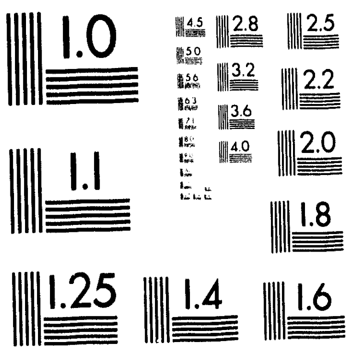
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METHODOLOGY FOR PERFORMING MEASUREMENTS TO RELEASE MATERIAL FROM RADIOLOGICAL CONTROL

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SUMMARY

This report describes, and provides the technical basis for, a new procedure for the release of material that may be radioactively contaminated, either release to controlled areas or unconditional release to the public. The procedure is based on a determination of the likelihood of contamination and either a statistical survey or a scanning survey. The release procedure first requires determining the likelihood that the material is contaminated by considering the actual and typical use of the material. Some material may be released without a survey, if it can be documented that the material has never been exposed or potentially exposed to radioactive contamination. If the material is likely to be contaminated, the procedure mandates a scan survey with instruments that can measure contamination, with a 95% confidence interval, down to the levels of the release guideline values (DOE 5400.5). If the material is not likely to be contaminated, the survey procedure is to first perform a survey for removable surface contamination by taking a swipe of the entire area of the material and then to conduct a survey for fixed contamination. The fixed survey involves performing a minimum of 60 measurements on material with a surface area of at least 0.45 m^2 (5 ft^2) but not more than 28 m^2 (300 ft^2). Each measurement, for both beta/gamma and alpha surveys, is made at a fixed location for 5 seconds, preferably in contact with the surface or at a maximum of 0.6 cm (1/4 in.) from the surface of the material. The 60 measurements ensure, with a 95% confidence interval, that 95% of the surface of the material is not contaminated above the highest reading. If the highest measured reading is less than the release guideline value, the material can be released. The statistical survey provides 95% assurance that 95% of the material is not contaminated at levels above the highest observed measurement. By biasing the fixed measurements toward those areas that are more likely to be contaminated, the confidence level associated with the statistical survey increases.

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INTRODUCTION

The U.S. Department of Energy (DOE) recognizes the need to minimize the volume of radioactive waste generated and shipped for disposal. For DOE, this means that material with radioactive surface contamination above designated background values is not released from nuclear facilities.

It is often necessary to release materials used within controlled and contamination areas at nuclear facilities for either controlled or unrestricted use. Prior to their release, however, the materials must be surveyed to measure any surface contamination to ensure that radioactively contaminated material is not released to the public. The goal of such release measurements is to prevent the release of any material that contains surface contamination above the guideline values listed in DOE Order 5400.5 (DOE 1990). This goal can be realized by using either a scanning or statistical survey protocol, depending on the likelihood that contamination is present on the surface of the material. The release values are listed in Table 1. The guideline values in Order 5400.5, however, are reserved for several radionuclides and do not address tritium. Therefore, for those radionuclides not covered by Order 5400.5, the protocol uses guideline values presented in the DOE Radiological Control Manual (DOE 1992).

A statistical survey for fixed contamination, described herein, can be used if the material that is being considered for release is not likely to be contaminated. If the material is likely to be contaminated, a scan survey should be used. A statistical survey consists of performing 60 fixed, 5-sec measurements (for a total survey time of 5 minutes) on those areas of the material that are most likely to be contaminated, while scanning the material at a rate of 5 cm/s (2 in./s) between measurement locations. The statistical survey will assure that, with 95% confidence, at least 95% of the surface of the material is not contaminated above the highest measurement. Biasing the measurements toward those areas that are more likely to be contaminated will further decrease the percentage of the material that may be contaminated above the highest measured value.

TABLE 1. Surface Contamination Guidelines

Radionuclides[b]	Allowable Total Residual Surface Contamination (dpm/100 cm²)[a] Average[c,d]	Maximum[d,e]	Removable[d,f]
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231	500[g]	1,500[g]	20[g]
Th-Natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay product, alpha emitters	5,000	15,000	1,000
Beta/gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above[h]	5,000	15,000	1,000
Tritium organic compounds, surfaces contaminated by HT, HTO, and metal tritide aerosols	10,000[g]	10,000[g]	10,000[g]

(a) As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

(b) Where surface contamination by both alpha- and beta/gamma-emitting radionuclides exists, the limits established for each type should apply independently.

(c) Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

(d) The average and maximum dose rates associated with surface contamination resulting from beta/gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

(e) The maximum contamination level applies to an area of not more than 100 cm^2.

(f) The amount of removable material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

(g) This release value requires special survey equipment to release material potentially contaminated solely with the listed radionuclide(s). If the potential contamination contains another radionuclide that is detectable with standard instruments, the release survey for that radionuclide will provide reasonable assurance that the material is not contaminated above the values provided in this table.

(h) This category of radionuclide includes mixed fission products, including the Sr-90 that is present in them. It does not apply to Sr-90 that has been separated from the other fission products or to mixtures in which the Sr-90 has been enriched.

A scanning survey consists of moving a contamination detector at a constant speed over the entire surface of the material. The speed of the scan should be chosen such that the guideline values for any contamination can be measured with 95% confidence. Generally, this requires a scan speed of 2.8 cm/s (1 in./s). A scan survey will assure that, with 95% confidence, 100% of the surface is not contaminated above the highest measured value.

Obviously, a scan survey is much more time-consuming than a statistical survey. For example, a statistical survey requires approximately 15 min for material with an area of 300 ft^2 (28 m^2), including the time required to move the detector from one measurement position to the next. The time required to perform a scan survey of the same area is at least 3 h if the surface is completely flat and no overlapping measurements are required. Typically, 3.5 h are needed to scan 300 ft^2 (28 m^2). For material that is not likely to be contaminated, it is not reasonable to expend the time required to perform a scanning survey when the improvement is less than 5%.

Historically, survey procedures at the Hanford Site have included a scan survey for fixed contamination. If contamination above the guideline values is detected, then the survey for fixed contamination is followed by a survey for removable contamination. The scan survey for fixed contamination involves slowly moving a detector over the entire surface of the material to verify that the surface of the material is free of detectable contamination. The survey instruments used, under a mandated procedure, must be capable of detecting levels of surface contamination equal to the guideline values presented in Table 1 and must be appropriate for the type of contamination expected.

In place of current procedures for performing surveys for the release of materials that are unlikely to be contaminated, this report proposes a procedure that includes a large-area swipe survey followed by a statistical survey. The proposed procedure minimizes the chance that the guideline values listed in Table 1 will be exceeded yet decreases the time required to perform the survey. For material that has never been exposed to removable contamination, the protocol would permit release either without a survey or after a large-area swipe survey only.

This report describes the existing and proposed methodologies for performing measurements of contamination prior to releasing material for uncontrolled use at the Hanford Site. The technical basis for the proposed methodology, a modification to the existing contamination survey protocol, is also described. The modified methodology, which includes a large-area swipe followed by a statistical survey, can be used to survey material that is unlikely to be contaminated for release to controlled and uncontrolled areas. The material evaluation procedure that is used to determine the likelihood of contamination is also described.

RELEASE SURVEY METHODOLOGY

All material that is released from the Hanford Site is currently evaluated for the presence of radioactive material, either by survey or by material history, and the release criteria are consistent for all site contractors. For this report, "release" signifies the change of control of material from the Hanford Site, either at the boundary of a radiological area or as the material is unconditionally released to the public. According to current policy, some material is exempt from being surveyed based on its history of use, and all non-exempt material undergoes a scan survey.

The new procedure, illustrated by the flow chart in Figure 1, would enhance the existing methodology and allow for more flexibility when evaluating material that is not likely to be contaminated. There are three main components of the procedure: a material evaluation, a survey for fixed contamination, and a survey for removable contamination. Each of these topics is described in the following subsections.

MATERIAL EVALUATION

The first and most important part of the material release procedure is material evaluation. Material evaluation includes 1) reviewing the material's history of use and the environment(s) in which that use took place; 2) evaluating the material's likelihood of contamination, which includes viewing the material to identify areas of possible contamination, such as stains, cracks, handles, etc., as well as noting possible contamination areas that may be inaccessible; and 3) identifying which radionuclides may be present.

History of Use

The first step in the material evaluation process is to determine the material's history of use. This determination includes an evaluation of the environment in which the material was used or stored, how the material was used or is typically used, and the level of any previous decontamination efforts applied to the material. The history of use may be used to release the material without a survey. Material that has never been used or stored in a contamination area and that has never come into contact with unsealed

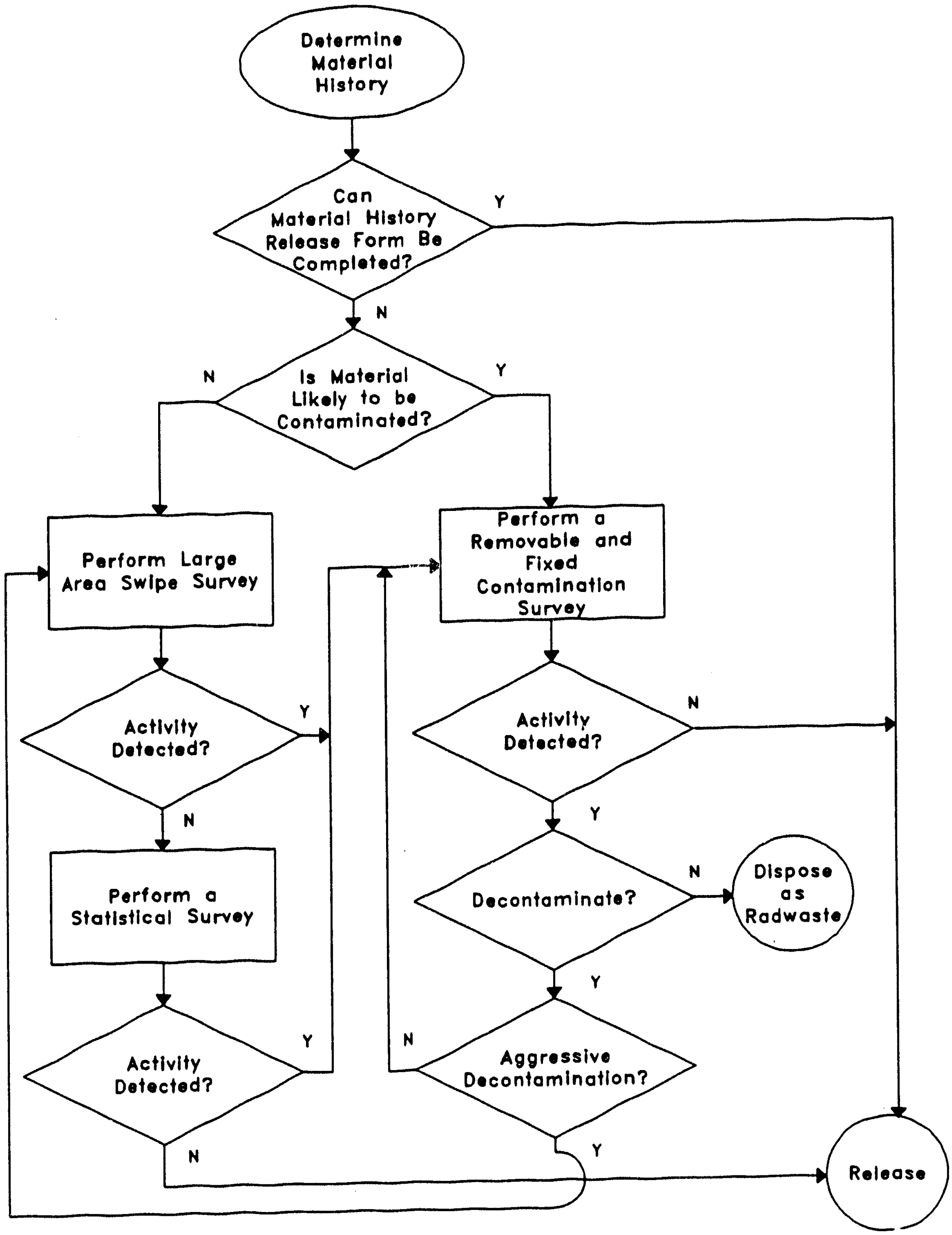

FIGURE 1. Proposed Protocol for Release of Materials

radioactive materials should be released solely on the documented history of its use. This material should be considered to be nonradioactive material and a contamination survey is not required. A Material History Release form is used to document the release of material that is known to be free of contamination by its history of use. If a Material History Release form cannot be completed, then an instrument survey must be made of the material.

Likelihood of Contamination

Prior to performing instrument surveys, the material should be categorized as either likely to be contaminated or unlikely to be uncontaminated. This determination is the second part of the material evaluation process and establishes whether the material is a candidate for release. If the material is considered likely to be contaminated, the purpose of an instrument survey is to characterize the amount of contamination on the material so that decontamination efforts can be initiated. If the material is considered unlikely to be contaminated, the intent of the survey is to support the opinion that the material may be unconditionally released. As will be discussed further, the determination of whether material is a candidate for release greatly impacts the survey technique. The classification of the material as either likely or unlikely to be contaminated may require documentation.

Material that is unlikely to be contaminated includes material used or stored in a radiation area where historical evidence or radiological data indicate that there is little or no unconfined radioactivity and where there is evidence to suggest that the inaccessible areas of the material are not contaminated above the release guidelines. This also includes material used or stored in a contaminated area but used or stored in a manner that would clearly preclude contamination of the material. Contamination of material in this group is possible but unlikely.

Material that is likely to be contaminated includes material known to be contaminated above the release guidelines or suspected to be contaminated because it was used or stored in an area containing unconfined radioactive material that is likely to have contaminated it to levels in excess of the guidelines.

Establishing Survey Regions

Part of the categorization process is to identify different survey areas within a given piece of material. The survey region is determined based on the likelihood of contamination for a given region of the material. For example, a desk located in a radiological area where the floor is known to be contaminated may consist of two survey regions. The legs of the desk may be categorized as a region that is likely to be contaminated while the remainder of the desk may be categorized as a region that is unlikely to be contaminated. The desk as a whole should be considered as likely to be contaminated, but the two survey regions will undergo evaluation by different survey procedures.

If material consists of two different survey regions, each region may be classified as unlikely to be contaminated. However, because the two survey regions were exposed to different environments, each region must be surveyed independently. For example, consider a large desk (surface area greater than 300 ft^2) that has been stored in a surface contamination area and is undergoing evaluation for release. Other desks from the same area have not exhibited contamination levels above the guideline values, so the desk is not likely to be contaminated. The desk can consist of three survey regions. The legs, which potentially have been in contact with surface contamination on the floor; the drawers, where particulate contamination could collect; and the remainder of the desk, including the desktop. Each of the survey regions is placed in the contamination-unlikely group, but each region must be surveyed separately. If one of the regions is found to be contaminated above the guideline values, then only that region requires decontamination and subsequent re-evaluation.

Areas of Likely Contamination

The third part of the material evaluation process is identifying the areas where contamination is likely to exist or accumulate. This includes cracks, corners, handles, wheels, knobs, etc., that are handled more often or that are more likely to become contaminated. Determining likely areas for contamination may not require documentation, but knowledge of areas that are likely to be contaminated is used during a statistical survey for fixed contamination.

Inaccessible Areas

Another use of the material history is in the treatment of inaccessible surfaces. Inaccessible surfaces are those that cannot be accessed by survey instruments in a way that satisfies the necessary source-to-detector geometry. Either the design of the probes and/or the geometry with respect to the material's surface can interfere with the ability to make measurements on all surfaces.

Material history can be used to determine if a mechanism exists for the material to become internally contaminated. It is important to note that fixed surface contamination must originate as loose or removable contamination before becoming fixed or migrating into the material in question. If there is no mechanism for preferential deposition of internal contamination of material, and the material is not contaminated on its accessible surfaces, then it is unlikely that the material can be internally contaminated. For example, a hand-held survey instrument is taken into a contamination area. The instrument does not have a fan and does not have any large vent openings into the body of the instrument. If neither removable nor fixed surface contamination is found on the accessible surface of the instrument, then it is not necessary to survey the internal portions of the instrument because there is no reasonable mechanism by which the inaccessible surface could have become contaminated.

An example of material for which a mechanism for internal contamination exists is a hand-held drill that was used in an airborne contamination area. The motor of the drill is accessible to the atmosphere through cooling vents, and air is propelled through the vents by the action of the motor. In this case, the internal portions of the drill could become contaminated, while the exterior remains uncontaminated and surveys of both the exterior and the interior of the drill are warranted.

SURVEYS OF MATERIAL THAT IS LIKELY TO BE CONTAMINATED

A survey of material that is likely to be contaminated is performed in the same manner as the existing survey procedure. This methodology is to first perform a fixed contamination survey of 100% of the accessible surface of the material. If contamination is detected, a removable contamination survey is performed to determine the location and quantity of any removable contamination.

Scan Survey for Fixed Contamination

A scan survey for fixed contamination requires that the detectors of both alpha and beta/gamma survey instruments be passed over the entire accessible surface of the material. Each detector is moved at a constant rate of 5 cm/s (1 in./s) at a maximum source-to-detector distance of 0.6 cm (0.25 in.). If a change in the audible output of the instrument is heard, that is, if the number of clicks increases noticeably, then the area under the window of the instrument is resurveyed using a fixed measurement for 2 sec to 3 sec. If the increase does not persist, then the scan continues. This procedure is followed until the entire surface of the material has been surveyed. If contamination above the guideline values for fixed contamination is detected, then the material should be reclassified as likely to be contaminated. Following the survey for fixed contamination, a survey for removable contamination is performed.

Survey for Removable Contamination

A survey for removable contamination is made by wiping an absorbent material over a 100-cm^2 area of the material. The surface of the material must be industrially clean, i.e., free of debris, grease, etc. Any removable contamination will be collected on the wipe. The wipe is then counted using an instrument that is sensitive to either alpha or beta/gamma radiation, depending on the type of contamination detected during the survey for fixed contamination. If no detectable radioactivity is measured, then the contamination is considered to be fixed.

SURVEYS OF MATERIAL THAT IS UNLIKELY TO BE CONTAMINATED

For material that is unlikely to be contaminated, a large-area survey for removable contamination (large-area swipe survey) is performed followed by a statistical survey for fixed contamination. Using the two surveys helps to validate the assertion, based on its history of use, that the material is free of contamination.

Large-Area Swipe Survey for Removable Contamination

It can be noted from Table 1 that the guideline values for removable contamination are considerably lower than those for fixed contamination. Because of the low guideline value for removable contamination, and because fixed contamination must originate as removable contamination, surveys using portable instruments are inappropriate for detecting removable contamination. For material that is not likely to be contaminated, a large-area swipe survey is adequate to confirm the absence of residual removable contamination.

The large-area swipe survey is made of the maximum area available, preferably the entire surface of the material, by wiping an absorbent material over the surface of the material. The surface of the material must be industrially clean, i.e., free of debris, grease, etc. Any removable contamination will be accumulated on the wipe and will increase the detection capability of the measurement. The wipe is then held as closely as possible to the window of both a beta/gamma and an alpha measurement instrument, and the count rate is observed. Placing the wipe in contact with the window, if the count rate does not indicate contamination above the guideline values, will further improve the detection capability of the instrument, and because the material is unlikely to be contaminated, it is unlikely that placing the wipe in contact with the window will lead to contamination of the detector. If no detectable radioactivity is measured on the wipe, then a fixed contamination survey is performed.

Statistical Survey for Removable Contamination

The final step in the proposed procedure is surveying for fixed contamination of material that is unlikely to be contaminated. This survey is based on a statistical sampling of measurements obtained on the surface of the material. Throughout this document, the statistical survey for fixed contamination will be denoted as a 5-minute survey, which corresponds to 60 fixed measurements. A series of fixed, 5-sec measurements should be made for a total survey time of 5 min (excluding the time required to move the probe) for each 300 ft^2 (28 m^2) of material. Two such 5-minute surveys should be performed, one each for beta/gamma and alpha contamination. If none of the measurements is higher than the guideline values, then the material can be released. This procedure provides assurance, with 95% confidence, that 95% of the surface of the material is not contaminated above the guideline values.

Each measurement is made at a fixed location for 5 sec preferably in contact with the surface or at a maximum of 0.6 cm (1/4 in.) from the surface of the material for both beta/gamma and alpha activity. Some local facilities may be able to justify not measuring either alpha or beta activity if these radionuclides are not present in the local population. For material that has a surface area less than 0.46 m^2 (5 ft^2), the entire accessible surface should be surveyed using a scan procedure with a 95% confidence interval. The technical basis for statistical surveys is provided in Appendix A.

The survey measurements should be chosen using detector placements that are biased toward those areas that are most likely to be contaminated as determined during the material evaluation process. Health physics personnel should be trained to select areas of higher risk, such as handles, horizontal surfaces, stains, cracks, and other anomalies in the surface in which foreign material is typically collected. This type of selection bias will improve the confidence associated with the statistical survey method. The minimum time of 5 min must be maintained for all material that has a surface area greater than 0.46 m^2 (5 ft^2).

If any contamination is uniformly distributed over the surface of the material, the statistical survey method is independent of the surface area of the material. Practically, however, contamination is typically not distributed uniformly; rather, it is concentrated in specific areas. A maximum area of 28 m^2 (300 ft^2) has been chosen as a practical limit. Thus, a 5-minute survey (60 locations) is required for each 28-m^2 (300-ft^2) area of material.

Material with a surface area less than 0.46 m^2 (5 ft^2) does not provide sufficient area for a statistical survey. In addition, 0.46 m^2 (5 ft^2) can require less than 5 min to scan. For material with less than 0.46 m^2 (5 ft^2) of surface area, all of the surface will be measured using the scanning technique at the scan speed that is required to meet the release guideline values in Table 1 with a confidence level of 95%.

DISCUSSION

The goal of a statistical survey is to reduce the time required to survey material that is not likely to be contaminated without increasing the likelihood of releasing contaminated material. The need to reduce the survey time without affecting detection capabilities is illustrated in the following example.

A bookcase with six removable shelves is to be surveyed. The material evaluation of the bookcase supports the opinion that it is not likely to be contaminated, and a large-area swipe survey does not indicate contamination levels above the guideline values. If 100% of the bookcase is to be surveyed with a beta/gamma instrument that has an area of 15 cm^2 and an alpha instrument that has an area of 45 cm^2, and the bookcase is 3 ft x 6 ft 8 in. with a depth of 1 ft, the time required to survey the bookcase would be 113 min at a scan rate of 2 in./sec (5 cm/s)—if an increase in the audible output of the detector is never heard during the survey and if the time required to complete the documentation of the survey is ignored. If an increase in audible output is heard, and the areas corresponding to the increase are resurveyed for 2 sec to 3 sec each, then the survey time could approach 2 h. A more realistic scan speed to perform measurements with 95% confidence is 1 in./sec (2.5 cm/s), resulting in a scan time of 4 h for the bookcase. The statistical survey procedure, however, will allow the bookcase to be surveyed in less than fifteen minutes, including the time required to move the detector from one location to another.

The greatest source of uncertainty for fixed contamination surveys is the variability associated with scanning. The process of moving the probe at a rate of 5 cm/s (2 in./s), while maintaining a distance of 0.6 cm (0.25 in.), has been the accepted method of performing surface contamination measurements. Personnel achieve varying degrees of success when attempting to meet these requirements because the rate of movement of the probe can vary significantly from person to person and maintaining the minimum distance can be difficult, especially over nonuniform surfaces. Even if the distance and rate are maintained, it is questionable whether the release levels can be consistently detected using the scanning technique, as demonstrated in the following discussion.

A study of the MDA of instrumentation used at the Hanford Site shows that the values in Table 1 cannot be met for some radionuclides under realistic conditions.[a] The measurements were performed using a flat, industrially clean surface with no inaccessible areas. Point sources of beta activity were placed under a thin, optically opaque cover on a plexiglas holder. The beta sources varied in count rate from 50 counts/min above background to 500 counts/min above background. Technicians with varying degrees of field experience were asked to survey the sheet and indicate when they found a source. A summary of the study results is provided in Table 2, with the deficient results noted.

The results presented in Table 2 were obtained by plotting the frequency of detection as a function of activity. The activity associated with 67% detection frequency was used as the MDA value for the radionuclide. The data presented in Table 2 reflect the MDA for scanning surveys with a 67% confidence interval under the measurement conditions. The data for a 95% confidence interval are obtained by assuming that 1 standard deviation is the difference between the 50% detection frequency and the 67% detection frequency and that 95% is essentially the 50% detection frequency plus two times the standard deviation. These data, presented in a separate column that was not a part of the original report, indicate that the appropriate scan speed required to measure the guideline values with a 95% confidence interval is less than 2.5 cm/s (1 in./s).

The statistical survey methodology can reduce the effect of both MDA and time constraints. This approach ensures that, with 95% confidence, 95% of the surface of the material will be free of contamination above the guideline values when surveying with instruments that are capable of detecting activity at the release guide levels. If the highest measurement is less than the guideline values, then the material can be released. This approach uses

(a) Goles, R. W., B. L. Baumann, and M. L. Johnson. 1991. *Minimum Detectable Activities of Portable Contamination Control Survey Instruments*. (PNL-SA-19841, Letter to the U.S. Department of Energy.)

TABLE 2. Comparison of Scanning MDAs and Surface Radioactivity Guides.[a] For this table the acronym PAM denotes a scintillator-based portable alpha monitor, and GM denotes a pancake-type Geiger-Mueller instrument.

	Removable[b]			Fixed		
Nuclide	Guide	PAM	GM	Guide	PAM	GM
U-nat, U-235, U-238, and associated decay products	1,000 alpha	20 alpha	-	5,000	750	-
Alpha transuranic elements, Ra-226, Th-230	20	20	-	500	750[c]	-
RA-228	20	-	200[c]	500	-	10,000[c]
Th-228	20	20	-	500	510[c]	-
I-125	20	N/A[d]	-	500	N/A[d]	-
I-129	20	-	1,700[c]	500	-	65,000[c]
Th-nat, Th-232	200	20	-	1,000	750	-
Sr-90	200	-	150	1,000	-	6,000[c]
I-126, I-131, I-133	200	-	N/A[d]	1,000	-	N/A[d]
H-3	10,000	-	N/A[d]	10,000	-	N/A[d]
Other beta/gamma emitters	1,000	-	150	5,000	-	6,000[c]

(a) Goles, R. W., B. L. Baumann, and M. L. Johnson. 1991. *Minimum Detectable Activities of Portable Contamination Control Survey Instruments*. (PNL-SA-19841, Letter to the U.S. Department of Energy.)
(b) Calculated removable MDAs assuming the detector is used in conjunction with a scaler.
(c) Above the RCM limit.
(d) N/A: Not evaluated because the radionuclides do not exist as surface contamination at the Hanford Site.

separate 5-minute surveys of fixed (not scanning) measurements each for alpha and for beta/gamma measurements randomly distributed over the surface of the material. Each measurement requires 5 sec, and the material may be scanned between fixed measurements. The time required to survey the bookcase for surface contamination in the above example is approximately 15 min for both alpha and beta/gamma measurements.

The rationale behind a scan survey is that measurements are taken over the entire surface of the material. Using a statistical survey method will not provide measurements over the entire surface, so it cannot be stated that the entire surface of the material is not contaminated above the guideline values. It can be stated after a statistical survey, however, that at least 95% of the surface is not contaminated above the highest measured value. Given that a scan survey is typically defined for a 67% confidence interval, a statistical survey of material provides a higher level of assurance at the guideline values than a scan survey. By biasing the statistical survey measurements toward those areas that are more likely to become contaminated, the likelihood of releasing contaminated material is further reduced.

CONCLUSION

For material that is not likely to be contaminated, the statistical methodology will reduce the amount of time required to perform surveys and will improve the detection capability of instrumentation at the guideline values. Based on the above discussion, it can be concluded that the statistical measurement methodology is superior to scanning measurements for detecting contamination near the MDA as measured in the laboratory. Using the material evaluation process will allow the unconditional release without a survey of material that has not been exposed to contamination.

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APPENDIX A

TECHNICAL BASIS FOR 95% STATISTICAL SURVEYS

APPENDIX A

TECHNICAL BASIS FOR 95% STATISTICAL SURVEYS

This appendix describes the technical basis for the minimum number of measurements needed to perform a statistical survey for fixed contamination in order to release material. The required number of measurements is based on a 95% detection rate and a 95% confidence interval.

The minimum number of survey measurements needed in order to release material was determined by using a one-sided nonparametric tolerance interval. This type of tolerance interval can be used to predict the number of measurements required to statistically verify the performance of a process.

The statistical approach to contamination surveys requires the choice of an acceptable tolerance interval, which is defined by two values. For unconditional release, the two values that must be chosen are as follows:

1. The acceptable number of false negative results at the release guideline value. This represents the fraction of the material's surface area that may exceed the guideline value.
2. The confidence interval associated with the number of false negative results.

For the statistical survey, if a confidence interval of 95% and a detection rate of 95% are chosen, the tolerance interval provides a minimum number of 59 measurements (Owen 1986). Thus, if 59 randomly located survey measurements on a material's surface are obtained and if all measurements are less than the release guideline, the following statement can be made: with 95% confidence, at least 95% of the population (all of the possible distinct measurements on the material) will have survey measurements less than the release guideline, and the material can be released. Note that the time required to perform 59 measurements, each having a duration of 5 sec, is nearly 5 min. If the maximum observed measurement is below the guideline value in Table 1 for fixed contamination, the material may be released for uncontrolled use.

A tolerance interval differs from a confidence interval, and that difference is illustrated in the following discussion. Statistically speaking, a confidence interval contains the mean of a sampled population a certain percentage of the time. If the true mean of a population lies in the center of a 95% confidence interval, then the mean of a number of measurements of the population will be within that interval with a frequency of 95%. However, more than 5% of the actual measurement values may be outside of the interval. A tolerance interval bounds a specified proportion of the sampled population and is, therefore, more restrictive than a confidence interval. For example, a tolerance interval for 95% detection with a 95% confidence interval will contain 95% of all measured values for a given distribution, and no more than 5% of the values will occur outside of the interval. Thus the tolerance interval can be used to predict the maximum fraction of measurements that will exceed a given limit. A confidence interval will only predict the frequency at which the mean of a group of measurements will exceed a given limit, and not the frequency at which a given measurement will exceed the limit.

An example that illustrates how a nonparametric tolerance interval works is to consider a barrel of nails. If the barrel contains 1000 nails, and 59 are chosen at random and measured for size, then at most 50 nails in the barrel, with 95% confidence, will be longer than the longest nail measured. If the barrel contains 10,000 nails and 59 are chosen, then at most 500 nails, with 95% confidence, will be longer than the longest nail measured. Note that the nonparametric tolerance interval does not provide any information on the size of the largest nail that is in the barrel.

When applying the nonparametric tolerance interval to surveys for fixed contamination as outlined herein, it is important to note that the chance that 5% of the material is contaminated above the highest measured value applies only if the measurements are taken anywhere on the surface of the material. By biasing the measurements toward areas that are likely to contain contamination, the 5% chance is greatly reduced. Quantifying the reduction, however, is beyond the capabilities of statistics. The likelihood of very high levels of contamination on the material is further reduced by scanning between fixed measurements.

The nonparametric tolerance interval requires that each of the 59 measurements be performed with 95% confidence. By using 5-sec fixed counts, the release guideline values can be measured with 95% confidence for most radioactive contaminants. If the guideline value for a radionuclide cannot be measured with 95% confidence using a 5-sec fixed measurement, then material that is potentially contaminated with this radionuclide should be placed in the contamination-likely group and a statistical survey should not be performed.

Based upon results of surveying less than 100% of any material, it can never be said that all of the possible measurements will be less than the release guideline. However, given that the scanning technique is typically defined for a 67% confidence interval at the release guideline values, the statistical survey represents an improvement over scanning measurements at the release guideline value.

In order to ensure that results obtained using a nonparametric tolerance interval are appropriate, the size of the population (number of distinct survey measurements) must be very large. If a measurement probe has a surface area of 2.4 $in.^2$ (15.5 cm^2), then material having a surface area of 30 ft^2 contains approximately 1800 (=30*144/2.4) distinct measurements. This is large enough to satisfy the requirements needed for the applicability of the nonparametric tolerance interval. Additional calculations show that a minimum of 59 readings is appropriate for material having a surface area as small as 5 ft^2 (0.46 m^2); i.e., a population of a least 300 is required to apply the nonparametric tolerance interval. Note that the same number of measurements must be performed on material with a surface area of 5 ft^2 as on material having a surface area of 300 ft^2.

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Owen, D. B. 1986. *Handbook of Statistical Tables*. Addison-Wesley Publishing Co., Reading, Massachusetts.

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