv/h** (micro-Sievert per hour) = units of measure used to monitor health exposure to alpha, beta and gamma radiation.

Dose Limits:
Occupationally exposed workers have an annual dose limit of 20 mSv over five years (for a total of 100 mSv), or a single year maximum of 50 mSv in a one-year period. The public have an annual dose limit of **1 mSv in any one year**.

At CSTMC: Staff are classified as "the public" for the purposes of determining their allowable exposure: their annual dose limit is **1 mSv in any one year, or 1000 µSv/yr**. Radiation levels are measured in micro-Sieverts per hour (µSv/h) and then translated into number of hours of allowed exposure at that level, per year. For comparison, typical background radiation levels are 0.1 µSv/h. Measurements are usually taken at normal working distances from the surface, and in the case of aircraft cockpits, at strategic locations such as head and groin heights. In many cases, the restricted space in cockpits means that working distances are unusually small. For instance in the Lancaster Bomber, both the navigator and the communications officer sit with their heads less than 20 cm from emergency oxygen regulators which measure in excess of 350 µSv/h.

Example: a reading of 350 µSv/h, divided into an annual exposure limit of 1000 µSv/yr = 2.857 hours of exposure to reach the annual allowable limit.

Appendix 2: Personal Protection and Handling Guidelines prepared for CSTMC staff for work on the Luminous Dial Re-housing Project

Occupationally exposed workers have an annual dose limit of 20 mSv over five years (for a total of 100 mSv), or a single year maximum of 50 mSv in a one-year period.

The public have an annual dose limit of 1 mSv in any one year. Museum staff are classified as "the public" for the purposes of determining our allowable exposure.

Exposure to Radiation

There are 3 ways to be exposed to radiation:
1. External radiation (beta and gamma radiation passing through materials)
2. Ingestion or absorption of loose surface contamination
3. Inhalation of airborne radioactive particles

The two types of radiation measured with an electronic personal dosimeter (EPD) are designated as "personal dose equivalents Hp(10) and Hp(07)":

Hp10: penetrating, deep or whole body dose;
Hp07: superficial, shallow or skin dose.

Since there are different types of measuring devices, it is important to choose one based on the needs of the project and associated exposure risks. EPDs with sounders and alarms to indicate when a dose has exceeded the corresponding dose alarm threshold can be useful for working on short-term projects requiring concentrated exposure. All dosimeters require monitoring by downloading the dose information (monthly or annually depending on use); in the case of CSTMC, through National Dosimetry Service of Health Canada.

Reducing your Exposure to Radiation

1. Increase shielding (see protective equipment below).
2. Reduce time you are exposed to radiation (monitored by dosimeter).
3. Increase distance from radiation source.

Personal Protection

Always wear the dosimeter provided, which monitors your daily and cumulative exposure to radiation. You must not exceed 1 mSv exposure in a calendar year.

1. Always wear **protective gloves** which shield from alpha particles, and prevent absorption of loose surface contamination through the hands, and possible ingestion if you fail to wash your hands thoroughly before eating.

2. Always wear a **mask or respirator**, since radiation particles are more potent if they are absorbed internally. Degradation particles of radon attach to airborne dust particles; and also fine particles from deteriorated radon paint can be airborne.

3. Wear **protective or disposable clothing** to prevent contamination of your own clothing, and the possibility of you carrying the contaminants home or to other workspaces.

4. Wear protective **goggles** to prevent contaminated dust or particles from getting into your eyes, where it can be readily absorbed into your blood-stream.

5. Designate an area for getting dressed/undressed, and keep protective clothing in this area to prevent unnecessary contamination of adjacent spaces.

Containment of Radioactive Materials

Sealing in plastic (thick Mylar recommended by Brian Gaulke, head of the Dosimetry Section of Health Canada)[7] will reduce diffusion of radon and prevent the spread of loose surface contamination, however; ***"if the plastic is serving its intended purpose of keeping the radon in, there will be a buildup of surface contamination from the longer lived daughters of radon, in particular polonium 210 and lead 210 on the interior of the plastic and its contents. Any future opening of the plastic must bear this in mind and have appropriate radiological controls in place."***

A less expensive and time-consuming alternative is to use thick polyethylene "Ziploc" bags which, while not as efficient at reducing the diffusion of radon, will contain friable paint during storage and handling, and somewhat reduce the diffusion rate of the radon gas.

Transportation of Radioactive Materials

Transportation of radioactive materials is regulated by the Canadian Nuclear Safety Commission under the Packaging and Transport of Nuclear Substances Regulations and the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Material (1996, Safety Series TS-R-1 (ST-1. Revised)).[8]

All packages must be identified with the following statement:
UN 2911 RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – INSTRUMENTS

Clean-up of Contaminated Areas

The Canadian Nuclear Safety Commission recommends that radioactive contamination be cleaned up by trained and qualified persons only. Contaminated materials should be bagged, identified, and disposed of by contacting the Low Level Radioactive Waste Management Office at 905-885-9488; info@llrwmo.org.