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HEALTH PHYSICS SURVEYS FOR BYPRODUCT MATERIAL AT NRC-LICENSED PROCESSING AND MANUFACTURING PLANTS

A. INTRODUCTION

Paragraph 20.201(b) of 10 CFR Part 20, "Standards for Protection Against Radiation," requires that each licensee make or cause to be made such surveys as may be necessary for him to comply with the regulations in Part 20. As used in Part 20, the term "survey" is defined as an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. This guide identifies the types and frequencies of surveys that are acceptable to the NRC staff for use in plants licensed by the NRC for processing byproduct material or manufacturing such material for distribution.[1]

B. DISCUSSION

Surveys are considered to be part of a comprehensive protection program established by the licensee according to the philosophy and principles of Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable." Principles, methods, and instrumentation for carrying out radiation and contamination surveys were developed early in the atomic energy program and have been discussed in reports of the National Council on Radiation Protection and Measurement (NCRP) (Refs. 1-3), the International Atomic Energy Agency (IAEA) (Refs. 4-8), and the International Commission on Radiological Protection (ICRP) (Ref. 9). The health physics literature contains abundant information for use in establishing radiation survey programs and selecting appropriate methods, procedures, and equipment for their implementation (Refs. 3, 5, and 6).

Surveys[2] are a necessary supplement to personnel monitoring, which measures individual radiation exposures with devices worn by the workers (Refs. 3, 5, 6, 8, and 9).

[1] NRC-licensed processing and manufacturing plants are referred to in this guide as "manufacturing plants."

[2] The word "survey," often used synonymously with "surveillance," "monitoring," or "area monitoring," is used in this guide to connote the personal inspection of various locations in a facility using radioactive materials, with or without accompanying measurements, to determine the effectiveness of measures to protect against radiation.

C. REGULATORY POSITION

Methods and procedures in this guide are acceptable to the NRC staff for establishing acceptable survey programs in accordance with the as low as is reasonably achievable (ALARA) philosophy. Manufacturers licensed by the NRC should have a health physics staff capable of developing and implementing survey programs as described below.

1. TYPES OF SURVEYS

1.1 General Description

Surveys performed in compliance with §20.201 of 10 CFR Part 20 should include those necessary to evaluate external exposure to personnel, concentrations of airborne radioactive materials in the facility, surface contamination levels, and radioactive effluents from the facility. Environmental monitoring of effluents is beyond the scope of this guide.[3]

Radiation protection programs should include the types of surveys discussed below.

1.2 Surveys of External Radiation Exposure Levels in Restricted Areas

Radiation safety personnel[4] should survey locations where individuals may be exposed to radiation intensities that might result in radiation doses in excess of 10 percent of the limits of paragraph 20.101(a) of 10 CFR Part 20 in any calendar quarter or where an individual is working with a source that could be used unshielded at any time to produce a gamma or beta dose rate exceeding 0.5 mrad/h at 1 meter. *

* Lines indicate substantive changes from previous issue.

[3] However, the radiation safety program should include surveys or records that indicate control of the quantities of radioactive material released in air and water to unrestricted areas, as required by 10 CFR Part 20.

[4] Reference to radiation safety staff or personnel in this guide is not intended to indicate that such staff necessarily consists of more than one person designated as responsible for radiation safety. The size and qualifications of the staff depend on the scope and kind of manufacturing activities involving radioactive materials.

Preoperational, routine, and special surveys of these areas should be performed by the radiation protection staff as described in Section C.2 of this guide. Results of these surveys should be recorded as described in Section C.3. In addition, workers should monitor themselves and their own individual activities if they are exposed to external radiation levels that could exceed any of the limits of paragraph 20.101(a). These surveys by workers should consist of periodic instrument surveys during work with radioactive materials. Workers should be properly trained to conduct such surveys.

Surveys are not acceptable for routine compliance with the personnel monitoring requirements of §20.202. However, in the event of accidental loss of personnel dosimetry data, e.g., as a result of losing the dosimeter or chemical or physical damage to the dosimeter, the best alternative means of estimating the exposure may be to use survey data in conjunction with any fixed station dosimeters, doses received by co-workers, and appropriate occupancy factors. In such case, the estimate, including the survey data used, should be documented and retained indefinitely (see paragraph 20.401(c)(2)(ii)). Survey results supplement personnel monitoring, when it is required, and they should be reviewed carefully by the Radiation Safety Officer in conjunction with personnel monitoring records to identify potentially hazardous situations and to ensure that all personnel are adequately monitored.

1.3 Measurements of Radioactive Material Concentrations in Air

The radiation safety staff should perform measurements of radioactive material concentrations in air, at frequencies specified in Section C.2 of this guide, for areas where radioactive materials are handled or processed in unencapsulated form and when operations could expose workers to the inhalation of quantities of radioactive material exceeding those specified in paragraph 20.103(b)(2). Special requirements for such monitoring may also be made a condition of the license.

Air samples collected should be representative of the air in the workers' breathing zone. However, when obtaining representative samples from the breathing zone is not practicable, the samples should be obtained from a location at which the radioactivity concentration in air is known to be greater than that of the workers' breathing zone. For example, samples taken outside the breathing zone are acceptable if the sampler head is located so that the concentration of radioactive material in air at the location of the sampler head is equal to or greater than the concentration in the breathing zone.

When measuring the quantity of radioactive material deposited on or in an air sample filter, the radiation safety staff should include appropriate corrections for alpha or beta absorption by the filter media and by material collected on the filter whenever these corrections may change results more than 10 percent. Filter media used for the collection of alpha emitters should retain collected material on the filter surface. Overestimates of the volume of air that has passed through the filter should be avoided by means of accurate calibration of the flow rate and by preventing or correcting for the loss of flow due to the accumulation of material on the filter.

Breathing zone or general air sampling should be conducted while work is in progress unless the results of continuous sampling verify that the concentration of radioactive material in the breathing zone is not likely to exceed 25 percent of the values given in 10 CFR Part 20, Appendix B, Table I, Column 1. The use of personal (lapel) samplers is acceptable for continuous air sampling as long as airflow rates are adequate to detect 25 percent of the appropriate values in Table I of Appendix B during the sampling period. The air sampling frequency, if not continuous, and the times selected for sampling should be based on the nature of the manufacturing process involved and the probability that airborne radioactive material will be present. When assessing this probability is difficult, frequencies based on information given in Section C.2 and Table 1 of this guide are acceptable.

An air monitor[5] may be needed to provide a warning signal that the concentration of airborne radioactivity has become unexpectedly high. For each room or area where radioactive material is handled, the licensee should perform an analysis to determine whether an air monitor is necessary. Each analysis should be kept available for inspection.[6] An air monitor should be provided if the analysis indicates that it is likely that, in the absence of an appropriate air monitor alarm, accidental conditions could cause an intake of radioactive material exceeding the intake that would result from inhaling such material for 40 hours at the concentrations specified in 10 CFR Part 20, Appendix B, Table I, Column 1.[7]

Workers should recognize that the principal function of an air monitor is to alert personnel to take immediate action to protect themselves from exposure to the unexpected release of airborne radioactive material. Inhalation exposures are in progress during the time between the release of the radioactive material and the sounding of the alarm. Thus, every reasonable effort should be made to minimize this time period. In particular, the air inlet of the monitor should be located near the potential source of airborne radionuclides, preferably between the source and the workers. The use of long tubing or piping leading to the inlet should be avoided because of the high probability of alarm delay due to radionuclide deposition on the interior

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[5] The term "air monitor" as used here refers to a device providing an air or particle collection system, a radiometric measurement system, a continuous recorder (when the monitor is also to be used to assess personnel exposures), a meter with preset alarm capability, and an audible-alarm system.

[6] Applicants should provide either the name of the manufacturer and model number of the air monitor to be used, specifications for the appropriate type of air monitor to be used, or a copy of the analysis that verifies that an air monitor is not required.

[7] To determine the quantity of radioactive material associated with this 40-hour exposure, multiply the concentration value specified in Appendix B to 10 CFR Part 20 by 4.8×10^7 ml.

walls of the tube or pipe. The dose to personnel may be reduced by selecting a low-activity-level setpoint for the alarm; however, this may result in false alarms that weaken the workers' confidence in the monitor. These alternatives should be balanced to maximize safety.

The dose to personnel may also be reduced by providing a high flow rate of air through the detection chamber or filter. A device such as a limiting orifice that is intended to provide a constant flow rate should not be used with an air monitor when it reduces the flow rate to a level inadequate for sufficient warning of an accidental release. It is more important to maintain a high volume of air drawn through the filter, thus reducing the time of exposure before the alarm by using a higher flow rate, than to measure the concentration accurately. However, it is also important that routine intermittent and continuous releases be monitored.

1.4 Surface Contamination Surveys

Routine monitoring for radioactive contamination that could be present on surfaces of floors, walls, laboratory furniture, and equipment is a necessary part of the survey program. Failure to control surface contamination may result in unnecessary external or internal exposure of personnel to radiation. Although external radiation levels from radioactive contamination may at times be hazardous, the primary concern is to avoid internal exposure resulting from the intake of loose radioactive material by inhalation, ingestion, or skin absorption. Also of concern is limiting contamination to areas where it can be controlled and maintaining contamination levels low enough that leaks or failures in control equipment can be detected as early as practicable.

1.4.1 Removable Contamination

For the purpose of this guide, *removable contamination* is that fraction of the contamination present on a surface that can be transferred to a smear test paper by rubbing with moderate pressure. Considerable information is available to aid radiation protection personnel in the selection and use of instruments for performing surface contamination surveys appropriate to the radionuclides involved in manufacturing plants (Refs. 1-22).

Methods and instruments used in surface contamination surveys should be sufficiently sensitive to detect the nuclides being monitored. Also, uniform methods for collecting and analyzing smear samples should be used over extended periods of time in order to evaluate trends. Counting equipment used to analyze radioactive contamination on smear samples should be properly calibrated and maintained and should be capable of detecting the radiation from the smears. For example, smears containing low-energy radiation emitters (e.g., H-3, C-14, I-125) should be analyzed with liquid scintillation or internal proportional counters. Check or calibration sources should be counted with each batch or daily workload of smear samples.

When contamination levels in restricted areas can potentially exceed 0.1 percent of the respective limits in line 2 of Table 2, the collection of smear samples should generally be preceded by a rapid overall survey with a portable, thin-window detector in order to:

a. Ensure that gross contamination levels are not already too high for counting in sensitive equipment,

b. Minimize the chance for inadvertent spread of contamination by the smear survey or other activities to be performed in the meantime, and

c. Determine which areas require greater attention in smear testing.

The instrument used should have a readout system with as short a time constant as appropriate for the type of radiation to be detected and should be equipped with earphones or an external speaker system.

A standardized method for smear testing of a relatively uniform area should be used to aid in comparing contamination at different times and places. A dry smear taken from an area of about 100 cm^2 is acceptable to indicate levels of removable contamination.

A diagram of each routinely surveyed area should ordinarily be used for recording survey results. When appropriate, the diagram may be supplemented by or replaced by a detailed list of items and equipment surveyed. This procedure will provide radiation safety personnel with a method for identifying trends as well as satisfying regulatory requirements for survey records. The surveyor will find it helpful to specify key locations on the survey diagram that are smear-tested at each survey, in addition to other areas to be smear-tested in particular surveys, and also to provide a space reminding the recorder to include:

a. Contamination levels converted to radioactivity units in terms of equivalent alpha, beta, or gamma emission per unit area, in units specified in 10 CFR Part 20,

b. Make and model number of instruments used in the survey and in counting the smear samples or appropriate reference to information in the same set of available records,

c. Disintegration rate of each sample,

d. Background count,

e. All counting times, and

f. Name of the person making the evaluation and recording the results and date.

Provision should also be made on the diagram for recording an instrument check with an appropriate check or calibration source.

The surveys discussed above are regularly scheduled, conducted by radiation safety personnel, and recorded on the survey diagrams. In addition, whenever the manufacturing process is such that excessive contamination could occur between surveys by radiation safety personnel, more frequent, informal radiation surveys should be conducted by the radiation workers themselves; they need not be recorded. For example, a contamination survey can be made by collecting a smear sample and holding it within a few mm of (but not touching) a thin (less than 2 mg/cm^2) end-window detector while the detector is in an area where radiation levels are less than about 0.05 mrem/h. At these levels, any appreciable surface contamination can be detected by simply holding the detector in a fixed position and moving the smear sample close to and away from the detector several times and noting the meter readings. This method may be used for the majority of radionuclides processed in manufacturing plants (excluding alpha and very low-energy beta emitters).

Part 20 of 10 CFR does not specify limits for surface contamination. Each applicant should propose and justify what removable surface contamination limits will be allowable before decontamination will be performed in each work area. These limits should be based on the types of work to be performed and the need to avoid transfer of significant amounts of contamination to unrestricted areas and to maintain exposures as low as is reasonably achievable (ALARA). The contamination limits for restricted areas presented in Table 2 of this guide are the maximum that will be acceptable to the NRC staff. Limits established for a particular installation should generally be lower than those in Table 2 and should be ALARA for the particular operations involved.

1.4.2 Fixed Contamination

For the purpose of this guide, *fixed contamination* is defined as radioactivity remaining on a surface after repeated decontamination attempts fail to significantly reduce the contamination level. Since most detectors respond to both removable and fixed contamination, limits should be based on total contamination. Total contamination surveys, using instruments suitable for the radionuclides involved, should be conducted at least quarterly and simultaneously with a removable contamination survey. The applicant may propose and justify what total contamination limits will be allowable for both restricted and in-plant unrestricted areas before decontamination will be performed. The limits appearing on line 2 of Table 2, multiplied by a factor of 5, are the maximum that will be acceptable to the NRC staff. Limits that are ALARA should be established and justified by each applicant.

1.5 Protective Clothing and Equipment Contamination Surveys

Individuals working in areas where a potential for skin or clothing contamination exists should be provided with suitable protective clothing. If respiratory protective equipment is needed to protect against inhalation of airborne radioactivity, the equipment should be used according to the instructions in Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection." Section 20.103 of 10 CFR Part 20 specifies monitoring requirements when protection factors are assumed to be provided by the use of respiratory protection devices.

Potentially contaminated protective clothing and equipment should be surveyed, removed, and placed in suitable containers or lockers before the worker leaves the restricted area. Since airborne radioactivity from contaminated protective clothing is likely to be produced by dislodging any absorbed radioactive particles during removal, fixed station monitors should also be available in clothing change areas to survey clothing before it is removed whenever clothing contamination levels may exceed 10 percent of the limits on line 4 of Table 2. In addition, suitable areas should be provided for surveying protective clothing and equipment before storing them for further use or for decontamination and laundering.

When protective clothing contamination levels exceed preselected limits, workers should be instructed to take care to avoid dispersal of contamination and to report the situation to the Radiation Safety Office. A member of the radiation safety staff should then survey and supervise any necessary decontamination or clothing disposal. The applicant should propose and justify protective clothing contamination limits considered adequate for each restricted area. The limits given on line 4 of Table 2 are the maximum that will be acceptable to the NRC staff.

Contamination levels observed and procedures followed for incidents requiring special surveys and decontamination should be recorded. The record should include the names of persons surveyed, a description of prior work activities, the probable causes, steps taken to reduce future incidence of contamination, times and dates, and the surveyor's signature. This information may be entered in a logbook. Individual worker surveys of themselves need not be recorded unless the limits on line 3 of Table 2 are exceeded. However, the radiation safety staff should maintain daily surveillance to ensure that the workers continue their own personal contamination surveys. Results of radiation safety surveillance should be recorded.

In restricted areas with little potential for surface contamination, personal clothing is often worn beneath protective clothing. Such personal clothing should be surveyed by the wearer before he or she leaves the restricted area. (However, this is neither practicable nor necessary for employees working with only submicrocurie quantities of tritium or carbon-14.) When personal clothing contamination levels exceed preselected limits, workers should be instructed to report the situation to the Radiation Safety Office. A member of the radiation safety staff should then survey and supervise any necessary decontamination or clothing disposal. The applicant may propose and justify personal clothing (total) contamination limits. The limits given on line 3 of Table 2 are acceptable to the NRC staff and need not be justified by the applicant. Clothing contamination is assumed to be removable but may be measured by a portable end-window detector as total contamination for survey purposes.

Records should be maintained in the same manner as those for protective clothing contamination.

For individuals whose work is conducted in restricted areas with a potential for high surface contamination levels, complete clothing changes are normally provided. In this case, personal clothing should be stored outside the restricted area. Surveys of personal clothing are not necessary, provided the area in which the clothing is stored is surveyed as discussed in Section C.1.4 of this guide and the survey results are below the limits adopted for in-plant unrestricted areas. Particular attention should be paid to surveying the body, hair, bottoms of the shoes or feet, and the hands after removal of protective clothing and to washing before donning personal clothing.

1.6 Personal Surveys

Individuals whose duties require work in restricted areas where radioactive contamination of body surfaces is probable should also survey all exposed areas of the body after showering and before donning personal clothing or leaving the restricted area. Workers should be required to report the detection of contamination on the body to the Radiation Safety Office. Decontamination attempts, under the direction of Radiation Safety Office personnel or a medical consultant, should be repeated until (a) such attempts cease to effect significant reductions or (b) such attempts threaten to damage the skin.[8] When decontamination attempts are terminated, there should be no further concern if the residual contamination does not exceed preselected levels since the contamination would no longer present a significant ingestion hazard. Such levels should be proposed and justified by the applicant. If residual contamination exceeds the selected limits, the affected individual should be released but periodic surveys should be made until the limits are no longer exceeded. The resulting dose should be determined and entered in the individual's personnel dosimetry record. Complete records should be maintained of each incident of this nature.

Since manufacturing plants often process large quantities of unencapsulated radioactive material, bioassay programs may be required. Acceptable features of such programs are published in Regulatory Guides 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program," 8.11, "Applications of Bioassay for Uranium," and 8.20, "Application of Bioassay for I-125 and I-131," or are issued by the License Management Branch.

1.7 Surveys of Equipment Prior to Release to Unrestricted Areas

Surface contamination surveys should be conducted for both removable and fixed contamination before potentially contaminated equipment is released from restricted to unrestricted areas. If contamination is detected, decontamination procedures should be repeated until contamination levels are ALARA or additional efforts do not significantly reduce contamination levels. The applicant may propose and justify total and removable contamination limits below which uncontrolled release of equipment is permitted. The limits given for unrestricted areas on line 1 of Table 2 are acceptable to the NRC staff and need not be justified by the applicant.

1.8 Ingestion

Although it is highly unlikely that significant internal exposures will result from ingesting drinking water near work areas (Ref. 4), any water fountains in areas where contamination of the fountains or water is possible should be smear-tested regularly, and the water should be sampled and analyzed at least quarterly. Also, surveillance should be included in the radiation safety program to ensure that workers observe rules to prevent ingestion of radionuclides, e.g., rules pertaining to eating, drinking, or smoking in work areas or while wearing potentially contaminated clothing, storing foods in work areas, or pipetting by mouth.

1.9 Surveys of Packages Received and Packages Prepared for Shipment

External radiation surveys and smear tests of external surfaces of packages received or packaged for shipment should be carried out near the receiving or packaging point to avoid unwarranted radiation exposures and inadvertent contamination of personnel or the facility. When many packages of a kind known to be generally free of contamination are received, smear testing of a suitable random sample should be considered in cases where smear testing of a large number of packages could increase external exposure of personnel. Surveys and required labeling must comply with regulatory requirements (see §§20.205, 32.19, and 32.70 through 32.74 of 10 CFR) and with specific license conditions. Delivery of packages within the plant should also be monitored when carried by personnel rather than mechanical conveyors. Surveys should be made to determine when carts rather than hand carrying should be used. Packages containing significant amounts of radioactive materials should not be surveyed or opened until the containers have been placed in the appropriate protective facility such as a radiological-type fume hood or hot cell.

No packages should be released for shipment or transfer to other users unless contamination levels of internal sources or devices have been tested and certified to meet (a) the criteria of paragraph 35.14(b)(5) of 10 CFR for Group VI products or (b) license conditions for other products as provided in §35.14 or in the manufacturer's license. Also, no packages may be released for shipment or transfer when external radiation or surface contamination levels exceed limits set by the Department of Transportation in Title 49 of the Code of Federal Regulations. External radiation and contamination levels should be maintained ALARA.

1.10 Checks on Posting of Caution Signs, Labels, Signals, Controls, and Notices to Employees

The radiation safety staff should perform surveillance at least weekly to ensure that signs, labels, signals, other access

[8] Decontamination attempts without the licensee's medical consultant present should be restricted to washing with mild soap and water, or with soaps specifically manufactured for hand washing, or to decontamination procedures previously agreed upon by the medical consultant. If such attempts do not reduce the contamination to acceptable levels, the aid of a physician should be obtained.

controls, and required Notices to Employees, copies of licenses, and other items are properly posted, legible, and operative, as required by 10 CFR Part 19, "Notices, Instructions and Reports to Workers; Inspections," and Part 20 or license conditions. Radiation alarm signals and access controls should be tested to verify that they will operate properly under both the normal and abnormal conditions that might be expected to occur. Care should be taken to minimize exposure to personnel who are conducting the tests. Any signs, labels, or notices found to be missing should be promptly replaced. Temporary signs, signals, or barriers together with appropriate worker notification and instruction may be used in the interim when items as specified in 10 CFR Parts 19 and 20 are not available, but acceptable corrections should be provided as soon as practicable.

1.11 Leak Tests of Sources

Leak testing of sealed sources must be carried out in accordance with the terms and conditions of the manufacturer's materials license. Also, as provided in paragraphs 35.14(b)(5) and 35.14(e)(1), sealed sources containing

a. More than 100 microcuries of a byproduct material with a half-life of more than 30 days (except iridium-192 seeds encased in nylon ribbon) or

b. More than 10 microcuries of an alpha emitter

must be leak tested for contamination or leakage at intervals not to exceed 6 months unless a different interval is specified for a particular manufactured source under the provisions of paragraph 32.74(b). Further provisions and exceptions to leak-testing requirements are established in paragraphs 35.14(b) and 35.14(e)(1).

1.12 Calibration of Radiation Safety Instruments

Portable survey instruments should be placed on a routine maintenance and calibration program that will ensure that properly calibrated and operable survey instruments are available at all times for use by the health physics staff.

An adequate calibration of survey instruments cannot be performed solely with built-in check sources. Electronic calibrations that do not involve a source of radiation also do not determine the proper functioning and response of all components of an instrument. However, an initial calibration with a radiation source and periodic tests using electronic input signals may be considered adequate for high ranges that are not used routinely.

Daily or other frequent checks of survey instruments should be supplemented every 6 months with a calibration of each instrument at two points separated by at least 50 percent of each linear scale that is used routinely, or with a calibration at one point near the midpoint of each decade on logarithmic scales that are used routinely. Digital readout instruments with either manual or automatic scale switching should be calibrated as are linear readout instruments. Digital readout instruments without scale switching should be calibrated as are logarithmic readout instruments. Survey instruments should also be calibrated following repair. A survey instrument may be considered properly calibrated when the instrument readings are within ± 10 percent of the calculated or known values for each point checked. Readings within ± 20 percent are considered acceptable if a calibration chart or graph is prepared and attached to the instrument.

1.13 Surveys of Protective Clothing Before and After Laundering

All garments with contamination levels exceeding those given on line 3 of Table 2 should be either disposed of as radioactive waste or properly surveyed, packaged, and labeled and sent to a laundry licensed to process and handle radioactively contaminated clothing.

Each garment returned from a licensed laundry, or a sample of garments that are returned within a single package, should be monitored before use. If contamination levels on the garment exceed those given on line 4 of Table 2, the garment should not be used.

1.14 Ventilation Surveys

Radiation safety personnel should conduct surveys monthly (or more frequently) to determine the face velocity of air at the entrance of radiological-type fume hoods in use to protect workers against the hazards from unencapsulated radioactive materials.[9] Such surveys should be made by using a properly calibrated thermoanemometer, velometer, or a U-tube observation after the initial measurement of flow rate to determine whether the airflow has been reduced to unacceptable levels by filter loading or the malfunction of blowers, fans, etc. The minimum average face velocity for a fume hood with the sash in the operating position or for an opening in a special enclosure should be 100 ft/min, as determined from at least five different measurement points.

Corrective action should be taken as soon as possible when the face velocity is found to be deficient. Work should be terminated if the average face velocity falls below 100 ft/min.

In addition to these surveys, each enclosure should be equipped with a device that measures pressure drop across the hood filter. Workers should be instructed to maintain daily checks of these devices and to notify radiation safety personnel when the pressure drop exceeds a preset level.

At least annually, or when changes occur that might affect airflow, a survey should be made to determine the number of air changes per hour provided by the ventilation system in each room in which work with unencapsulated radioactive materials is conducted. A minimum of six changes per hour should be provided.

[9] Where filtered exhausts are employed, devices such as U-tube manometers or the equivalent should be provided to indicate the pressure drop across the filters so that the filters may be changed before becoming excessively plugged.

1.15 Surveys of In-Plant Unrestricted Areas

Unrestricted areas should be surveyed periodically to ensure that radiation and radioactive material are adequately confined in restricted areas, except in cases where these materials must be transported between areas. Such transportation should be surveyed or planned with the radiation safety staff.

1.15.1 Surface Contamination Surveys

Removable surface contamination surveys in unrestricted areas should be performed and recorded at frequencies consistent with the potential for spreading contamination but not less frequently than quarterly. With the exception of lunch rooms and snack bars, random smear testing of floors and furniture is adequate. In lunch rooms and snack bars, equipment should also be surveyed. If such surveys reveal that radioactive contamination is being transferred out of restricted areas, immediate corrective action should be taken to eliminate such transfers, and decontamination efforts in the unrestricted areas should be repeated until it is evident that subsequent efforts would not significantly reduce contamination levels. If contamination is found in unrestricted areas, surveys should be performed on a more frequent schedule as necessary until the source of contamination is ascertained and corrected. The applicant may propose contamination levels, following decontamination efforts described above, for in-plant unrestricted areas. The limits given on line 1 of Table 2 are acceptable to the NRC staff and need not be justified by the applicant.

1.15.2 Radiation Surveys

Radiation surveys in unrestricted areas should be performed and recorded at frequencies consistent with the types and quantities of materials in use but not less frequently than quarterly. These surveys should be made in areas adjacent to restricted areas and in all areas through which byproduct materials are transferred and temporarily stored before shipment. Dose rates in these areas should be evaluated to determine whether they comply with the requirements of §20.105 of 10 CFR.

1.16 Surveillance

1.16.1 Surveillance by Individual Performing Surveys

The term *surveillance*, as used in this section, refers to observations of radiological working conditions in restricted areas made by the person who performs the routine radiation and contamination surveys. Such surveillance, one of the most important aspects of a radiation protection program, allows health physics personnel to acquire detailed knowledge of each operation in order to (a) identify ways of preventing or minimizing exposures, (b) select appropriate times for making health physics measurements, and (c) adequately prepare for emergency conditions. Health physics personnel should be sufficiently familiar with each operation to explain it in detail, to describe potential hazards and the precautions taken to minimize exposures, and to discuss how this knowledge of the operation has influenced the selection of appropriate times for performing health physics measurements.

1.16.2 Regular Inventory of Radioactive Material, Audit of Procedures, and Instruction of Personnel

The surveillance program includes:

a. Regular inventory of radioactive materials and their locations,

b. Frequent audits of radiation safety procedures and the uses and amounts of material in process compared to licensed possession limits, and

c. Discussions with personnel to ensure their continued awareness of safety procedures and the appropriateness of their instruction and training for the tasks they are performing.

These surveillance activities may be conducted during the performance of other survey measurements or tests. The radiation safety staff should conduct surveillance inspections in a manufacturing plant at least weekly. The surveillance should be performed at least annually by the Radiation Safety Officer in the presence of a management representative such as the plant manager to provide management with an awareness of the nature and importance of activities conducted for personnel protection and plant safety.

2. FREQUENCY OF SURVEYS

The frequency of routine surveys depends on the nature, quantity, and use of radioactive materials, as well as the specific protective facilities, equipment, and procedures that are designed to protect the worker from external and internal exposure.

Generally, surveys should be performed before radioactive materials are used in a new facility in order to establish a baseline of background radiation levels and radioactivity from natural sources, structural components of the facility (including radon and thoron emanation rates and concentrations), and any already existing operations with radiation sources in nearby rooms or facilities. These baseline surveys should be performed under the various conditions of containment, shielding design, and process heat loads to be expected under manufacturing conditions. Surveys of simulated process operations with nonradioactive reagents or smaller amounts of radioactive material should also be performed where appropriate to establish the performance of protective equipment and procedures before full-scale production using any new or untested facilities or processes.

Surveys should be repeated as soon as process operations begin with normal levels of radioactive material and with all potentially exposed workers present and carrying out their job functions. Surveys should also be conducted after any significant changes in the conditions that existed at the time of the most recent survey, including changes in the

quantities of radioactive material handled or in protective equipment and procedures.

Routine and repetitive surveys are necessary to control the containment of radioactive materials within handling systems and to ensure the continued integrity of protective equipment and procedures. Surveys are also necessary for procedures in which sealed sources are handled outside shielded containers. For operations involving materials in gas, liquid, or finely divided forms, the survey program should be designed to monitor the continued adequacy of containment and control of the materials involved.

The minimum acceptable frequencies of surveys for manufacturing plants are given in Table 1. The NRC staff considers the frequencies established in Table 1 to meet the requirements of §20.101 of 10 CFR.

3. RECORDS OF SURVEYS

Reference should be made to §§20.401 and 30.51 and Parts 31-35 of 10 CFR for recordkeeping requirements regarding surveys related to the receipt, use, packaging, transfer, export, and disposal of byproduct material. Section 20.401 requires that licensees maintain records in the same units used in Part 20. Thus, external exposure rates should be recorded in estimated maximum dose equivalent units to relevant parts of the body as specified in 10 CFR Part 20. Air concentration measurement results should be recorded in units of μCi/ml, and surface contamination measurement results should be recorded in units of dpm/100 cm^2, μCi/100 cm^2, or μCi/cm^2 (or as in §20.5). SI unit conversions may be specified as part of the record.

Record retention requirements are given in the regulations cited above. Paragraph 20.401(c)(2) requires that survey records be preserved for 2 years, except that records of air monitoring and (in the absence of personnel monitoring data) records of surveys to determine external radiation dose are to be maintained until the NRC authorizes their disposition.

Records may be maintained in logbooks or on special forms as long as they are clear, legible, understandable, and authenticated by authorized personnel. The signature of the person making the record and the date of the signature should be on the same page as the record and should immediately follow each record entry. Either the original or a reproduced copy or microform (duly authenticated) may be maintained to meet the storage requirements of §20.401.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which the applicant or licensee proposes an acceptable alternative method, the staff will use the methods described herein in evaluating an applicant's or licensee's capability for and performance in complying with specified portions of the Commission's regulations after November 15, 1979.

If an applicant or licensee wishes to use the method described in this regulatory guide on or before November 15, 1979, the pertinent portions of the application or the licensee's performance will be evaluated on the basis of this guide.

REFERENCES*

1. National Commission on Radiological Protection (NCRP) Report No. 8, "Control and Removal of Radioactive Contamination in Laboratories," December 15, 1951.

2. NCRP Report No. 9, "Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users," November 2, 1951.

3. NCRP Report No. 10, "Radiological Monitoring Methods and Instruments," April 7, 1952.

4. International Atomic Energy Agency (IAEA) Technical Report Series No. 120, "Monitoring of Radioactive Contamination on Surfaces," 1970.

5. IAEA Safety Series No. 38, "Radiation Protection Procedures," 1973.

6. IAEA Safety Series No. 1, "Safe Handling of Radionuclides," 1973 Edition, Code of Practice Sponsored by the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO), 1973.

7. IAEA Technical Report Series No. 133, "Handbook on Calibration of Radiation Protection Monitoring Instruments," 1971.

8. IAEA Safety Series No. 25, "Medical Supervision of Radiation Workers," sponsored jointly by IAEA, WHO, and ILO, 1968.

9. International Commission on Radiological Protection (ICRP) Publication 12, "General Principles of Monitoring for Radiation Protection of Workers," Pergamon Press, 1969.

10. AAPM Monograph No. 1, "Biophysical Aspects of the Medical Use of Technetium-99m," J.G. Kereiakes and Karen R. Corey, Editors (available from American Association of Physicists in Medicine, Dr. James G. Kereiakes, E555 Medical Sciences Building, University of Cincinnati, Cincinnati, Ohio 45267), 1976.

11. International Commission on Radiation Units and Measurements (ICRU) Report No. 12, "Certification of Standardized Radioactive Sources," September 15, 1968.

12. NCRP Report No. 57, "Instrumentation and Monitoring Methods for Radiation Protection," 1978.

13. NCRP Report No. 58, "A Handbook of Radioactivity Measurement Procedures," 1978.

14. C. B. Meinhold, "Facility Monitoring Programs, Techniques, and Problem Solving," *Health Physics Operational Monitoring*, Vol. 1, C. A. Willis and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 363.

15. C. A. Willis, "Safe Specific Activity: A Useful Concept in Monitoring Areas Containing Activated Materials," *Health Physics Operational Monitoring*, Vol. 1, C. A. Willis and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 373.

16. H. J. Deigl, "Guidelines for Determining Frequency of Wipe Surveys," *Health Physics Operational Monitoring*, Vol. 1, C. A. Willis and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 385.

17. R. C. Henle and P. E. Bramson, "Evaluation of Internally Deposited ^{241}Americium from Bioassay Data," *Health Physics Operational Monitoring*, Vol. 1, C. A. Willis and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 731.

18. P. G. Voilleque, "Calculation of Expected Urinary and Fecal Excretion Patterns Using the ICRP Task Force Group Report on the Human Respiratory Tract," *Health Physics Operational Monitoring*, Vol. 1, C. A. Willis and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 773.

19. R. L. Kathren, "Instruments in the Field Use, Abuse, and Misuse," *Health Physics Operational Monitoring*, Vol. 2, C. A. Willis, and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 811.

20. W. P. Howell and R. L. Kathren, "Calibration and Field Use of Ionization Chamber Survey Instruments," *Health Physics Operational Monitoring*, Vol. 2, C. A. Willis and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 925.

21. A. Brodsky, N. Wald, R. E. Lee, J. Horm, and R. Caldwell, "Plutonium-Americium Contamination Aspects of a Dry Box Incident Involving Hand Amputation," *Health Physics Operational Monitoring*, Vol. 3, C. A. Willis and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 1601.

22. F. E. Gallagher, A. N. Tschaeche, C. A. Willis, J. C. Evraets, and J. C. Rogers, "Progress on Surface Contamination Standards," *Health Physics Operational Monitoring*, Vol. 3, C. A. Willis and J. S. Handloser, Eds., Gordon and Breach, New York, 1972, p. 1767.

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*IAEA reports may be obtained from UNIPUB, Inc., P.O. Box 433, New York, N.Y. 10016.

ICRP reports may be obtained from Pergamon Press, Maxwell House, Fairview Park, Elmsford, New York 10523.

ICRU reports may be obtained from the International Commission on Radiation Units and Measurements, P.O. Box 30165, Washington, D.C. 20014.

NCRP reports may be obtained from NCRP Publications, P.O. Box 30175, Washington, D.C. 20014.

TABLE 1
ACCEPTABLE FREQUENCIES FOR SURVEYS

	Radionuclide Group	External Radiation Surveys (nuclides with asterisks only)*		Amounts (Curies) in Process at Any One Time or Placed into Process in Any 3-Mo. Period Within Any Room Requiring Surveys					
				Air Sampling**			Surface Contamination		
		Weekly	Monthly	Weekly	Monthly	Quarterly	Weekly	Monthly	Quarterly
I:	H-3, C-14, F-18,* K-42,* Cu-64,* Tc-99m,* In-113m*	If point source of activity could exceed 50 mrad/h at 1 meter	If point source of activity could exceed 0.5 mrad/h at 1 meter	≥ 10	≥ 1 <10	<1	≥ 100	≥ 10 < 100	<10
II:	Br-82, Cr-51,* Fe-55, I-123,* Hg-197*			≥ 1	≥ 0.1 <1	<0.1	≥ 10	≥ 1 < 10	<1
III:	S-35, Au-198, Ca-47, I-132, Ce-141, Mixed fission products,* Sr-85, La-140, Nb-95, Zn-65, Co-58,* Fe-59,* Na-24,* Co-57,* Se-75,* Mo-99*			≥ 0.1	≥ 0.01 <0.1	<0.01	≥ 1	≥ 0.1 < 1	<0.1
IV:	Hf-181, Pm-147, P-32,* Ba-140,* Th-234, Kr-85, Ir-192,* Cl-36, Y-91, Ta-182, Ca-45, Sr-89, Cs-137, Co-60,* Ce-144,* I-126, Eu-154, I-131,* I-125,* Tm-170, Na-22,* Mn-54,* Ag-110m,* Hg-203,* Rn-222,* Sn-113*			≥ 0.01	≥ 0.001 <0.01	<0.001	≥ 0.1	≥ 0.01 < 0.1	<0.01
V:	Tc-99, I-129, Ru-106			≥ 0.001	$\geq 10^{-4}$ <0.001	$<10^{-4}$	≥ 0.01	≥ 0.001 <0.01	<0.001
VI:	Ra-223, Po-210, Th-227, Sr-90, Pb-210, Cm-242, U-233*			$\geq 10^{-4}$	$\geq 10^{-5}$ $< 10^{-4}$	$<10^{-5}$	≥ 0.001	$\geq .10^{-4}$ < 0.001	$<10^{-4}$
VII:	Sm-147, Nd-144, Ra-226,* Cm-244, Ra-228, Pu-241			$\geq 10^{-5}$	$\geq 10^{-6}$ $< 10^{-5}$	$<10^{-6}$	$\geq 10^{-4}$	$\geq 10^{-5}$ $< 10^{-4}$	$<10^{-5}$
VIII:	Am-243, Am-241,* Np-237, Ac-227, Th-230, Pu-242, Pu-238, Pu-240, Pu-239, Th-228, Cf-252			$\geq 10^{-6}$	$\geq 10^{-7}$ $< 10^{-6}$	$<10^{-8}$	$\geq 10^{-5}$	$\geq 10^{-6}$ $< 10^{-5}$	$<10^{-6}$

*Nuclides with asterisks are those more likely to require external radiation surveys.

**Assuming continuous sampling is unnecessary (see Section C.1.3).

TABLE 2

RECOMMENDED ACTION LEVELS FOR REMOVABLE SURFACE CONTAMINATION IN MANUFACTURING PLANTS

Type of Surface	Type of Radioactive Material[a]			
	Alpha Emitters		Beta or X-Ray Emitters (μCi/cm^2)	Low-Risk Beta or X-Ray Emitters (μCi/cm^2)
	High Toxicity (μCi/cm^2)	Lower Toxicity (μCi/cm^2)		
1. Unrestricted areas[b]	10^{-7}	10^{-7}	10^{-6}	10^{-6}
2. Restricted areas[c]	10^{-4}	10^{-3}	10^{-3}	10^{-2}
3. Personal clothing worn outside of restricted areas	10^{-7}	10^{-7}	10^{-6}	10^{-6}
4. Protective clothing worn only in restricted areas	10^{-5}	10^{-5}	10^{-4}	10^{-4}

[a]High toxicity alpha emitters include Am-243, Am-241, Np-237, Ac-227, Th-230, Pu-242, Pu-238, Pu-240, Pu-239, Th-228, and Cf-252. Lower toxicity alpha emitters include those having permissible concentrations in air greater than that for Ra-226 (s) in 10 CFR Part 20, Appendix B, Table I, Column 1. Beta or x-ray emitter values are applicable for all beta or x-ray emitters other than those considered low risk. Low-risk nuclides include those whose beta energies are less than 0.2 MeV, whose gamma or x-ray emission is less than 0.1 R/h at 1 meter per curie, and whose permissible concentration in air in 10 CFR Part 20, Appendix B, Table I, is greater than 10^{-6} μCi/ml.

[b]Contamination limits for unrestricted (non-contamination-controlled) areas in this table are considered to be compatible in level of safety with those for release of facilities and equipment for unrestricted use, as given in Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors," and in "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," which is available from the Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

[c]As adapted from Table I of Reference 4. Averaging is acceptable over inanimate areas of up to 300 cm^2 or, for floors, walls, and ceiling, 100 cm^2. These limits are allowed only in those restricted areas where appropriate protective clothing is worn.

Note on Units: The above units of μCi/cm^2 have been used in this table since they are consistent with units adopted as national standards in several other nations and the IAEA (see Reference 6); the units of μCi and cm are already used to express concentration in 10 CFR Part 20, and they are readily convertible to SI units by the well-known relation; 1 μCi = 3.7 x 10^4 dis/sec = 3.7 x 10^4 Becquerels (Bq). They may also be easily converted to other frequently used units of radiation protection practice, i.e., disintegrations/minute per 100 cm^2 = 2.22 x 10^8 x (activity expressed in μCi/cm^2).

Note on Skin Contamination: Skin contamination should always be kept ALARA. Exposed areas of the body of persons working with unsealed radioactive materials should always be monitored and should be washed when any contamination is detected. It is important, however, that contaminated skin should not be so treated or scrubbed that the chance of intake of radioactivity into the body is increased. See Section 1.6 of this guide.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555