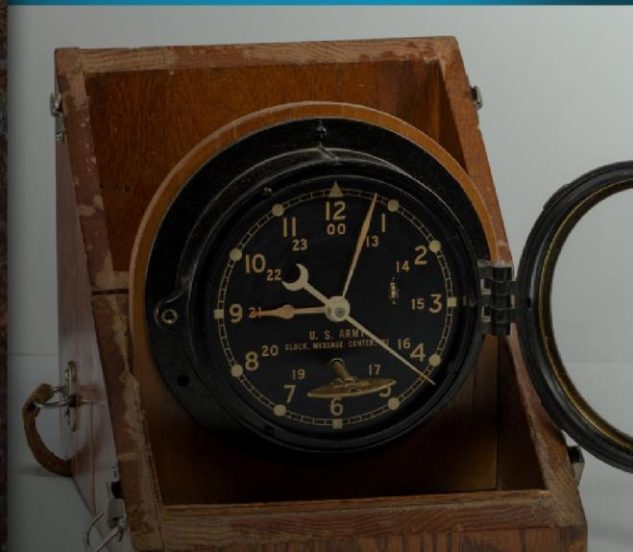
Tech Guide 385

RADIATION SAFETY GUIDANCE

for the U.S. Army Museum Enterprise



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1. PURPOSE

This technical guide (TG) provides guidance for addressing radiation safety issues encountered during performance of routine display, storage, disposal, and shipping of radioactive artifacts at Army Museum Enterprise (AME) activities and for ensuring compliance with Federal and Army regulations. The goals of the radiation safety guidance provided in this TG are to protect the health and safety of AME staff and the general public; protect the site environment; and meet all applicable Federal, Department of Defense, and Army regulations.

2. REFERENCES

See Appendix A.

3. BACKGROUND

The AME is composed of museums and activities throughout the U.S. and its territories. The US Army Center of Military History (CMH) is responsible for managing the AME and the Army Artifact Collection. The Army Artifact Collection is centrally managed and is comprised of artifacts and artwork that represent the history of the U.S. Army and its Soldiers. Radioactive artifacts are present in the Army Artifact Collection, and may include: radioluminescent timepieces, weapons sights, compasses, and aircraft and vehicle instruments (e.g., gauges and dials). The majority of radionuclides used in radioluminescent devices are radium (Ra-226), promethium (Pm-147), tritium (H-3), and americium (Am-241). Thorium and depleted uranium may be found in tanks, vehicles, and aircraft as well.

To assist the AME in establishing an effective radiation safety program, this TG will—

- Explain licensing regulations.
- Define the roles and responsibilities of supporting radiation safety staff.
- Identify the health hazards associated with radioactive artifacts.
- Describe the appropriate radiation safety procedures to display, store, dispose, ship, and handle radioactive artifacts.

The recommendations listed in this guide are in addition to any other safety requirements per Army, State, and Federal, and Department of Defense regulations.

4. DEFINITIONS

The following definitions are intended to introduce AME staff to terms used in radiation physics.

- A **radionuclide** is a radioactive atom that can spontaneously transform and emit radiation.

- **Radioactivity** is the spontaneous emission of radiation in the form of particles (e.g., alpha and beta) or high energy photons (e.g., gamma and x-rays) resulting from the transformation of a radionuclide.

- **Activity** is the rate of transformation of a radionuclide and is expressed in units of curies (Ci), becquerel (Bq)[1] transformations per second or disintegrations per minute (dpm) 1 Ci = $3.7x10^{10}$ Bq = 2.22×10^{12} dpm. Note that, 1 Bq = 60 dpm.

- The absorbed energy in tissue, known as the **dose**, is expressed in units of roentgen equivalent man (rem) or sievert (Sv). Conveniently, 1 Sv = 100 rem, and 1 rem = 1,000 millirem (mrem) = 10 millisieverts (mSv).

5. REGULATIONS GOVERNING RADIOACTIVE ARTIFACTS

The Department of the Army (DA) Safety Program prescribes the safety regulations involving the use and possession of radioactive materials in Army Regulation (AR) 385-10. The program states that all DA organizations will develop management and quality control processes to identify, mitigate, and control activities involving the use of radioactive materials (reference 1). The organizations will also ensure the implementation of the concept of "as low as reasonably achievable (ALARA)" regarding exposure to radiation. ALARA involves making every reasonable effort to maintain radiation exposures as far below applicable dose limits as is practical, consistent with the purpose for which the activity is undertaken.

AR 385-10 mandates the implementation of the technical requirements published in DA Pamphlet (DA Pam) 385-24 for the management and control of radioactive materials (reference 1). DA Pam 385-24 requires compliance with the U.S. Nuclear Regulatory Commission (NRC) regulations for NRC-regulated radioactive items according to the Code of Federal Regulations (10 CFR) (reference 2). Some artifacts containing radioactive materials in Army museums are either exempt or do not require NRC licensing, or are covered under an NRC general license. Other radioactive artifacts do not require NRC licensing; however, they may require an Army Radiation Authorization (ARA) (reference 3).

As stated in DA Pam 385-24, items licensed under an ARA are required to comply with the requirements listed in the issued ARA (reference 2). As stated in AR 870-20, the vast majority of radioactive artifacts requiring licensing are commodities licensed to the Army Materiel Command (AMC) by the NRC (reference 3). All museums should contact the AMC radiation safety officer (RSO) to inquire about the licensing status of their inventory to find out if the items in the inventory are exempt, regulated by NRC, or regulated by an ARA. In this case, museums, museum activities, historical collections or the Clearinghouse should keep copies of these licenses and be familiar with the requirements regarding handling, disposing, and shipping of the radioactive materials. The AME staff should contact the licensee for consultation before disposal, transfer, or shipping of these licensed items.

[1] A curie equals 3.7 x 10^{10} transformations per second. A becquerel is 1 transformation per second.

Items covered under the general license rule must satisfy the NRC requirements published in 10 CFR Part 31 during handling, storage, and all other activities (reference 4). According to 10 CFR 31.12, "A general license is hereby issued to any person to acquire, receive, possess, use, or transfer, radium-226 contained in the following products manufactured prior to November 30, 2007:

a. Antiquities originally intended for use by the general public.

b. Intact timepieces containing greater than 0.037 megabecquerel (1 microcurie), broken/cracked timepieces, and timepiece hands and dials no longer installed in timepieces.

c. Luminous items installed in air, marine, or land vehicles.

d. All other luminous products, provided that no more than 100 items are used or stored at the same location at any one time.

e. Small radium sources used in educational demonstrations (such as cloud chambers and spinthariscopes), electron tubes, lightning rods, ionization sources, static eliminators, and survey instruments check sources, containing no more than 0.037 megabecquerel (1 microcurie) of radium-226."

There are no limitations on the numbers nor the activity of radium dials and gauges installed in vehicles and aircrafts. However, if these gauges and dials are removed, then there is a 100 items limit per one single building (reference 5). All items covered under the general license rule except timepieces are not authorized to be disassembled or repaired for the purpose of restoration.

10 CFR 31.7 states that radioluminescent devices installed in aircraft and containing other radionuclides cannot exceed the limit of 10 Ci for H-3 and 300 millicuries for Pm-147. Under these limits, the radioluminescent devices are covered by a general license (reference 4).

For questions regarding licensing and regulations, contact the Army Radiation Safety Office. The U.S. Army Safety Office contact information is listed in Appendix B.

6. IDENTIFICATION OF RADIOACTIVE ARTIFACTS

The AME should identify radioactive artifacts as part of their risk assessment, management, and monitoring of inventory processes (reference 3). It is possible that accurate descriptions for some artifacts (e.g., activity, radionuclide identification) will be challenging to find, especially if the artifacts are too old and/or brought from other countries. However, AME may seek help from a radiation protection subject matter expert, such as from the U.S. Army Public Health Center (APHC), Health Physics Division.

The U.S. Communications and Electronics Command (CECOM) RSO website and Technical Bulletin (TB) 43-0116 can be used as resources to obtain information about specific U.S. Army radioactive commodities (reference 6). Alternatively, a qualified profession can perform a radiological survey, which is the preferred method to search for radioactive artifacts. The

qualified professional can be either a health physicist or an installation RSO. The advantage of hiring a professional is not limited to only identifying the radioactive artifacts; they can also provide an evaluation of the physical condition of the items (i.e., whether it is intact or leaking) and advise how to safely manage the radioactive artifacts.

7. ROUTES OF RADIATION EXPOSURE

Radioactive materials are naturally present at low concentrations in air, cosmic rays, rocks, soil, and water. The levels of ionizing radiation from these sources are fairly low and known as background radiation. Exposure to ionizing radiation that exceeds background levels may carry a risk in developing long-term health effects if these levels exceed certain thresholds. Exposure occurs when a person is exposed to radiation from a radioactive source and/or is contaminated with a radioactive material. The health risk is related to the dose, route of exposure to radioactive materials (external exposure versus internal exposure), and type of radiation (i.e., alpha, beta, and photons). External exposure refers to an individual being exposed to radiation from a radiation source outside of the body (i.e., either partially or completely). Internal radiation exposure results from radioactive material that gets inside the body through ingestion, inhalation, wounds, or absorption through the skin.

Alpha and beta radiation are charged particulates that travel at velocities determined by their energies and have relatively short ranges in air. Radioactive materials that emit alpha and beta particles are most harmful when they are internalized; therefore, they are considered an internal hazard. Beta particles can also partially penetrate the skin, causing burns depending on their energy. Exposure to gamma rays is mostly an external hazard. Gamma radiation is more penetrative and can travel larger distances in air. The gamma radiation released from some radionuclides can penetrate the housing material (e.g., metal and glass) of the radionuclide and deposit energy in human tissue. The higher the energy deposited, the more likelihood of damaging the target tissue.

All radionuclides, regardless their type of emitted radiation, are potentially hazardous if inhaled, ingested, or absorbed. The adverse health effects contributed from these exposures occur when some threshold is exceeded, such as exposure from high-dose sources (reference 7). Exposure to radon is another scenario of internal exposure. Radon is a radioactive gas that results from the decay of Ra-226 and may contribute to the internal dose of individuals exposed to artifacts containing Ra-226 (reference 8). The levels of radon released from these artifacts are very low and can be easily mitigated by providing good ventilation (reference 9).

8. MITIGATION OF EXTERNAL RADIATION EXPOSURE

As mentioned above, the application of ALARA aims to maintain exposures to radiation as far below applicable dose limits as is practically consistent with the purpose for which the activity is undertaken. Adequate measures including more shielding, more distance, and less time are used for planning the use of radioactive materials in order to achieve ALARA doses. These measures should always be used during storage and display of radioactive artifacts. The following techniques are some examples of applying the ALARA concept at the museum to reduce or eliminate any unnecessary exposure to all individuals:

- Reduce the number of the radioactive artifacts stored or displayed at one location.
- Use large display cases and storage cabinets with thicker walls.
- Place the radioactive artifacts at the backend of the display case in order to increase the distance to the observer.
- Place artifacts stored or displayed in trays to limit the spread of any potential contamination.
- Place storage cabinets away from routinely occupied areas (e.g., offices).
- Perform frequent external radiation surveys of areas used to display or store radioactive artifacts.

9. MITIGATION OF INTERNAL RADIATION EXPOSURE

Inhalation and ingestion are the common routes of internal uptake and may result in radiation exposure. The following techniques can be used at the museums to reduce or eliminate any unnecessary internal exposure to all individuals:

- Reduce radon buildup by frequent ventilation of storage and display cabinets, and by opening doors/windows of storage rooms.

- Use protective equipment such as gloves and disposable respirators (e.g., N95 mask) as necessary during handling and maintaining radioactive artifacts. Wash hands with soap and water after removing your gloves. Gloves should be disposed of separately and not with regular waste. Disposal should be in plastic bags. The museum can contact the installation RSO to dispose the waste appropriately.

- Perform removable contamination surveys at least annually, and decontaminate areas suspected to be contaminated by broken or leaking artifacts as needed.

10. RADIATION SURVEYS

Conducting a routine radiological survey is an important part of radiation safety that protects the museum staff and visitors. Radiation exposure could come from artifacts in forms of removable contamination that leaked from the enclosure, fixed contamination on a surface, and intact artifacts that emit radiation. Routine surveys allow early determination of the root cause of exposure and are important for prevention of spillage incidents. These surveys must be performed by trained and qualified personnel. The training requirements are discussed in Section 16.

10.1 External Radiation Surveys

External radiation surveys allow detection of radiation sources in an area, on a surface, or in an object. Hand-held survey meters, such as ion chambers, are used for measuring dose or exposure rates. Other types of hand-held radiation meters such as Geiger-Muller (GM) tubes, sodium iodide detectors, and pancake probes can be used to scan for potentially contaminated areas. When using these detectors, the scanning speed must be relatively slow; typically no more than 2 inches (in) per second and with the audio mode enabled. Pancake probes and GM tubes are more convenient for museums in applications such as identifying radioactive artifacts and finding contamination on surfaces. The readout of pancake and GM tube devices is usually in counts per minutes.

Ion chambers are sensitive to radiation and used to measure doses in units such as radiation absorbed dose (rad), Roentgen (R), and rem. However, radioactive artifacts are usually weakly radioactive. The doses from these artifacts are normally below the detection sensitivity of the majority of ion chambers, unless the source is either unusually strong or a large number of items are stored/displayed together. By following the recommendations to reduce external exposure (see Section 8), the external exposure will not be expected to be significant. Section 11 provides more details on how to estimate the dose from the timepieces and gauges – common radioactive artifacts displayed in the museums. Therefore, the information below describes how to perform a radiation survey using a GM probe to locate and identify radioactive artifacts in the museum collection and survey areas for potential contamination.

All survey instruments must be calibrated in accordance with Army and manufacturer requirements (e.g., TB 9-6665-285-24). In addition, each museum, in conjunction with a qualified professional, should develop survey procedures (including instrumentation quality assurance procedures) appropriate for their collections.

Use the following standard procedures to perform a radiation survey:

- Check the calibration date of your probe and record the background radiation before surveying any area.
- Draw a diagram of the area you are surveying (e.g., room, a cabinet or a display) and create a grid of small squares for the whole area if it is big. This will ensure that you will be able to identify and focus only on a small contaminated area rather than on a large or the whole surveyed area. If the room is small, use your body as a shield by standing in between the sources of stored radioactive materials and the contamination you are measuring.
- Measure the exposure rates at 1 meter (m) from the radioactive artifacts.
- For surface contamination, hold the probe at 0.5 in (1.3 centimeters (cm)) above the surface (see Figure 1).

- Move slowly in parallel to the surface at a speed of 1 to 2 in (2.5 to 5.1 cm) per second.

- Measure the counts in areas of blocks that are on the diagram and write down the reading at each point measured.

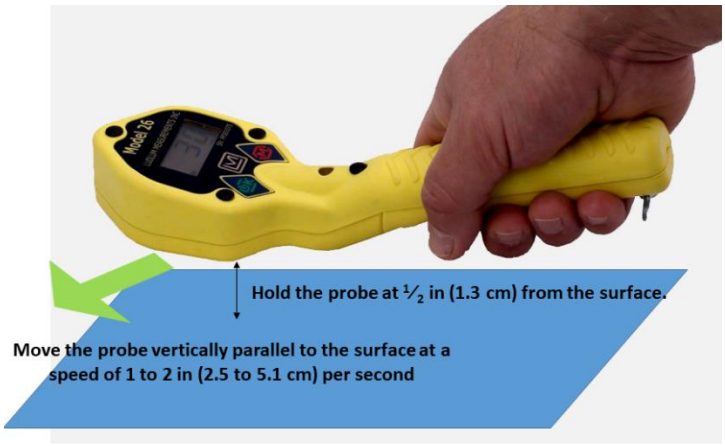

Figure 1. Area Survey with a GM Probe

For identification of radioactive artifacts in the inventory, or when the museum receives new items (e.g., timepieces, gauges, vehicles, and aircrafts), use the following procedures:

- Measure the background radiation.

- Place the item separately on a table and ensure no other sources of radiation are around.

- Move the probe closely to the item at a distance of no more than 0.5 in (1.3 cm). If the item is a vehicle or an aircraft, scan gauges, and dials inside the cockpit or fuel gauges in vehicles. Note that some helicopters (e.g., AH-1 (Cobra), UH-1 (Iroquois or Huey), Ch-47 (Chinook) and OH-58 (Kiowa)) have some parts of the engine that are made of alloys containing Thorium. The engine should be surveyed carefully by opening the engine service panel and scan it using GM tube or pancake probe (see Figure 2). Other items (e.g., timepieces) have very small amounts of radioactive painting and may need to be surveyed with a more sensitive detector such as a sodium iodide detector.

Figure 2. Surveying a Helicopter Engine Made of Magnesium-Thorium Alloy

10.2 Removable Contamination Surveys

Because historical artifacts are prone to deterioration over time and may leak radioactive material, it is highly recommended to monitor removable contamination by performing removable contamination surveys. Removable contamination surveys should be performed by swiping the surface of the artifact. Usually, an area of 100 cm^2 (approximately 4 in x 4 in) is swiped with moderate pressure with an appropriate material (e.g., a 47-millimeter paper filter) in order to consistently determine the amount of removable surface contamination. For small artifacts where surfaces are less than 100 cm^2, the whole surface around the peripheral sealing should be swiped. Cotton swabs can be used to swipe corners, grooves, or areas difficult to reach. Each wipe should be accompanied with the following information: item serial number, name of the surveyor, location, time, and date. The swipes should be individually placed in plastic bags and sent to one of the Army radiation counting labs for analysis. The contact information of Army radiation counting labs are listed in Appendix B. The lab returns the results in a report listing the activity detected on the swipes, which can be compared to some screening levels.

The screening levels in Table 1 are the screening levels for radioactive materials listed in DA Pam 385-24 and are adopted from the ANSI 13.12 standard (references 2 and 10). These screening levels are applicable for items or areas potentially contaminated by radioactive materials and are released to the general public as nonradioactive for further use. As stated in ANSI 13.12, measurement of removable surface activity is not necessary or appropriate to demonstrate compliance with the standard (reference 10). The standard is not a regulation, and it does not specify screening criteria for radionuclides. The screening criterion for leakage from sealed sources published by the NRC can also be used, since radioactive artifacts are similar to sealed sources (reference 11). The NRC criterion states that a source is considered to be leaking if the removable contamination exceeds 185 Bq (11,100 dpm) (reference 11). However, there are no screening criteria or requirements in the regulations for historical artifacts and neither of these screening levels strictly applies. The museum can use either of them as action levels to control removable contamination and to support ALARA decisions (references 10 and 11).

The screening levels in Table 1 are more conservative than the NRC criterion. Depending on the situation and the value of the item, the museum can assess the risk when selecting between both action levels. For example, the museum can use the values in Table 1 for highly visible or significant artifacts or use the NRC criterion for items to be disposed of. Additionally, AR 870-20 mandates reporting spills or leakage incidents to the installation RSO (reference 3).

Table 1. Screening Levels for Clearance of Radioactive Materials (references 2 and 10)

Radionuclides Group	Screening Levels (dpm 100 cm^{-2})
Radium, and Thorium: Ra-226, thorium and associated decay chains	600
Other Beta-Gamma Emitters: H-3, and Pm-147	600,000

11. ESTIMATING DOSE FROM EXPOSURE

Buchholz (2008) has reported the estimated doses from activities involving radium gauges during display in collection, storage, or accident-type events, such as a fire and subsequent cleanup (reference 12). Buchholz evaluated different scenarios of potential radiation doses to collectors, users and repairers of radioluminescent devices such as timepieces and gauges, which contain Ra-226 as radioluminescent paint. The evaluation is based on the methodologies reported in NUREG-1717, *Systematic Radiological Assessment of Exemptions for Source and Byproduct Materials*, published by the NRC. The report presented several scenarios of how an individual may be exposed to radiation from radium timepieces. The discussed scenarios include external radiation exposure, inhalation, and ingestion of the radium paint, and inhalation of the radon produced from the decay of the radium. According to the report, Buchholz indicated that gauges have more radioactivity than timepieces due to the larger size of the needle and the instrument face. The majority of radioluminescent devices contain 1 microcurie (µCi) or less of Ra-226, and few devices may range from 15 to 25 µCi (reference 12).

The dose modeling used to evaluate the scenarios is based on some conservative assumptions presented in Table 1 and were normalized to a 1 µCi activity, except as otherwise noted. The 1 µCi also corresponds to the value for exemption from licensing requirements in NRC rule making, discussed previously in Section 5. Table 2 summarizes the calculated dose to an individual during different scenarios involving radioluminescent devices (e.g., radium gauges and timepieces) similar to radium artifacts displayed in military museums. It is assumed that museums store artifacts in cabinets and periodically clean and maintain them. Thus, scenarios 1, 3, and 4 can be used as examples to estimate the dose to an individual performing those common activities. The second scenario is applicable when someone is trapped during an emergency with 30 minutes exposure to the burning collection and inhales suspended radioactive dust. Note that this scenario is based on the assumption that the person was exposed to radium used in timepieces and gauges. For other radioactive materials, the estimated dose might be different and shall be assessed by a qualified professional.

Table 2. Scenarios for Radioluminescent Gauge Dose Modeling

Scenario description	Exposure pathway	Calculated dose in each scenario	
1) Dose due to collecting 20 radioluminescent gauges stored or displayed in area next to offices, **each 1 µCi**	External exposure Inhalation of radon	Office occupant sitting 1 m away from the collection for 2,000 hours yr^{-1}	42 mrem yr^{-1}
		Office coworker sitting 6 m away from the collection for 100 hours yr^{-1}	< 1 mrem yr^{-1}
2) Dose due to a catastrophic fire involving a collection of radioluminescent gauges	Inhalation	A person trapped for 30 minutes in a room its volume 40 m^3	1 mrem for 10 piece collection
		A person trapped for 30 minutes in a room its volume 450 m^3	< 1 mrem for 10 piece collection
3) Inhalation of suspended radioactive dust during post-fire cleanup activities (for a collection of 10 pieces)	Inhalation of suspended radioactive dust	0.5 mrem	
4) Ingestion of paint particulate during handling or cleanup of nonintact timepieces (for a collection of 10 pieces)	Ingestion of paint	1.3 mrem	

Legend:
µCi = microcuries
m = meter
mrem yr^{-1} = millirem per year
Note:
Adapted from**:** Buchholz, MA. 2008. Supplement to Radium Timepiece Dose Modeling: Radium Gauge Dose Modeling. Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, USA. DEAC05-06 OR23100 for the U.S. Nuclear Regulatory Commission.

Note that the assumptions made in the dose modeling are conservative and the expected dose to an individual in the museum is likely lower than the estimated dose in Table 2 scenarios. The application of the ALARA principle (e.g., distance, and time) will imply a significant reduction in the estimated dose to the individual. Table 2 presents the effect of either increasing the distance, reducing the number of items stored per location, or reducing exposure time to an individual staying in that room. The calculated doses in Table 3 are derived from the estimated value shown in the first scenario of Table 2. The combination of these three factors will reduce individual doses even more. Therefore, it is highly recommended to consider the applications of these factors.

Table 3. Effect of Distance, Time, and Total Number of Items on the Estimated Dose to Individuals

Estimated dose (mrem yr^{-1}) Based on 20 items each (1 µCi), 1 m away, and 2000 hour per year = 42 mrem yr^{-1}					
Effect of distance	**Dose (mrem yr^{-1})**	**Effect of number of items**	**Dose (mrem yr^{-1})**	**Effect of time per year**	**Dose (mrem yr^{-1})**
2 m	10.5	*50*	105	*1,000 hours*	21
4 m	2.625	*10*	21	*500 hours*	10.5
6 m	1.17	*5*	10.5	*200 hours*	4.2
8 m	0.66	*1*	2.1	*100 hours*	2.1
Legend: µCi = microcuries m = meter mrem yr^{-1} = millirem per year					

Check the calibration date of your probe. As mentioned previously, radiation exists everywhere naturally and therefore it is important to record the background radiation before surveying any area.

12. ACQUIRING AND MONITORING RADIOACTIVE ARTIFACTS

The museum director has the authority to keep, store, display or return new radioactive artifacts that are brought into the Army Artifact Collection. If a new acquisition contains a radioactive artifact, it must be identified as such when presenting to the AME Collections Committee. Monitoring and tracking the inventory of radioactive artifacts is part of the management of hazardous materials at museums. Radioactive artifacts must be flagged in the current museum Accountable System of Record. Proper accountability assists AME activities museums in coordinating efforts with the supply, information management, and environmental activities to facilitate both management of the radioactive artifacts and compliance with Federal and Army regulations.

A detailed inventory will allow the museum staff to identify items that are either exempt, under NRC license, or under ARA, and to ensure proper handling, storage, use, and disposal of items accordingly. Some items are licensed to other organizations and are loaned to the museums. Losing these items may result in penalties or the suspension of the license. According to AR 870-20, all radioactive artifacts will be verified at least annually or in accordance with the Center for Military History guidelines (reference 3).

13. DECONTAMINTION AND DISPOSAL OF RADIOACTIVE ARTIFACTS

During contamination surveys, it is possible to find some broken artifacts that started to leak radioactive material. When an artifact is found leaking, the surrounding area could potentially be contaminated. It is imperative to swipe the surrounding area and proximate items by following the procedures described in paragraph 10.2. Leaking artifacts should be handled carefully with gloves, double-bagged in two plastic bags, labeled, and isolated from the rest of the inventory.

Note that the gloves used to handle the leaking items and artifact containers and tray must be disposed as radioactive waste. Items containing radioactive materials under general license cannot be abandoned and shall be disposed according to 10 CFR 20.2008 (reference 4). DA Pam 385-24 provides guidance for disposal of radioactive materials and requires coordination with the Army Low-Level Radioactive Waste Disposal Division, U.S. Army Joint Munitions Command (See contact information in Appendix B). AR 870-20 states that the museums, historical collection, and Clearinghouse will have either its own radiation incident response plan due to a spill or spread of a contamination or they will be familiar with the servicing installation plan (reference 3). It is highly recommended to consult a qualified professional before performing any decontamination effort. For quick decontamination of small areas, use commercial decontamination kits if available, or wash the area with soap and water. For more information regarding decontamination, the museum can consult qualified experts such as the installation RSO or the APHC Health Physics Division.

14. EXPOSURE LIMITS AND REGULATORY CONCERNS

As stated in DA Pam 385-25, the U.S. Army dosimetry program is based on the concept of ALARA (reference 13). The AME shall assess radiation exposure to demonstrate compliance with occupational dose limits and effectively support the ALARA concept at all Army museums. The RSO in charge of the museum (e.g., the installation RSO or hired qualified professional) shall assess radiation exposure from artifacts at the museum to ensure compliance with occupational dose limits in Federal standards, such as NRC (10 CFR 20) and Occupational Safety and Health Administration (OSHA) (29 CFR 1910.1096) regulations (reference 13). According to DA Pam 385-24, ionizing radiation exposures resulting from radionuclides or radiation-producing devices not covered under NRC licenses will be reported in accordance with OSHA regulation 29 CFR 1910.1096 (reference 2). For Army radiation exposures, the dose limits listed in Table 5-1 in DA Pam 385-24 apply when they are more restrictive than OSHA regulations (references 1 and 2). One of the differences between both standards is that OSHA standards only address exposure to workers, while NRC standards address exposure to workers and the general public.

AME shall consider applying the Army dose limits in DA Pam 385-24 to ensure the safety of workers and museum visitors. The annual limits for occupational workers and general public are 5,000 mrem (50 mSv) and 100 mrem (1 mSv), respectively. The occupational dose limit to a declared pregnant woman is 500 (mrem) (5 mSv) for the duration of the pregnancy. For the general public, the maximum exposure limit is 2 mrem in any 1 hour (reference 2). In general, the expected radiation exposure to occupational workers in museums is expected to be low, as estimated in Section 11.

At levels of radiation exposure less than 10 percent of the applicable limits, individuals may be occupationally exposed to ionizing radiation but not meet the criteria in DA Pam 385-25 to be issued individual dosimetry (reference 13). The exposure for the museum's staff is not expected to exceed the 100 mrem limit for general public. However, the RSO may consider placing temporary area dosimeters in storage and display areas for a limited period to obtain a representative area dose to confirm that occupational doses to individuals are less than 10 percent of the applicable limits. To keep exposure rates below the 2 mrem in any 1 hour and 100 mrem/yr for the public at the museums' exhibitions, the RSO may consider a dose rate of

50 µrem/hour at 1 meter from the source as an action level. If the exposure rate will exceed 50 µrem/hour in a specific area, then other arrangements may be needed to reduce the exposure of the staff in that area and by using the approaches discussed in Section 11.

15. POSTINGS AND SIGNS

The AME needs to ensure that posting follows the requirements in 10 CFR 20 for licensed items and items under a general license (reference 14). The sign "CAUTION, RADIOACTIVE MATERIAL(S)" shall be used when the amount of the radioactive artifacts, containing a specific radionuclide, in a stored or displayed area exceeds 10 times the quantity of such radionuclide specified in Appendix C of 10 CFR 20. For example, Ra-226 is 0.1 µCi, so 10 times this would be 1 µCi; therefore, areas containing Ra-226 will be posted with the required signs.

Table 4 shows the values for radionuclides – commonly found in Army museums – that require labeling according to 10 CFR 20. Other signage such as, "eating, drinking, or smoking are not allowed" and the emergency contact number of a qualified professional (e.g., Installation RSO, Health Physicist) must be placed in areas where radioactive items are stored. According to AR 870-20, employees will receive appropriate training to identify labeling and marking requirements as required by DA Pam 385-24, the NRC license, and the ARA (reference 3).

Table 4. Quantities of Licensed Material Requiring Labeling

Radionuclide	Quantity listed in App C of 10 CFR 20 (µCi)	Signage required if the total activity of the items exceeds (µCi)
Radium (Ra-226)	0.1	1
Tritium (H-3)	1,000	10,000
Promethium (Pm-147)	10	100
Strontium (Sr-90)	0.1	1
Thorium	100	1,000
Americium (Am-241)	0.001	0.01

16. RADIATION SAFETY ORGANIZATION, TRAINING, AND RESPONSIBILITIES

CMH falls under the Training and Doctrine Command (TRADOC) and their safety office. CMH does not have the capability to maintain radiation survey equipment at each site that maintains radioactive artifacts. The AME is dependent on the support of installation RSOs, however, some installations lack an experienced RSO or do not have the capabilities to support the museums. In this case, a Memorandum of Understanding (MOU) can be developed with commands or units that have the capability to support the survey of radioactive artifacts. The AME staff who handle radioactive artifacts must take annual radiation safety training. The training shall cover the following topics: basic radiation interactions, radioactivity, terms and units, biological effects, radiation detection and measurement, and radiation and contamination control. By looking at the type of activities performed at Army museums and their inventory, AME shall consider training at least one person to become an RSO level 1 or 2. The training requirements for RSOs are listed in Chapter 7 of DA Pam 385-24 (reference 2). As stated in DA Pam 385-24, RSOs who are at units or facilities that are responsible for AMC commodities or items under NRC

jurisdiction should receive RSO training level 1 or 2 (reference 2). Level 1 RSOs are required to complete a distance learning or a resident radiation safety course. To become a level 2 RSO, an individual must complete the 1-week basic RSO course (phase 1), receive source-specific training for items under their purview, and receive annual radiation safety training. Acceptable RSO courses are offered by the U.S. Army Chemical School, U.S. Army Medical Command, National Guard Bureau, and AMC licensees. Other courses are available through commercial institutes and centers.

The main responsibility of an RSO is to ensure the implementation of the radiation safety program, the compliance with Federal laws and regulations, and that radiation exposures are ALARA by—

- Tracking and maintaining radioactive artifacts at the museum;
- Training employees on the safe use of radiation and radioactive materials;
- Performing routine surveys of all radioactive items and areas where they are located;
- Overseeing the display and storage of the radioactive items;
- Disposing of unwanted radioactive items; and,
- Auditing the museum radiation safety program.

17. SHIPPING OF RADIOACTIVE ARTIFACTS

Shipping of some artifacts between museums and disposing of damaged items are two of the expected activities at the museums. According to the U.S. Department of Transportation (DOT), radioactive materials are classified as hazardous materials class 7 and are regulated by the NRC and DOT based upon a MOU. DOT regulations in 49 CFR are more comprehensive and cover all the details of transportation, including packaging, shipper and carrier responsibilities, documentation, and all levels of radioactive material from exempt quantities to very high levels (reference 15).

Before shipping and after receiving any radioactive artifacts, Army museums are required to check the radiation levels of packages to ensure that all levels are within allowed limits. The packaging limits are based on the activity of the material shipped and are divided into four categories: excepted, industrial, type A, and type B.

The majority of the museums artifacts are shipped as excepted packages and few are type A (e.g., larger amounts of radioactivity shipped as a single package). Any package containing radioactive materials must have the proper labels and package marking to inform transportation workers and emergency response personnel about the package's radioactive contents. The difference between excepted packages and type A packages are described below.

- Excepted packages: These packages are used to transport limited quantities of radioactive materials, instruments or articles, articles manufactured from natural or depleted uranium or natural thorium with low levels of radioactivity that would pose a very low hazard if released in an accident. Requirements for excepted packages are addressed in 49 CFR 173.421. The activity per package of the radioactive material shipped as excepted packages must not exceed the limited quantity package limits specified in Table 4 in § 173.425. Note that excepted packages are excluded from

most of the specific packaging, labeling, and shipping paper requirements except that they are required to have the four-digit UN identification number marked on the package. This category may be suitable to ship a single item radioactive artifact (if the radioactivity meets the limits in Table 4 of §173.425) between museums.

- Type A packages: These packages are used to transport small quantities of radioactive material with higher concentrations of radioactivity than those shipped in excepted packages. The packaging used to ship radioactive materials is typically constructed of strong materials that withstand impact and limit the release of the radioactive materials in case of accidents. Requirements for Type A packaging are addressed in 49 CFR 173.412. This category may be used to ship various items between museums (e.g., whole inventory of the museum).

Upon receiving a package containing radioactive material, the certified shipper or the RSO must be notified before opening the package. The package has to be cleared by a trained individual to ensure the safety of the staff from any potential contamination or unnecessary exposure. Only individuals who are trained in accordance with 49 CFR 172 are allowed to ship, receive or release radioactive materials (reference 16). The annual “Radioactive Commodity Identification and Transportation” course offered by CECOM satisfies the requirements in 49 CFR 172.704(d) and certifies individuals to transport radioactive commodities (i.e., compasses, and weapon sights) similar to the majority of the items displayed in the Army museums. Other transportation of hazmat courses are acceptable and are available through some commercial institutes and centers. Shipping radioactive artifacts outside the U.S. must be according to the International Air Transport Association (IATA) Dangerous Goods Regulations. Air cargo carriers are requiring proof that the shipper has completed IATA-based training before accepting any package for air shipment (reference 17).

18. CONCLUSION

Even though it is unlikely that museum personnel will incur doses high enough to increase long-term health risks, AME shall develop a plan to support the ALARA principle. To achieve ALARA, each museum and activity needs to identify the radioactive artifacts in its inventory, train its staff on how to safely handle these items, ensure surveys are performed frequently, and follow the regulations for handling, possessing, shipping, and disposal of radioactive materials. Finally, the information in this TG is intended to help the museum staff understand the basic concepts of radiation safety applicable to radioactive artifacts and is in addition to, not in lieu of, any other safety requirements listed in an NRC license, ARA, or AME policy.

19. TECHNICAL ASSISTANCE

For more information or questions related to this TG, please contact the APHC Health Physics Division at 410-436-3502/8396 (commercial) or 584-3502/8396 (DSN). Requests for products or services can be submitted though the APHC Mission Service Request website: https://usaphcapps.amedd.army.mil/MSRV_mvc

APPENDIX A

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APPENDIX B

LIST OF ADDRESSES

The U.S. Army Safety Office
ATTN: DACS–SF
2530 Crystal Drive Suite 3058
Arlington, VA
E-mail: ASO@hqda.army.mil
Phone: (703) 697-1194 or (703) 697-1128
DSN: 227-1194 or 227-1128
Support questions and inquiries related to radiation safety

U.S. Army Test Measurement and Diagnostic Equipment Activity (USATA)
ATTN: AMSAM-TMD-SR
5417 Jungerman Rd
Redstone Arsenal, AL 35898-0001
Phone: (256) 876-5593
Support all types of wipe samples

U.S. Army Communications Electronics Command (CECOM)
Life Cycle Management Command (LCMC)
Commander, U.S. Army CECOM
ATTN: AMSEL-SF-R (LAB)
3200 Raritan Avenue
Aberdeen Proving Ground, MD 21005-1850
Phone (443) 395-4017 or DSN 648-4017
FAX (443) 395-3836 or DSN 648-3836
Support National Guard Bureau museums and NRC licensed thorium optical coatings

U.S. Army Public Health Center
Laboratory Analytical Division - Inorganic
8252 Blackhawk Road
Building E2100
Aberdeen Proving Ground, MD 21010
Website: http://phc.amedd.army.mil/organization/institute/dls/Pages/LAD-I.aspx
Phone: 410-436-2208
DSN: 584-2208
Possible fee associated with wipe test analysis

U.S. Army Tank Automotive Command LCMC
6501 E 11 Mile Rd
Warren, MI 48397-0001
Phone: (586) 282-0891
DSN: 786-0891
Support TACOM NRC licensed commodities to include H-3 (tritium) and Ni-63 (nickel)
U.S. Army Joint Munitions Command

Army Low-Level Radioactive Waste Disposal Division
ATT: AMSJM–SF
2695 Rodman Ave
Rock Island, IL 61299–6000
Phone: (309) 782-2113
DSN: 793-2113
Support low-level radioactive waste disposal