Risk Management for Museums:
Focusing on Dealing with Cultural Objects Contaminated by Radionuclides
(Revised Dec. 4, 2014)

Tokyo National Research Institute for Cultural Properties

Explanatory Note on March 30, 2022

This document is translated from its Japanese version “博物館美術館等のリスクマネージメント – 放射性物質に汚染された塵埃への対応を中心に – (20140210 案)” dated February 10, 2014. Correctness of information was confirmed at the time of English version’s publication on December 4 of the same year. Revisions and/or enactments of related laws and regulations which have been made after the publication of Japanese version are not reflected on this document.

Regarding the name of the organization in 2014, the Tokyo National Research Institute for Cultural Properties was called as “the National Research Institute for Cultural Properties, Tokyo” in English, but the present name is used in this document considering the readers’ convenience.

Tokyo National Research Institute for Cultural Properties

Measures to Prevent/Mitigate Radiation Damage to Cultural Properties

The Great East Japan Earthquake and resulting tsunami on March 11, 2011 caused severe accident due to power loss at Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company in Fukushima Prefecture, and this accident resulted in the release of large amounts of radionuclides, which were mainly deposited in Fukushima Prefecture. Post-Chernobyl accident studies on damage to cultural property were surveyed, but any contributions were not found. To ascertain the extent of radiation damage and to study decontamination techniques, further study on measures to prevent/mitigate radiation damage to cultural properties was necessary.

From 2012-2013, the Tokyo National Research Institute for Cultural Properties (TOBUNKEN) conducted a Study of Measures to Prevent/Mitigate Radiation Damage to Cultural Properties in conjunction with the National Institutes for Cultural Heritage, the National Museum of Art, the Japanese Council of Art Museums, the Fukushima Prefectural Board of Education, and museums in Fukushima Prefecture. The documents "Risk Management for Museums: Focusing on Dealing with Cultural Objects Contaminated by Radioactive Dust-(June 24, 2013 draft) and Basic Concepts of Decontamination for Cultural Properties (Feb. 10, 2014 draft) were compiled as a result.

This document includes emergency response and usual mitigation measures to radioactive iodide and cesium disaster. Measuring techniques and criterion for transporting surface contaminated objects are also noted. Basic concept of decontamination procedures for cultural properties is defined. Although such an accident is unlikely to ever occur again, measures to safeguard cultural properties must be established as part of crisis management.

We hope that this document is beneficial to the improvement of risk management method of all museums.

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on Measures to Prevent/Mitigate Radiation Damage to Cultural Properties
(At that time of Deputy Director General of TOBUNKEN)

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1. Preface

Cultural properties are essential to understanding of Japanese history and culture, and these are also public property that constitutes the basis for cultural advances in the future. Preserving cultural properties means preserving form and their value as objects to be appreciated. The exhibition of these properties provides new value and fosters creativity.

The Tohoku Earthquake and Resulting Tsunami that struck on March 11, 2011 caused a loss of power. This in turn caused a hydrogen explosion in reactors 1-4 at the Fukushima Daiichi nuclear power plant. Fission products from the plant contaminated eastern Japan. A nuclear reactor accident and leakage of radionuclides from a facility handling radionuclides are not supposed to occur. Since there is no previous study of handling cultural properties under the contaminated area, we learned that gaseous iodine-131 and dusts contaminated by radioactive cesium-134 and cesium-137 (denoted here as “radioactive dust”) can be generated soon after such an accident amidst the chaos following the unforeseen accident in Fukushima. This Document summarizes ways to protect cultural properties in the event that the outside of a museum is contaminated by radionuclides from a nuclear power plant reactor. This Document also summarizes ways to ensure the safety of visitors and museum staff.

2. Points that warrant attention when formulating a disaster preparedness plan

Facts assumed: Leakage of radioactive material into the atmosphere and radioactive fallout

Applicable period: From the early days following the disaster until the amount of radioactive dust is reduced

Radioactive material leaks into the atmosphere as a result of an accident, and this material is dispersed by air currents as a gas or as particles adhering to dust. Dust in the atmosphere forms the nucleus of raindrops when rain falls, so the material falls to the ground and deposits in soil.

An evacuation plan for such an accident differs considerably from a response to an earthquake or fire. For the former, two major differences are that : steps are taken to avoid taking in outside air in order to lessen the impact on cultural properties ; the need for an evacuation plan to reduce the level of radiation that people are initially exposed to.

Accident involving leakage of radioactive material

Verified with public info

Place, distance, scale

Evacuation policy, determining whether to accept evacuees

⇩

Steps to protect cultural properties

Closing openings such as windows and doors

Stopping the intake of outside air with air conditioning

Steps to protect visitors and personnel

Explanation of the evacuation policy to visitors and workers, guests and incoming evacuees

3. Sample: crisis management form (in principle, the response is the same as that to some other type of disaster)

Facts assumed	Leakage of radioactive material into the atmosphere and radioactive fallout
Applicable period	From the early days following the disaster until the amount of radioactive dust is reduced

1. Establishment of a headquarters for disaster response

(1) Predicated on a system based on a firefighting plan. Personnel in charge of air conditioning or a representative of a company contracted for air conditioning are added.

(2) After establishment of the headquarters for disaster response, the activities of a firefighting team or organization are supported and overseen based on a firefighting plan.

2. Notification

(1) The head of the headquarters for disaster response or a representative delivers an initial report to personnel that includes a report, if there is one, from the firefighting team.

(2) Once the general situation is apparent, a second report is issued.

(3) A report is issued when circumstances change or every 2 hrs.

(4) Information in announcements for people other than personnel, and particularly an unspecified number of visitors, will be fully compiled and then disseminated to avoid unnecessary confusion.

3. Gathering and conveying of information

(1) The information supervisor in the headquarters for disaster response will determine the status of individual departments. The number of museum visitors will be ascertained by each of these departments and that information will be conveyed to the information supervisor.

(2) Gathered information will be reported to the head of the headquarters for disaster response via the headquarters for disaster response.

(3) The information supervisor will promptly inform individual departments of decisions made by the headquarters for disaster response.

(4) Steps to deal with people who will have difficulty returning home will be in accordance with steps to deal with "Suspension of Public Transportation Services."

(5) In addition to the usual methods, the following methods will be used to perform safety checks and contact relevant parties.

*Public phones *Automated phone messages for disaster-related information ("171" service)

*Mobile phone-based "Message boards for disaster-related information"

*Contact between individuals such as mail, Line, etc. *Social networking services such as Twitter

4. Responses to sudden events

(1) Organizations with the closest link to arising events will respond as the organization in charge.

(2) If the organization in charge is not apparent, the headquarters for disaster response will respond as the organization in charge.

(3) Instructions will be sought from the headquarters for disaster response for responses to other events.

If, however, events are urgent, then senior personnel on-site will respond accordingly.

5. Other

A system for cooperation should be established to conduct rescue efforts in concert with related organizations such as museums, universities, experts-working company and a fire department.

4. Manual for actions by personnel

4-1. Responses to a typical disaster:

Measures to deal with radioactive dust are the same as usual measures to deal with dust

Disaster envisioned	Disaster response
Accident involving leakage of radioactive material	・Methods of stopping air intake will be publicized so that the intake of outside air can be stopped. ・Doors without cracks when closed will be installed to reduce the amount of dust brought into the museum. An effective approach is to install air curtains above openings. ・In anticipation of radioactive dust being brought in by shoes, doormats will be laid out and periodically vacuumed or washed with water. ・Entrance halls will be vacuumed daily. ・Necessary items such as dust masks, gloves, shoe covers, and crack sealing tape will always be on hand. ・On days when the radiation level rises, the intake of outside air will be stopped as a precaution and openings will be closed.

4-2. Responses in the event of exigent circumstances

(1) Initial action: Roles will be determined beforehand.

(2) Actions in the event of an accident involving the leakage of radioactive material

***Measures to reduce levels of radiation exposure in order to avoid health hazards**

Masks that can completely remove radioactive iodine are not typically available commercially, so in the event of a nuclear reactor accident, for example, trips outside will not be permitted except in an emergency in order to reduce initial internal exposure to radiation. Air conditioning will be used to stop the intake of outside air.

When a disaster occurs, art museums and museums in the projected disaster zone or art museums and museums damaged by the disaster will consider closing. In the event of a disaster, information will be announced to visitors and guests. If there are no issues with building strength or ventilation, then temporarily seeking refuge inside the museum is recommended. When approving a return plan for people wishing to return home, that plan will be examined from the perspective of Preventing Health Hazards due to Inhalation of Atmospheric Pollution in the Form of Highly Concentrated Radioactive Material.

When clouds containing radioactive dust are nearby, efforts will be made to avoid contact with rain as a measure to deal with radioactive dust. Otherwise, a disposable raincoat will be worn and taken off prior to entering the building. Removed raincoats will be placed in a plastic bag. The bag will be sealed and placed outdoors to prevent dust from scattering once it has dried.

Accepting people who will have difficulty returning home differs from the response to other types of disasters. A temporary intake for visitors will be determined beforehand to Prevent Health Hazards due to Inhalation of Highly Concentrated Radioactive Material in the Air.

When seeking refuge indoors, coats should be removed to prevent contamination of the inside of the facility. Removed coats will be placed in a plastic bag and the bag will be sealed to prevent dust from becoming airborne again. In the event of cold weather requiring a coat, a dust mask will be worn and dust deposited on the outside of the coat will be removed with adhesive tape. An effective approach is to remove dust via laundering.

***Measures to reduce radiation doses in order to avoid contamination of cultural properties**

Openings such as entrances and exits and windows will be sealed to the extent possible. Completely preventing the entry of gaseous radioactive material is difficult, but the amount of that material entering the building can be reduced by sealing cracks with adhesive tape. Unused doors will be prepared to prevent radioactive dust from entering and cracks will also be sealed tightly as possible. Exposed exhibits will be covered with a material that does not hamper the absorption or desorption of moisture, such as tissue paper, to prevent radiation exposure and the deposition of dust will be prevented.

5. Other responses

In the event of a disaster, assessments must be made using measurements and remedial actions such as decontamination must be taken, the media needs to be informed, and explanations need to be given to visitors. The cooperation of an expert in radiation should be sought and responses should be considered.

<Annex I>

The Fukushima Daiichi nuclear power plant accident

"The Great East Japan Earthquake of March 11, 2011 resulted in a "severe accident" as a result of the fuel rods melt and hydrogen explosion at TEPCO's Fukushima Daiichi nuclear power plant (denoted here as the Fukushima Daiichi power plant) by energy power loss. This accident caused large quantities of radioactive material to become airborne and it caused contaminated water to flow into the ocean. The radioactive elements that constituted the bulk of the contamination were iodine-131 (half-life: about 8 days), cesium-134 (half-life: about 2 years), and cesium-137 (half-life: about 30 years). From June-July 2011, the Ministry of Education, Culture, Sports, Science, and Technology surveyed the amount of contamination deposited in the soil, and results of that survey indicated that roughly equal amounts of cesium-134 and cesium-137 were deposited. Thus, equal amounts of cesium-134 and cesium-137 were released by the power plant. On the International Nuclear Event Scale (INES), the accident was a level 7 (severe accident), the same as the Chernobyl incident in the former Soviet Union." (The Fukushima Daiichi Power Plant Accident and the 4 Accident Investigation Committees, Economic and Industrial Research Office, Issue Brief no.756, Aug/ 23, 2012)

Accident investigation committees were established by the Diet, government agencies, private organizations, and TEPCO to investigate the accident, determine its causes, and inspect the response. A government investigation of the accident, independent investigations of the accident, and TEPCO's investigation of the accident determined that the tsunami caused the loss of all AC and DC power sources, and the plant lost the ability to consistently cool the nuclear reactor. This was considered to be the direct cause of this massive accident (the core meltdown, hydrogen explosion, and dispersal of large amounts of radioactive material).

When radioactive material is released into the atmosphere, the effects of that contamination on cultural properties differ depending on if the radioactive elements fall to the ground or if they fall to the ground, where they are trapped by soil. Iodine is an element of the genus halogen and is less reactive than chlorine or bromine, but it reacts with silver and potentially produces a silver iodide. Iodine is barely soluble in water, so it spreads as a gas. Thus, blocking the flow of outside air into a building soon after iodine is released into the atmosphere is crucial to reducing its impact on cultural properties. The iodine from the Fukushima Daiichi nuclear power plant that entered the atmosphere was iodine-131. It has a short half-life of 8 days and it was spread over a wide area, so it had little potential to cause cultural properties to deteriorate. In contrast, cesium is an element of the genus alkaline earth metals and is highly reactive. It reacts with water while falling and is ultimately trapped in soil. Most of the amount of cesium-134 and cesium-137 from the Fukushima Daiichi nuclear power plant accident were trapped in soil, and there is no need to study the effects of their chemical properties on cultural properties. Dust does affect cultural properties, so steps must be taken to deal with its physical effects (e.g. fouling, wear, and changes in moisture absorption). The potential response to damage due to atmospheric release of radioactive material was not considered at all in terms of safeguarding cultural properties. Ultimately, the conclusion reached was to "take the same actions as when dealing with dust."

Diffusion of radioactive material

In the event of a nuclear power plant accident, the extent of contamination differs vastly depending on the extent of the accident, how far away a museum is from the nuclear power plant, and the wind direction and wind speed.

If a nuclear reactor accident causes radioactive material to enter the atmosphere, substances such as xenon and gaseous iodine will quickly spread. Then, substances such as cesium will adhere to liquid droplets and dust and waft into the atmosphere. Substances with a particle size larger than 2 μm will travel to different areas (radioactive dust) and settle depending on the distance. When suspended dust particles contaminated by radioactive material develop into clouds, they will fall as rain drops and locally contaminate the place where they fell.

Substances with a particle size smaller than 2 μm will remain in the atmosphere for a considerable time and travel around the earth. When loess (yellow sand) is carried mostly by the troposphere, it is known to circle the globe in 12-13 days. When a large explosion occurs and radioactive material passes through the tropopause (about 3,000m) and into the stratosphere, it has a half residence time of 0.3 of a year just above the tropopause, 0.7 of a year in the lower stratosphere (altitude of 21 km or lower), and 0.5 of a year in the upper stratosphere (altitude of 21 km or higher).

When an accident is accompanied by an explosion like a hydrogen explosion, contamination by radioactive dust can range further is the gas is more explosive. Thus, the initial evacuation guideline is determined based on distance. Where to seek shelter is determined with the wind direction and wind speed in mind. To the extent possible, reliable information is gathered in addition to information disseminated by the government.

At shorter distances, airborne particles contaminated by radioactive material are larger in size. Highly contaminated particles are produced, and contamination occurs locally in above-average levels.

Radioactive cesium strongly adsorbs to clay and it resides near the soil surface (about 5 cm from the surface). Thus, not bringing dust (soil) into a building is an effective way to avoid contamination in a museum.

Wearing a mask to avoid inhaling dust is an effective way to avoid internal exposure, and a dust mask with better ability to remove dust is more effective. A dust mask will not prevent gas inhalation, so refuge should be sought indoors while gaseous radioactive material is released.

An explanation of an action manual

I. The initial response phase

The initial response phase is the period from an accident until that accident is under control. Accidents can increase in severity, so this is the period in which to decide whether to evacuate a facility in the evacuation zone or to wait in a crack-free building.

Preserving human life, preventing injuries, and reducing the level of radiation exposure should take precedence over all operations.

When a disaster occurs, art museums and museums in the presumed fallout zone for radioactive dust will consider closing in order to prevent health hazards to visitors and personnel and to prevent contamination of cultural properties in exposed exhibits (including those indoors). Closing of the museum should be considered until the amount of radioactive dust in the atmosphere is reduced.

In non-urban areas with expanses of open ground, the amount of radioactive dust in the atmosphere will quickly decrease as that dust is absorbed by the ground, precluding that dust from becoming airborne again. In urban areas, however, "deposition and re-suspension" repeatedly occur, hampering the prediction of changes in the amount of radioactive dust in the atmosphere. If information on environmental monitoring (e.g. soil, water, and air) is released by a municipality, a period of museum closure will be considered based on that information. During the Fukushima Daiichi power plant accident, information on measurement of environmental radiation levels (drinking water and fallout) was announced by municipal departments measuring environmental radiation (in Tokyo, for example, the Tokyo Metropolitan Institute of Public Health). This allowed information on radioactive dust in the atmosphere to be obtained far quicker.

I-1. Steps to protect cultural properties

(1). In the event that the facility has to be evacuated

If possible, the following steps should be taken prior to evacuation in order to avoid bringing contamination into the museum.

a. Stopping the intake of outside air by air conditioning equipment. Otherwise, air conditioning equipment can be temporarily shut off. Once the levels of gaseous radioactive materials such as iodine have dropped, outside air can be taken in or equipment can resume operation.

b. Openings will be closed to prevent entry by dust contaminated by radioactive material.

c. Dust will be prevented by covering cultural properties with some material that does not hamper absorption or desorption of moisture, e.g. exposed exhibits will be covered with tissue paper. Shelf doors and box lids will also be closed. If time permits, paintings such as hanging scrolls will be rolled up and placed in storage boxes as far away from openings as possible.

(2). In the event that the facility does not need to be evacuated

Even if an accident is distant and emergency evacuation is not required, the museum will operate with the following points in mind until the accident has been controlled.

a. When the accident occurs, openings will be closed, and the intake of outside air by air conditioning equipment will be stopped.

b. Dust control mats will be diligently cleaned to prevent dust (soil) from being brought into the museum. The entrance hall will be cleaned to prevent dust from being spread into galleries. In the event that floor materials such as stone or flooring can be cleaned with a wet mop, they will be cleaned to avoid dust from being stirred up.

I-2. Steps to protect visitors and facility staff

Among the gaseous radioactive materials that are released into the atmosphere soon after an accident, the material that poses the biggest threat to human health iodine since it potentially concentrates in the thyroid gland. Action will be taken to identify an evacuation route and evacuation time so that unnecessary inhalation of large amounts of iodine can be avoided.

During evacuation, a mask will be worn to reduce the inhalation of dust and coat, hats, and gloves with smooth surfaces will be worn so that dust can easily be removed. Near the entrance of an evacuation site, clothing will be kept separate in a plastic bag except for clothing that may be contaminated with dust. This will allow the level of external exposure to radiation to be reduced. Another option is to don a plastic bag and to prevent dust from adhering to the head or body to the extent possible, but one drawback is that dust can readily adhere due to static electricity.

If evacuees must be taken in soon after an accident, they should remove their coats near the entrance and separate their clothing with plastic bags to the extent possible.

Even if an accident is distant and emergency evacuation is not necessary, preparations will be made in the event that suspended dust particles contaminated by radioactive material reach the museum in accordance with meteorological conditions. Information will continually be gathered, and a mask will be worn for protection to avoid internal exposure.

When operations need to be performed for facility management, such as cleaning, removing dust from, or restoring an exhibit, a dust mask will be worn to prevent internal exposure.

II. Recovery phase

The recovery phase is the period from when an accident is under control until a museum is essentially restored to its prior state.

In an area where evacuation is not required, the extent of contamination inside and outside of the building will be verified with the cooperation of an expert in properties of radioactive material so that normal operations can promptly resume. If necessary, decontamination of the facility will proceed and gloves, masks, and materials used in decontamination will be managed as waste.

In an area where evacuation is required, worker safety will be emphasized in accordance with instructions from the government, and the timing for recovery work to start will be considered.

A preliminary investigation must be conducted so that safe operations are performed, necessary actions and their effectiveness are determined, and operations are performed in the appropriate amounts and locations. This is true regardless of the where the facility is and regardless of whether operations are repairing the facility or enhancing it. To that end, radiation levels will be verified and requirements for worker protection will be identified.

An NaI (Tl) scintillation detector (with an energy-compensated Geiger–Müller tube) will be used to gauge the effect of radiation on humans (ambient dose rate) and a Geiger–Müller counter will be used to test the exterior of cultural properties or a cultural facility for contamination (surface density). The probe of either device will be covered with plastic wrap or a plastic bag to prevent contamination, and the probe will promptly be replaced if it is potentially contaminated. Based on the Calibration of Radiation Detectors and Radiation Counters on the Ministry of Economy, Trade, and Industry website, both devices will be appropriately calibrated once a year, in principle, and reliable devices will be used.

At a site where the ambient dose rate exceeds 2.5 μSv/h, the site will be managed (dose management and recording) and personnel will be managed (training and drills, health examinations, and management and recording of individual levels of radiation exposure) in accordance with the Guidelines for Prevention of Radiation Hazards for Workers Engaged in Operations with Specified Exposure Levels (Notification no. 0615-6 dated June 15, 2012, denoted here as the Guidelines for Operations with Specified Exposure Levels).

If operations continue at a site where the ambient dose rate one-tenth of 2.5 μSv/h, the site should be managed in accordance with the Guidelines for Operations with Specified Exposure Levels.

If worker protection is required, radiation doses will be managed and gloves and masks will be used.
Plastic sheets and shoe covers will be used appropriately to prevent the spread of contamination.

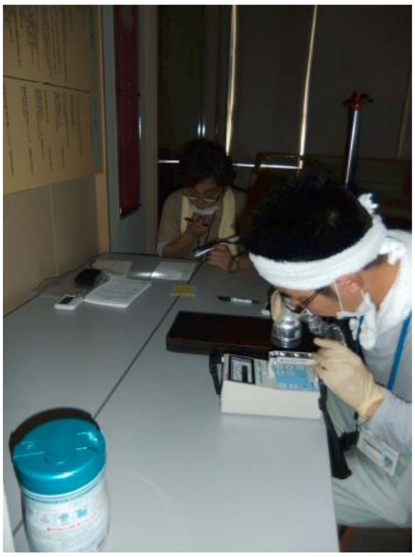
・**Methods of ensuring worker safety**

a. A calibrated NaI(Tl) scintillation detector (with an energy-compensated Geiger–Müller tube) will be used.
b. The probe will be held parallel to the floor at a height of about 1 m.
c. Routes that people travel will be tested.
d. A time constant of 3 sec. will be set and the probe will be oriented sideways and held firm at a height of 50 cm from the ground. Radiation will then slowly be detected.
e. In places with apparently higher radiation, further testing will be done with a time constant of 10 sec. Readings will be read at 30-sec. intervals 3-10 times, and results will be recorded.
f. Radiation will be verified to not exceed 2.5μSv/h.
g. If radiation exceeds 2.5 μSv/h, the site will be managed in accordance with the Guidelines for Operations with Specified Exposure Levels.

Fig. NaI(Tl) scintillation detector (with an energy-compensated Geiger–Müller tube)

・**Methods of testing cultural properties and facilities for surface contamination**

a. A calibrated Geiger–Müller counter will be used.
b. The probe will be pointed in the direction of the object being tested. An object will be tested for radiation about 1 cm from its surface.
c. A time constant of 3 sec. will be set and the probe will be moved at a speed of 3cm/sec. to verify that the site is not contaminated site.
d. In places where the needle fluctuates widely, a time constant of 10 sec. will be set and the probe will be moved at a speed of 1 cm/ sec. to locate contamination.
e. Sites of contamination will be tested for radiation at 30-sec. intervals 3-10 times, and the results will be recorded.



Figs. L.: Geiger–Müller counter R.: Testing for surface contamination

・**Methods of identifying contamination in areas with high levels of background radiation**

If the readings increase as the probe nears the exterior of cultural properties or a cultural facility, the object being tested is contaminated with radioactive material. If the readings decrease as the probe nears the exterior of cultural properties or a cultural facility, the readings are heavily affected by radiation from the surroundings and the object being tested is not considered to be contaminated.

II-1. Steps to protect cultural properties

If a facility is inspected and contamination is noted, the site will be vacuumed and decontaminated prior to operations. If the site cannot be decontaminated, the site will be enclosed with plastic sheets and clearly identified as a contaminated area. Steps will be taken to reduce external and internal exposure for workers.

(1) Routes of contamination in concrete buildings with relatively limited ventilation

If a cultural facility is equipped with filters that have moderate or better performance, the route of contamination is via openings, via portions of the facility that were damaged by an earthquake, or via soil brought in people.

Plastic sheets will be laid out in potentially contaminated areas near the entrance and action will be taken to prevent the spread of contamination.

The facility will be tested for surface contamination in accordance with the Methods of Testing Cultural Properties and Facilities for Surface Contamination as are described later, contamination will be located. If contamination of the facility is noted, the exterior of the facility will be decontaminated using appropriate methods.

(2) Routes of contamination in homes and facilities with good ventilation

There is a potential for dust containing radioactive contaminants to enter a building from the outside depending on distance. This is primarily true of areas near openings.

During a preliminary investigation, thin plastic sheets will be laid on the floor surface to prevent the spread of contamination upon entry. The air dose will be verified in accordance with the Methods of Ensuring Worker Safety. Coverage by sheets will gradually be expanded and the air dose in the facility as a whole will be determined. In places where the dose exceeds 2.5 μSv/h, a determination will be made as to whether or not to perform "operations with specified exposure levels."

The facility will then be tested for surface contamination in accordance with the Methods of Testing Cultural Properties and Facilities for Surface Contamination, contamination will be located. If contamination is noted, the exterior of the facility will be decontaminated using appropriate methods.

If contamination of cultural properties is noted, those properties will be covered with tissue paper and stored in a separate area to prevent the spread of contamination.

(3) Responses for facilities that are found to be contaminated

An expert in handling radioactive material will be consulted and operations will proceed.

Radioactive contaminants that have been deposited as dust will be removed. Workers will be protected with a dust mask and gloves, and dust removal work will proceed with the following points in mind.

a. Avoid enlarging the contaminated site (hasty wiping with a damp cloth will not be done)

b. Decontaminate facilities before contamination becomes a problem

c. Decontamination work will be done by multiple individuals

d. The amount, status, and extent of contamination will be ascertained with the following points in mind.

  (i) Which materials are contaminated, and the state of their surface

  (ii) Identification of a contaminated site

  (iii) Determination of the type and amount of contaminating nuclides

e. The following approaches will be attempted, starting with the least aggressive. (*not recommended after wiping with a damp cloth)

  Vacuuming→Wiping with a damp cloth→Wiping with a warm, damp cloth

  →For WAX, WAX eluate (highly alkaline)→acid wash→Scraping

f. Materials used in decontamination will be managed appropriately in accordance with the extent of contamination.

(4) Operations to deal with cultural properties (including movement of those items) that are or may be contaminated with radioactive material

When cultural properties that are potentially contaminated with radioactive material are to be entrusted to another facility or placed in temporary storage, the Industrial Safety and Health Act will be followed to protect workers during the movement of those properties. A rescue plan will also be devised. In addition, the concept of "limits on surface contamination density" in the Act concerning Prevention of Radiation Hazards due to Radioisotopes (this Act came into effect prior to March 11, 2011) will also apply so that radioactive material is not spread indiscriminately. The limit on the density of surface contamination (when beta rays or gamma rays are released) is 40 Bq/cm^2. In principle, objects with surface contamination exceeding one-tenth of that limit, i.e. 4 Bq/cm^2, will not be moved. During the Fukushima Daiichi nuclear power plant accident in 2011, cesium-134 and cesium-137 were released into the atmosphere, and these radionuclides are absorbed into the soil where they remain for a long period. Since the ratio of the amounts of cesium-134 and cesium-137 was known, the standard value of surface contamination density was converted into 1,300 cpm or lower (including background radiation) at that time. This level was read using a Geiger–Müller counter with a tube having a diameter of about 50 mm.

The count will be derived statistically in accordance with the Methods of Testing Cultural Properties and Facilities for Surface Contamination. If the value obtained by subtracting the background radiation count from the count for the exterior of a cultural property clearly exceeds the suggested levels mentioned earlier (beyond the margin of error), the cultural property is considered to be "contaminated by radioactive material."

A thorough preliminary investigation will be conducted when cultural properties that are potentially contaminated with radioactive material are to be moved, e.g. entrusted to another facility or placed in temporary storage. Efforts will be made to avoid contamination of the storage site. When a temporary storage site is used, the background radiation at the facility will be measured beforehand in order to quell harmful rumors that bringing in cultural properties caused contamination of the facility. Surface contamination will be measured and recorded before and after properties are brought in.

Before cultural properties are moved, surface contamination will be verified to not exceed the suggested levels mentioned earlier. When cultural properties are accepted, they may have been damaged by mold or pests, so they will not be immediately brought into the museum's repository. Instead, they will be temporarily stored in a separate locked area and their condition will be assessed. If damage from mold or pests appears to be worsening, it will be dealt with promptly using appropriate methods.

Storage in such a location may not feasible in terms of disaster or theft prevention, e.g. the building appears ready to collapse. In such an event, cultural properties with surface contamination exceeding 1/10 of the limit on surface contamination can be temporarily entrusted to another facility. When that occurs, the ambient dose at the site will be determined and thorough planning will be done and thorough preparations will be made so that work can conclude in the shortest amount of time possible to reduce health hazards. While working, workers will wear a dust mask, gloves, shoe covers, and protective coveralls (e.g. hooded overalls that radioactive dust cannot readily adhere to). When rescuing cultural properties, those properties will be covered with tissue paper so that radioactive dust does not become airborne again. They will then be packaged in bubble wrap and transported to a temporary storage facility.

If cultural properties that may be highly contaminated will be temporarily stored in a location where the ambient dose rate in the surrounding area exceeds 1/10 of 2.5 μSv/h, those properties will be temporarily stored in a clearly demarcated area separate from other cultural properties. A location that can be locked and that has a floor with a smooth surface (e.g. vinyl flooring) will be provided. Cultural properties will be packaged in bubble wrap for transportation, and after transportation that bubble wrap will be removed to reduce the risk of damage from mold. Cultural properties will be left covered in tissue paper that absorbs or desorbs moisture to prevent radioactive dust from becoming airborne. Once properties are at a site with relatively low radiation levels, surface contamination will be measured and recorded.

An expert in radiation will be consulted, and necessary steps will be taken with regard to measurement frequency, record management, management of worker health, creation of personnel rosters, and retention of those roster.

When decontamination is necessary for public health, necessary steps will be taken in accordance with the Basic Concepts for Decontamination of Cultural Properties as described later. In principle, decontamination procedures up to dust removal will be performed. If surface contamination is above the suggested level, time will be allowed to pass so that the radiation dose decreases.

(5) Working in areas with somewhat high levels of radiation

In areas with somewhat high radiation levels, radioactive dust can settle on cultural properties and use of water can presumably cause that dust to spread or be absorbed by those cultural properties. Thorough preparations will be made to reduce external exposure and a plan will be devised to minimize the time spent working in areas with somewhat high levels of radiation.

If cultural properties can be moved, the priority is to move them out of an area with high radiation levels, and decontamination in such an area should be avoided to the extent possible. When moving cultural properties, information on the materials and techniques used to create those items and their structure should be gathered beforehand. A system will be established so that cultural properties can be promptly transported without damaging them to the extent possible. In a safe location, the following aspects will be verified and subsequent operations will be determined.

If cultural properties cannot be moved (e.g. radiation levels in the surrounding area remain high despite decontamination work), quantitatively assessing the effectiveness of decontamination may not be possible. When determining the effect of radioactive dust on cultural objects, decontamination should not be performed in order to prevent health hazards if the objects are not markedly degrading.

II-2. Steps to protect workers and visitors

(1) Protecting workers during the restoration of exhibits

The amount of external radiation entering a facility will differ depending on the extent of contamination by radioactive dust in accordance with the level of air circulating into or out of the facility and shielding in the facility.

Steps will be taken to reduce internal and external exposure, gloves and a dust mask will be worn to internal exposure, and a hood will be work to prevent dust from adhering to hair on the head. If necessary, shoe covers will be used. Recovery efforts will proceed safely while preventing the spread of contamination.

In some indoor work areas, the ambient dose rate may not exceed 2.5 μSv/h, but it may exceed 1/10 of that value. In such areas, the cumulative dose may increase as work is performed daily. Thus, the site and personnel should be managed in compliance with “operations with specified exposure levels,” although this is not mandatory.

(2) Criteria for when to start the intake of outside air

The intake of outside air should resume once dust contaminated by radioactive material is no longer detected in the atmosphere. Indices for that detection will be Dust Monitoring measurements made by the government and highly accurate measurements of the level of contamination of tap water.

(3) Criteria for when to resume exhibition

A museum will reopen to the public once the dose no longer exceeds 2.5 μSv/h in all places accessible to visitors and barriers are erected to demarcate areas that are off-limits to visitors.

Otherwise, a museum will reopen to the public once the dose is verified to be at or below that level based on instructions from the government.

In locations where fine dust can easily accumulate (such as drainage ditches, culverts, and at the foot of a mountain), radiation levels may repeated increase, so monitoring should be performed once a month to determine the effects of that dust on humans. Monitoring will be performed in accordance with the Methods of Ensuring Worker Safety, and the safety of workers and visitors will be ensured.

III. Daily preparations

Facilities should meet the following requirements to provide an environment clean of radiation.

(1) Strength and load-bearing capacity so as not to collapse in an earthquake

(2) Heavy shielding materials and walls with sufficient thickness

(3) Geographic conditions precluding flooding

(4) A building with no water leaks

(5) Clean air can be supplied through fine filters with moderate or better performance

(6) A windbreak is installed to prevent dust from being carried in through openings, and a downdraft is created through the installation of air curtains.

To prevent the entry of dust, doors, windows, and all openings that connect with the outside should be sealed with crack sealing tape, masking tape, and so on. This will help to maintain a consistent humidity/temperature and help to prevent entry by pests. This will in turn improve overall conditions for the preservation of cultural properties.

Time is a factor in the event of evacuation in an emergency, so cultural properties will not ordinary be left exposed to the air in order to prevent unnecessary fouling by dust. Hanging scrolls will be rolled up and placed in storage boxes, closable shelf doors will be closed, and cultural properties will be stored in their original locations, e.g. a repository or cabinet. Such daily management is crucial.

In order to protect cultural properties from radioactive contaminants, the equipment and structure of a cultural facility must be upgraded. The cleanliness of a facility must also be improved to prevent the entry of dust. Periodic monitoring is required and lecture course with training are needed to allow an organizational response in the event of an emergency.

Knowledge about the handling of radioactive material differs vastly from that normally required of a curator, so opportunities should be provided for curators to supplement their knowledge through training.

III-1. Measuring a facility’s background radiation

The earth is bathed in radiation from space, and there are places on the earth’s surface where radioactive materials are found depending on geology. Measurements can be obtained regardless of where radiation is measured. Whether or not a museum is contaminated by radioactive contaminants cannot be determined without knowing what the state of surface contamination was prior to an accident. Radiation levels must also be measured during normal operations in order to dispel harmful rumors.

The amount of cosmic radiation is known to fluctuate to an extent, and background radiation at a facility need to be measured frequently, if possible.

III-2. Methods of testing cultural properties and facilities housing those items for surface radiation

(1) A calibrated Geiger–Müller counter will be used.

(2) Point the probe in the direction of the object being tested.

(3) Measurement sites will be determined for each type of structural material used in a facility.

(4) A time constant of 30 sec. will be used to test for radiation in 90-sec. intervals 3-10 times, and the results will be recorded at points with low radiation dose.

There is a risk of jarring the probe when measuring the surface contamination on cultural properties, so measurements need not be repeated except when necessary.

The determination of whether or not radiation is given off by cultural properties is based on whether or not the count increases when the probe is placed nearby.

Museums and natural history museums with ore containing uranium in their collections should manage those collections themselves based on the Safety Guidelines for Materials and Products Containing Uranium or Thorium (June 26, 2009, Ministry of Education, Culture, Sports, Science, and Technology). In some instances, luminous paint containing radium has been used on WWII-era aircraft instruments for night flying, dials on transformers, and watch dials. If those materials are present, the air dose should be measured to ensure the safety of workers and visitors. An expert should aldo be consulted and appropriate steps should be taken.

III-3. Steps to reduce dust

Dust can be contaminated by radioactive contaminants, but its intrinsic threat is that it can cause cultural properties to degrade. Dust fouls the exterior of cultural properties and it chemically damages cultural properties as a result of the mold spores, atmospheric contaminants, and particles of sea salt it brings in. Dust is a factor that can exacerbate biodeterioration. Dust should be viewed as a potential cause of degradation. In addition, the following approaches are effective ways to reduce the risk of degradation caused by dust.

(1) Near entrances and entrance halls

Installation of a windbreak. Modifications will be made so that doors are not opened simultaneously (allowing dust in).

Installation of dust control mats. Or use of a sticky floor wax.

Periodic cleaning. An effective approach is use of a wet mop.

(2) In galleries

Important materials will be exhibited in display cases to prevent dust.

Gallery floors will be cleaned daily. Vacuuming is an effective way to do this.

(3) In repositories

Changing into slippers.

Removal of dust and cleaning of shelves and floors, health management.

Dust will be prevented by storing important materials in storage cases.

Vacuuming of outer cases before bringing materials in.

(4) Treatment of materials

Dust will be removed from important materials by a restorer.

(5) Ensuring the cleanliness of cultural facilities

Installation of medium-performance or high-performance (HEPA) filters and periodic replacement.

(6) Monitoring techniques

Measurement of dust concentrations.

Testing for airborne microbes.

The amount of adhering microbes will be determined using a sampling technique that does not leave nutrients behind in a repository (e.g. use of cotton swabs).

(7) Training and education will be provided with regard to managing facility cleanliness

For more information

Environmental monitoring information and information on correct use of measuring equipment is featured on the websites of the following agencies/organizations in Japan. (in Japanese)

Ministry of Education, Culture, Sports, Science, and Technology

Ministry of Economy, Trade, and Industry

Ministry of Health, Labor, and Welfare

Ministry of Agriculture, Forestry, and Fisheries

Ministry of Land, Infrastructure, Transport, and Tourism

Japanese Society of Radiation Safety Management

Japan Society of Nuclear and Radiochemical Sciences

Japan Radioisotope Association

Japan Radiological Society

Japanese Society of Radiological Technology

Radiation Effects Research Foundation (cooperative Japan-US research organization)

Center for the Promotion of Disarmament Non-Proliferation, Japan Institute of International Affairs Has CTBT monitoring data from Takasaki

Tokyo Metropolitan Institute of Public Health as well as institutes involved in public health in each prefecture

Home pages of local governments

<Annex II>
Rules and regulations on radiation in Japan

- Ordinance on Prevention of Ionizing Radiation Hazards (the “Ionizing Radiation Ordinance,” Ministry of Labor Ordinance no. 41 of 1972) and Regulation 1015 of the National Personnel Authority (Preventing Radiation Hazards to Personnel)

In order to protect workers, the Ionizing Radiation Ordinance specifies the following.

(1) Areas where radiation levels exceed 1.3 mSv in 3 months must be managed as controlled areas, and efforts must be made to reduce levels of radiation exposure.

(2) If the level of radiation exposure is anticipated to exceed 1/10 of the baseline for a controlled area, individual levels of radiation exposure must be measured and managed.

The Act concerning Prevention of Radiation Hazards due to Radioisotopes manages areas where radioactive material is brought in. If an individual will be exposed to a radioisotope for 24 hours straight, then the hourly dose should be 0.6 μSv/h. In the Ionizing Radiation Ordinance, however, the dose differs. There, if an individual will be exposed while working a 40-hour week, then the hourly dose should be 2.5 μSv/h.

- Guidelines for Prevention of Radiation Hazards for Workers Engaged in Operations with Specified Exposure Levels (Notification no. 0615-6 dated June 15, 2012)

Special decontamination areas and areas surveyed for heavy contamination are specified in accordance with the Act on Special Measures concerning the Handling of Environmental Pollution by Radioactive Material. The Guidelines for Prevention of Radiation Hazards refer to operations besides decontamination at sites in the aforementioned areas where the average ambient dose rate exceeds 2.5 μSv/h. If the average ambient dose rate in indoor work areas is 2.5 μSv/h or lower, then those operations are not considered operations with specified exposure levels even if the average air dose outdoors exceeds 2.5 μSv/h. When simply passing through areas where the average ambient dose rate exceeds 2.5 μSv/h, the spent in those areas is limited, so such travel is not considered an operation with a specified exposure level.

- Ordinance on Preventing Ionizing Radiation Hazards in Decontamination (Ministry of Health, Labor, and Welfare Ordinance no. 152 of 2011, revised April 12, 2013, Ministry of Health, Labor, and Welfare)
- Guidelines on Decontamination Procedures (2nd ed., May 2013, Ministry of the Environment)
- Ordinance on Prevention of Ionizing Radiation Hazards in Operations to Decontaminate Soil Contaminated by Radioactive Material Generated as a Result of the Great East Japan Earthquake (Notification 0615-6 dated June 15, 2012, Ministry of Health, Labor, and Welfare)
- Guidelines on Preventing Radiation Hazards for Workers Engaged in Decontamination and Other Operations (Notification 0615-6 dated June 15, 2012, Ministry of Health, Labor, and Welfare)
- Guidelines for Dealing with Local Sites Contaminated with Radioactive Material (March 2012, revised April 2013, Ministry of the Environment)
- Policies for Decontamination of Special Decontamination Areas (Decontamination Plan)(Jan. 26, 2012, Ministry of the Environment)
- Guidelines on Waste March 2013 2nd ed. (March 2013, Ministry of the Environment)

- Guidelines on Preventing Radiation Hazards for Workers Engaged in Disposal of Waste from the Fukushima Nuclear Accident (Notification no. 0412-2 dated April 12, 2013, Ministry of Health, Labor, and Welfare)
- Act on Special Measures concerning the Handling of Environmental Pollution by Radioactive Material Released by the Nuclear Power Plant Accident Associated with the Tohoku Earthquake and Tsunami of March 11, 2012 (Law no. 80, Aug. 30, 2011)
- Basic Policies regarding the Act on Special Measures concerning the Handling of Environmental Pollution by Radioactive Material Released by the Nuclear Power Plant Accident Associated with the Tohoku Earthquake and Tsunami of March 11, 2012 (Nov. 11, 2011, Ministry of the Environment)

Qualifications identifying experts on radiation

- Supervisor of Radiation Protection
- Class 1 Workplace Assessor (Radiation)
- Persons with knowledge and skills commensurate with the above

Sources of information on radiation monitoring

The following information has been available to the public following the Fukushima Daiichi nuclear power plant accident. Initially, this information was provided separately on the websites of the Ministry of Economy, Trade, and Industry, the Ministry of Health, Labor, and Welfare, the Ministry of Land, Infrastructure, Transport, and Tourism, the Ministry of Internal Affairs and Communications, and the Prime Minister and his Cabinet for different reasons. Ultimately, this information is now provided on the website of the Ministry of Education, Culture, Sports, Science, and Technology.

	Sources of information	
State of extensive soil contamination	Monitoring with aircraft	Indicates the distribution of the ambient dose rate on the ground and at a height 1 m above the ground based on monitoring results obtained by helicopter.
Contamination of surrounding soil	Map of contaminant concentrations in soil	A germanium semiconductor detector is used to perform a nuclide analysis of soil.
Extent of contamination of surrounding roadways	Assesses the effects on vehicles traveling on national roads	Estimates the level of radiation exposure for vehicles traveling on and traversing roads.
Potential air dose	Monitoring posts (measurements of environmental radiation levels)	Summarizes measurements of the ambient dose rate at fixed monitoring posts (average for 9-10 AM on the previous day).
	Measurements from a system measuring doses in real time	Measurements from fixed sites are updated every 10 min. A site can be chosen and daily, weekly, and monthly changes can be

		verified graphically. Results from portable measuring devices are also included.
	Readings of the ambient dose rate from portable survey meters	Summarizes measurements of the ambient dose rate at a height 1 m above the ground based on reports from prefectural and city governments.
State of air pollution	Monitoring of fallout (measurement of environmental radiation levels)	Samples are obtained with a precipitation sampler and nuclide analysis is performed with a germanium semiconductor detector. Sampling times differ depending on conditions.
	Dust sampling	Air is filtered and dust is collected from the filter to measure the surface density and dose rate. Results are indicated along with the results of nuclide analysis.

Facility inspections following a disaster

A summary is presented below.

	Measurement	Remedial actions such as decontamination
Indoors	The ambient dose rate will be measured with a scintillation detector to assess the impact on human health. Surface contamination will be measured with a Geiger–Müller counter.	Decontamination will be performed based on numerical standards that provide an index of contamination (such as the ambient dose rate as stipulated by the Ministry of Education, Culture, Sports, Science, and Technology) as well as standards indicated by official bodies.
Facility surroundings	The ambient dose rate will be measured with a scintillation detector to assess the impact on human health. Surface contamination will be measured with a Geiger–Müller counter.	Decontamination will be performed based on numerical standards that provide an index of contamination (such as the ambient dose rate as stipulated by the Ministry of Education, Culture, Sports, Science, and Technology) as well as standards indicated by official bodies.
Frequency of inspections	Soon after a disaster, inspections should be performed about once a week. When measurements are made outdoors, a mask will be worn as a precaution.	If a site is found to have a level exceeding 10 μSv/h, area will be clearly demarcated, and the views of an expert will be solicited. Decontamination will then be performed. Contaminants may accumulate in some places depending on the flow of water, so decontamination may need to be performed every few months, e.g. after a rain.

***Types of gloves and their use**

Once radioactive dust gets under the fingernails, it is hard to remove. Ultimately, this can increase the risk of internal exposure. Gloves should be worn to prevent the adherence of dust.

Gloves made of coarser material are uncomfortable, so they should not be used when handling cultural properties. Use of gloves is effective in terms of reducing adherence of radioactive dust to the fingers when cleaning or decontaminating a facility.

Type of gloves	Reduction of the impact of radioactive dust on human health	Handling of cultural properties
Powder-free latex	The potential for external exposure can readily be avoided simply by removing gloves, providing they are not ripped. Dust will not adhere to the skin so the potential for internal exposure can be reduced.	More comfortable to wear than other gloves. Little potential for cultural properties to be dropped or slip. If cotton gloves are worn inside, they can absorb sweat, so properties can be handled safely.
White cotton gloves	The potential for external exposure can readily be avoided simply by removing gloves. Dust will not adhere to the skin so the potential for internal exposure can be reduced.	Not comfortable, so there is a potential for cultural properties to be dropped.
Cotton work gloves	Coarse mesh, so radioactive dust particles may get under the fingernails. Thus, there is a potential for external exposure.	Coarse mesh, so there is a potential for gloves to get caught on the exterior of cultural properties and damage those properties. There are limitations on which types of cultural properties these gloves can be used to handle.
No gloves	Once dust gets under the fingernails, it is quite difficult to remove, so there is a potential for external exposure. Dust can readily enter the mouth, so there is also an increased potential for internal exposure.	If the hands are washed thoroughly, properties can reliably be handled with dry hands. The hands secrete salt in sweat as well as amino acids, glucose, and organic acids, so caution is required.

***Use of masks**

Using masks is recommended to reduce internal exposure. Disposable masks are recommended. If possible, a mask should be replaced before and after meals.

Various types of masks are commercially available. The risk of internal exposure can be reduced by wearing a mask more so than not wearing one.

Whether or not a mask with high dust-filtering performance is required should be determined based on the work being done and the distance from dust-generating areas.

Typically, a mask with better dust removal performance produces more inhalation resistance and is thus not suited to more demanding work.

Masks are in contact with the skin for long periods. They can also become stuffy and cause inflammation of the skin. A potential solution to this problem is to have several types of masks available.

Mask type	Dust filtration efficiency, breathability, cost, etc.
Procedural mask	A mask with a 3-ply structure that can filter out 95% of 2.8-μm dust. Masks with a high PFE should be chosen. Has relatively good breathability. Stuffy.
Dust & pollen mask	Incorporates a special filter in unwoven cloth to filter out particles smaller than pollen. Masks that conform to the face need to be chosen. Has relatively good breathability. Stuffy.
Surgical mask	Masks with a high PFE should be chosen.
Mask with an activated charcoal filter	A mask to remove gaseous or volatile chemical substances. Masks with an indicated dust removal rate should be chosen. Little potential for iodine removal.
DS2/N95 dust mask	Inhalation and exhalation resistance, can cause breathing discomfort. Masks that conform to the face should be chosen. Stuffy.
Asbestos-rated respirator	Typically, this respirator has a high inhalation resistance and is thus not recommended.
Vilene nonwoven fabric mask	This mask is considered to have the same performance as about 30 sheets of gauze. Has relatively good breathability.
Gauze mask	Most masks with an indicated particle filtration efficiency are not available commercially.

<Standards for disposable dust masks>

*Particle filtration efficiency

N95 US NIOSH standard, tested with NaCl particles, count median diameter: 0.075±0.02 μm, filtration efficiency of 95% or better

DS2 Japanese domestic testing standard, tested with NaCl particles, count median diameter: 0.06-0.10 μm, filtration efficiency of 95% or better

FFP2S European EN standard, tested with NaCl particles, count median diameter: 0.6, filtration efficiency of 94% or better

*Other standards

Particle filtration efficiency (PFE) test Performed with polystyrene particles having a particle size of 0.1 μm.

Bacteria filtration efficiency (BFE) test Based on the permeability of aerosolized microbes (including Staphylococcus) with a particle size of 3 μm.

Radiation-related units

・Unit of radioactivity becquerel (Bq)

1 Bq represents the amount of radioactive material that will produce 1 radioactive decay in 1 sec.

When Bq are used to express radioactivity per unit volume or per unit weight, they are written as Bq/L, Bq/kg, or the like, and this form is often found in reports such as measurements of environmental radiation levels.

・Units used to express the effects of radiation

Absorbed dose　gray (Gy)

A gray represents the amount of energy (radiation) absorbed by a material.　1 Gy is 1 joule of energy deposited in 1 kg of a material.

Exposure dose　sievert (Sv)

The effect that radiation has on an organism differs depending on the type of radiation or energy and the site of exposure.　Thus, the exposure dose is calculated by multiplying the actual dose by a coefficient to account for the effect that radiation has on the human body.

Exposure dose for a specific type of tissue: equivalent dose = absorbed dose x radiation weighting factor

Whole-body exposure dose: effective dose = sum of (equivalent doses x tissue weighting factors) for the entire body

・Prefixes for units

10^{12}　T (tera-)

10^{9}　G (giga-)

10^{6}　M (mega-)

10^{3}　k (kilo-)

10^{-3}　m (milli-)

10^{-6}　μ (micro-)

10^{-9}　n (nano-)

10^{-12}　p (pico-)

Terminology regarding radiation counters

・Time constant　The time required for a count to reach a certain value after starting at an initial value. Assuming the time constant is T sec., then the reading after T sec. will be 63% of the final reading, the reading after 2T sec. will be 86%, and the reading after 3T sec. will be 95%.　Typically, a measurement time that is 3 or more times greater (longer) than the time constant is needed to obtain an accurate measurement.

A small time constant will result in good responsiveness, but there will be vast fluctuations in the readings obtained, so the time constant must be changed depending on the purposes of measurement and the levels of radiation that are being measured.　A time constant of 30 sec. and taking readings at 90-sec. intervals are recommended for accurate measurement of background radiation.　If contamination by radioactive dust is readily apparent, a time constant of 10 sec. and taking readings at 30-sec. intervals are recommended.　A time constant of 3 sec. and taking readings at 10-sec. intervals are recommended when surveying a contaminated site.

SPEEDI

SPEEDI stands for the System for Prediction of Environmental Emergency Dose Information. The SPEEDI Network System rapidly predicts radiation in the event of an emergency. In the event of an incident where large amounts of radioactive material are released by a nuclear power plant, the system uses information on the source of emission to rapidly predict the ambient concentration and dose of radioactive material in the surrounding area in light of terrain and wind and precipitation measurements at the time.

Properties of radioactive material

1） Decay of radioactive material

Half-life: time taken for the amount of a radioactive material to be halved

The density of surface contamination after t years will decrease in accordance with the following formula.

For cesium-137 with a half-life of 30 years

density of surface contamination after t years = (current density of surface contamination) x $(1/2)^{t/30}$

For cesium-134 with a half-life of 2 years

density of surface contamination after t years = (current density of surface contamination) x $(1/2)^{t/2}$

During the Fukushima Daiichi nuclear power plant accident, a mixture of cesium-134 (which has a half-life of about 2 years) and cesium-137 (which has a half-life of about 30 years) was released. When the accident initially occurred, the ratio of the amounts of these substances was about 1: 1. The amount of cesium-134 quickly decreased, so surface contamination quickly decreased in the immediate aftermath of the accident.

2) Error in the radiation count

Radioactive decay is probabilistic, and there are variances in decay, i.e. the count. Performing repeated measurements to arrive at the true counting rate is not practical. Given the fact that the probability distribution of the counting rate can be approximated using a Gaussian distribution, and the accuracy of that counting can be determined based on the following calculation.

Net counting rate

$n_s - n_b \pm \sqrt{(n_s/t_s + n_b/t_s)}$

Based on the time constant, the standard deviation can be determined using the following equation. The standard deviation σ means that the true counting rate is within the identified range with a probability of about 68.3%.

$\sigma = \sqrt{(n/2\tau)}$ n: counting rate τ: time constant

Ordinance on Prevention of Ionizing Radiation Hazards

Article 2

2 In this ministerial ordinance, “radioactive material” refers to radioactive isotopes (hereinafter referred to as "radioisotopes"), compounds of those radioisotopes, and substances containing those radioisotopes to which any of the following apply:

(1) A substance with one type of radioisotope as listed in the leftmost column of Table 1 and in a greater quantity, as listed in the second column of said table, or a greater concentration, as listed in the third column of said table.

(2) A substance with one type of radioisotope as listed in the leftmost column of Table 2 and in a greater quantity, as listed in the second column of said table, or a greater concentration, as listed in the third column of said table. However, the aforementioned does not apply to substances in a solid state with a concentration of 74 Bq/g or less and those in a hermetically sealed state with a volume of 3.7 MBq or less.

(3) A substance with two or more types of radioisotope as listed in the leftmost column of Table 1 to which any of the following apply:

I Radioisotopes as listed in the leftmost column of Table 1 in ratios that will exceed 1 when the quantities of said radioisotopes, as listed in the second column of said table, are added.

II Radioisotopes as listed in the leftmost column of Table 1 in ratios that will exceed 1 when the concentrations of said radioisotopes, as listed in the third column of said table, are added.

(4) A substance with two or more types of radioisotope to which the preceding do not apply, with said radioisotopes as listed in the leftmost column of Table 1 or Table 2 in ratios that will exceed 1 when the quantities of said radioisotopes, as listed in the second column of Table 1, are added or when the concentrations of said radioisotopes, as listed in the second column of Table 2, are added. However, the aforementioned does not apply to substances in a solid state with a concentration of 74 Bq/g or less and those in a hermetically sealed state with a volume of 3.7 MBq or less.

(Indicating controlled areas)

Article 3 1 A business (hereinafter referred to as a “business” except in Article 62) engaged in work involving radiation must demarcate areas to which the following apply (hereinafter referred to as “controlled areas”):

(1) An area in which the total dose consisting of the effective dose due to external radiation and the effective dose due to radioactive substances in air exceeds 1.3 mSv every 3 months.

(2) An area in which the surface density of radioactive material exceeds one-tenth of the limit listed in Table 3.

2 Calculation of the effective dose due to external radiation as specified in 1 of the preceding section shall be performed using the 1-cm dose equivalent.

3 Calculation of the effective dose due to radioactive material in the air as specified in 1 of Section 1 shall be performed by multiplying the ratio equivalent to one-tenth of the average limit on the average concentration of radioactive material in air during working hours in a week over a 3-month period, as specified by the Minister of Health, Labor, and Welfare, by 1.3 mSv (in the event that the number of working hours in a week exceeds or is less than 40 hours, this value shall be obtained by multiplying the average concentration of radioactive material in air during working hours in a week by the value obtained by dividing said working hours by 40 hours. This value shall hereinafter be referred to as the “weekly average concentration”).

4 A business shall not allow persons other than essential personnel to enter a controlled area.

5 A business must post signs indicating precautions related to wear of radiation dosimeter badges as mentioned in Section 3 of Article 8, precautions concerning the handing of radioactive material, and requirements to prevent health hazards to workers due to radiation, such as emergency actions in the event of an accident. Said signs must be posted in a controlled area in places where they clearly visible to workers.

(Workrooms where radioactive material is handled)

Article 22 1 When a business (excluding disposal businesses as specified in 3 of Article 41; the same shall apply in this section) handles radioactive material that is not sealed, a dedicated workroom shall be provided for that work and that work must be performed in that workroom. This restriction shall not apply when extensively distributing or moving radioactive material to investigate a water leak, to epidemiologically investigate pests, to investigate the movement of raw materials during the production process, etc. and such actions are temporary or when nuclear source material (nuclear source material as specified in item 3 of Article 3 of the Basic Law on Atomic Energy (law no. 186, 1955; the same shall apply hereinafter) is mined.

2 The provisions of Section 4 of Article 3 and Section 2 of Article 15 shall apply to a workroom where radioactive material is handled (a workroom as mentioned in the preceding section and a dedicated passageway for persons engaged in work mentioned in the text of that section; the same shall apply hereinafter).

(Structure of workrooms where radioactive material is handled)

Article 23 A business must ensure that areas, such as walls and the floor, inside a workroom where radioactive material is handled that have a potential for contamination comply with the following provisions:

(1) Structures such as walls and the floor shall be made of materials that are highly resistant to permeation by gas or liquids and that are resistant to corrosion.

(2) Structures such as walls and the floor shall have smooth finished surfaces.

(3) Structures such as walls and the floor shall have few projections, indentations, and crevices.

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<Annex III>

Basic Concepts of Decontamination of Cultural Properties (rev. Dec. 4, 2014)

Forms of radioactive contaminants

Radioactive material can be released into the environment as a result of a nuclear reactor accident. If this material is not a gaseous substance at normal temperatures, then it adsorbs to dust in the atmosphere or it dissolves into water in rivers or seas. When radiation exceeding the specified dose is measured from cultural properties, that source is dust containing radioactive material that is contaminating the exterior of the cultural property. However, this does not apply to natural history collections and instruments and timepieces with fluorescent paint containing radium. If that dust moves with water, it can spread to cultural properties.

*Specified dose

This Manual was compiled as a response to the radioactive material that was released into the atmosphere by the Fukushima Daiichi nuclear power plant accident in 2011. If the density of surface contamination on a cultural property exceeds 4 Bq/cm^2 (about 1,300 cpm according to a Geiger–Müller counter with a tube having a diameter of about 50 mm), it is considered to be “contaminated with radioactive material.”

*Response principles

A hydrogen explosion at the Fukushima Daiichi nuclear power plant dispersed airborne radioactive material(tritium, iodine-131 into the environment. Radioactive material in waste from the accident included cesium-134 and cesium-137. These are the types of substances assumed when handling cultural properties that are “contaminated with radioactive material.” “Radioactive material” is defined in Article 2 of the Ordinance on Prevention of Ionizing Radiation Hazards. The basic concepts described below assume that cultural properties are not contaminated with quantities or concentrations of “radioactive material” exceeding the quantities and concentrations of cesium-134 and cesium-137 (quantity of cesium-134 and cesium-137: 10 kBq, concentration of cesium-134 and cesium-137: 1 kBq/kg).

When decontaminating cultural properties, the safety of cultural properties will be thoroughly considered and a reduction in external exposure for workers will also be thoroughly considered based on the Guidelines on Decontamination Procedures (2^{nd} ed., May 2013, Ministry of the Environment, denoted here as the “Decontamination Guidelines”). An operational plan will also be formulated.

A respiratory protection device with a guaranteed ability to remove dust will be used to reduce internal exposure for workers. If there are no issues in terms of ensuring the safety of cultural properties, gloves will be used in principle. A hood will be worn to avoid dust adhering to the hair of the head. Overalls should be laundered daily.

There are ways to reduce the external exposure dose, such as reducing work hours, creating distance between workers and the radiation source, and installing high-density shields between workers and the radiation source. These methods will be used as necessary.

Material used to wipe, in principle, will not be re-used. Solid or liquid waste generated by operations will be disposed of in accordance with the policies of the municipality.

Items specified by the prefecture will be left to the discretion of a committee created by that the local government.

Verification of the effectiveness of decontamination

The density of surface contamination will be verified to be 4 Bq/cm^2 or below (about 1,300 cpm according to a Geiger–Müller counter with a tube having a diameter of about 50 mm) after operations, and then decontamination work will conclude. If the density of surface contamination is higher than that level, a yellow sign indicating "Caution: This area is contaminated with radioactive dust" will be posted to alert people and barriers will be settled. Radiation levels will be allowed to decrease.

*Measurement of surface contamination

Workers will attend a course on measuring techniques. Devices should be appropriately calibrated once a year based on the Calibration of Radiation Detectors and Radiation Counters on the Ministry of Economy, Trade, and Industry website, and reliable devices will be used.

*Proposed responses

- Cultural properties indoors

  The safety of cultural properties will be emphasized based on the Removal of Dust Containing Radioactive Material as described later. Surface fouling and deposits will be removed with a soft brush or broad brush to the extent possible.

  If dust containing radioactive material combines with water to spread to cultural properties, barriers will be erected at a sufficient distance from those properties, and radioactive material will be allowed to decrease.

  Indoors, radiation levels will decrease as anticipated. Cesium-134 has a half-life of about 2 years and cesium-137 has a half-life of about 30 years. At the time of the accident in 2011, those substances were thought to have been released into the atmosphere in almost the same amounts. Cesium-137 has a long half-life, and its decay will determine how long levels will take to decrease. That decrease may take a long time. About once a year, the density of surface contamination should be monitored to determine if it is decreasing.

- Cultural properties located outdoors

  Radiation levels will be measured at a height of 1 m in surrounding places where water collects, and those levels will be verified as not exceeding radiation levels specified by the government. Initially, the level was set at 0.23 μSv/h, but this may be revised in the future, so attention must be paid to notifications from the government. If this level is exceeded, the municipality will be consulted, and decontamination of the surrounding soil, grass, asphalt, and laid stone will proceed. Responses must be in accordance with the Decontamination Guidelines. Afterwards, the extent of surface contamination of the object will be verified, and decontamination work will be performed if necessary.

  If restoration is required, contamination on the object's surface will be verified as not exceeding about 1,300 cpm according to a Geiger–Müller counter with a tube having a diameter of about 50 mm. Restoration will then be planned.

- Historic sites, scenic sites, gardens, etc.

  Measurement sites will be determined primarily in places accessible to visitors and where water pools, and radiation levels will be below levels specified by the government before the site reopens to the public. If the air dose has exceeded radiation levels set by the government, barriers will be installed to ensure visitor safety, and the amount of radioactive material will be allowed to decrease. The safety of cultural properties will be ensured and effective decontamination techniques will explored in conjunction with maintenance. These techniques will be based on the Decontamination Guidelines and may include covering of grass and replacement of gravel.

- Historic buildings

  If necessary for public safety, decontamination will be performed during maintenance and restoration based on "Techniques and precautions for decontamination of roofs" on page 2-23 of the Decontamination Guidelines. The safety of cultural properties will also be ensured.

  Measurement sites will be determined based on the example of "Measurement sites for steps to decontaminate structures such as buildings" on page 2-16 of the Decontamination Guidelines, and conditions before and after decontamination will be ascertained.

*Order of decontamination steps

1. Preparations: Steps to reduce exposure of workers and the public
   Prepare equipment

↓

2. Preliminary measurement: Determination of measurement sites and techniques

↓

3. Decontamination techniques: Procedures to prevent airborne suspension or outflow of contaminants or the spread of contamination as a result of decontamination
   Decontamination work will start high and proceed downwards

↓

4. Procedures following work: Handling of waste, treatment of liquid waste, cleaning of equipment, etc.

Removal of dust containing radioactive material

Dust containing radioactive material can adhere to the surface of cultural properties. If the radiation level of that dust exceeds 1,300 cpm measured by Geiger–Müller counter with a probe having a diameter of about 50 mm, dust will be removed to decontaminate the cultural property.

If dust has strongly adsorbed to the property, the property will be covered with tissue paper so that dust does not become airborne again. Barriers will besettled at a distance from the property, and the property will be isolated. When cultural properties giving off a dose exceeding the specified dose are placed in isolation, people will be alerted to their presence. If necessary, they will be stored in a separate area.

When decontaminating cultural properties contaminated by radioactive material, a dedicated workroom will be provided for that work and that room will be isolated from other areas. Areas, such as walls and the floor, inside a workroom where decontamination is taking place that have a potential for contamination will be made of materials that are highly resistant to permeation by liquids and that are resistant to corrosion. Structures such as walls and the floor will have smooth finished surfaces and few projections, indentations, or crevices. Dust removal can potentially produce contaminants and covering the working area with plastic sheets will facilitate the removal of contaminants from the floor. In addition, local exhaust ventilation will be provided or sources of dust will be enclosed as needed.

Signs will be posted indicating precautions related to wear of radiation dosimeter badges, precautions concerning the handing of radioactive material, and requirements to prevent health hazards to workers due to radiation, such as emergency actions in the event of an accident. These signs will be posted in places where they clearly visible to workers.

An expert will be summoned and worker will receive 6 hours of training and practice pursuant to the Decontamination Guidelines.

Disposal of waste from an accident will be entrusted a waste disposal company.

Decontamination involves usual dust removal from a cultural property. However, removal primarily involves dry removal of dust since the substance to remove is also dust. Use of water has the potential to cause radioactive material to spread to the property, so a restorer will be asked to remove dust using dry methods.

First, deposits that can be removed manually will be removed while wearing surgical gloves.

1） Removal of dust with a vacuum cleaner

If an object has a sturdy surface and there are no concerns about suction from a vacuum cleaner causing damage, dust will be removed with a conservation vacuum cleaner (dust removal and dry cleaning). A conservation vacuum cleaner with an adjustable air flow and a head made out of a soft material like rubber will be used.

2） Radiation will be verified to be at or below 1,300 cpm, and then decontamination work will conclude.

3） If surface contamination remains above 1,300 cpm during the aforementioned dust removal, the cultural property will be isolated and its safety ensured. The density of surface contamination will be determined about once a year with a Geiger–Müller counter. The property will be stored while verifying that the density of surface contamination is decreasing.

4) If restoration is requested, radiation will be verified to be at or below 1,300 cpm and then restoration will be performed.

5) Working conditions

During the aforementioned operations, a dust mask (N95 rating), surgical gloves, overalls, and a hood for head protection will be worn pursuant to guidelines for decontamination.

When decontaminating highly contaminated cultural properties, overalls will be quickly changed after the conclusion of decontamination work in order to reduce internal exposure.

Equipment used in work can normally be washed and then re-used. If highly contaminated cultural properties are being decontaminated, that equipment will only be used once.

Eating, drinking and smoking in the area will be prohibited to avoid internal exposure.

This Manual is a joint product of members of the project on Measures to Prevent/Mitigate Radiation Damage to Cultural Properties.

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The authors of this Manual are indebted to YOSHINO Takamitsu, a collection curator in the Lifelong Education Section, Board of Education, Town of Futaba, Fukushima Prefecture for his help arranging decontamination tests on-site. The authors also wish to thank personnel of the National Museum of Japanese History, the National Museum of Ethnology, and cultural facilities in Fukushima Prefecture for their help with this research. The authors also wish to thank TSUCHIYA Yuko for her help with proofreading.

This Manual has been compiled as part of Measures to Prevent/Mitigate Radiation Damage to Cultural Properties funded by the discretionary fund of the Director General of the Tokyo National Research Institute for Cultural Properties.

Risk Management for Museums：Focusing on Dealing with Cultural Objects Contaminated by Radionuclides (Revised Dec. 4, 2014)

Publication date: December 4, 2014

Published by: Tokyo National Research Institute for Cultural Properties

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