PNL-8923

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

October 1993

M. L. Johnson

Evaluation of the Eberline TCM-2 Tool Contamination Monitor

PNL-8923
UC-606

12/23/93
DSO

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes **any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.** Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401. FTS 626-8401.

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

EVALUATION OF THE EBERLINE TCM-2
TOOL CONTAMINATION MONITOR

M. L. Johnson

October 1993

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

MASTER

JB

SUMMARY

The Health Physics group at Hanford's B Plant intends to use the Eberline Tool Contamination Monitor (model TCM-2) to survey potentially contaminated objects for unconditional release from the plant. Prior to using the TCM-2, it was evaluated to determine its capability for detecting beta/gamma-emitting contamination at or below the levels given in the Hanford Site Radiological Control Manual. The evaluation addressed how surveying irregular objects and multiple objects affects the sensitivity of the instrument. The results led to development of definitive guidelines for the placement of objects and the distance from the detector to the objects being surveyed. The evaluation determined that the TCM-2 may be used to release from radiological controls items potentially contaminated with mixed fission products if the survey meets the prescribed criteria that were derived from the evaluation process.

CONTENTS

SUMMARY	iii
1.0 INTRODUCTION	1
2.0 METHODOLOGY USED TO EVALUATE THE TCM-2	5
3.0 RESULTS OF THE EVALUATION	9
4.0 RECOMMENDATIONS FOR USING THE TCM-2 FOR UNCONDITIONAL RELEASE OF OBJECTS	13
5.0 CRITERIA FOR RELATING OBJECTS MONITORED WITH A TCM-2	15
6.0 REFERENCES	17

FIGURES

1	Counting Efficiency Required to Achieve an RDA of 5000 dpm in a Given Count Time	6
2	Method Used to Determine Detector Efficiencies for Sources That Are Perpendicular to the Detector	7
3	Efficiency of TCM-2 Detectors	10
4	Efficiency of Top and Side Detectors	11

TABLES

1	Unconditional Release Limits from Hanford Site Radiological Control Manual	2
2	Efficiency of the TCM-2 for Detecting ⁹⁹ Tc Contamination on Perpendicular Surfaces When Multiple Objects Are Surveyed	12

1.0 INTRODUCTION

Pacific Northwest Laboratory^(a) staff, under the Hanford Test and Evaluation Program, evaluated the Eberline Tool Contamination Monitor model TCM-2 with RM-22TB electronics to determine its applicability for use at Hanford's B Plant. B Plant is a waste separation facility that is operated by Westinghouse Hanford Company. The Health Physics group at B Plant plans to use the TCM-2 to release small articles such as hand-held measuring and test equipment from radiological controls. The primary isotopes of concern at B Plant are separated ^{137}Cs , $^{90}\text{Sr(Y)}$, and mixed fission products. The purpose of the evaluation was to determine the conditions under which the TCM-2 can be used to unconditionally release items from radiological controls at B Plant.

The TCM-2 uses six large, gas proportional detectors arranged to form a box into which small items may be placed to be surveyed. The detectors are operated by an RM-22TB electronics package that collects and analyzes data from the detectors. The TCM-2 has the ability to discriminate between pulses caused by alpha and beta/gamma contamination by using anti-coincidence counting. However, the capability of the TCM-2 to detect alpha contamination was not addressed in this evaluation, and the anti-coincidence switches were placed in the OUT (off) position.

The radiation detection instrument may be used to unconditionally release materials or equipment if the minimum detectable activity (MDA) is less than or equal to the values given in the Hanford Site Radiological Control Manual (HSRCM 1992) as shown in Table 1. In this evaluation, the MDA of the TCM-2 for detecting beta/gamma-emitters shown in Group IV of Table 1 was determined. The capability of the TCM-2 to detect contamination in other groups was not evaluated because the isotopes in these groups are generally not present at B Plant. If the TCM-2 will be used to unconditionally release articles potentially contaminated with isotopes from any other group, such as transuranic elements, a separate evaluation will be required.

(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

TABLE 1. Unconditional Release Limits from Hanford Site Radiological Control Manual

Group	Nuclide ^(a)	Removable, dpm/100 cm ^{2(b)}	Total (fixed + removable), dpm/100 cm ²
I	U-natural, ²³⁵ U, ²³⁸ U and associated decay products	1,000 alpha	5,000 alpha
II	Transuranics, ²²⁶ Ra, ²²⁸ Ra, ²³⁰ Th, ²²⁸ Th, ²³¹ Pa, ²²⁷ Ac, ¹²⁵ I, ¹²⁹ I	20	500
III	Th-nat, ²³² Th, ⁹⁰ Sr, ²²³ Ra, ²²⁴ Ra, ²³² U, ¹²⁶ I, ¹³¹ I, ¹³³ I	200	1,000
IV	Beta/gamma-emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ⁹⁰ Sr and others noted above. Includes mixed fission products containing ⁹⁰ Sr.	1,000 beta/gamma	5,000 beta/gamma
V	Tritium organic compounds, surfaces contaminated by HT, HTO, and metal tritide aerosols	10,000	10,000
<p>(a) The values in this table apply to radioactive contamination deposited on, but not incorporated into the interior of the contaminated item. Where contamination by both alpha- and beta/gamma-emitting nuclides exists, the limits established for the alpha- and beta/gamma-emitting nuclides apply independently.</p> <p>(b) The amount of removable radioactive material per 100 cm² of surface area should be determined by swiping the area with a dry filter or soft absorbent paper, while applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. For objects with a surface area that measures less than 100 cm², the entire surface should be swiped, and the activity per unit area should be based on the actual surface area. Except for transuranic elements, ²²⁶Ra, ²²⁷Ac, ²²⁸Th, ²³⁰Th, ²³¹Pa, and alpha-emitters, it is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual contamination levels are below the values for removable contamination.</p> <p>The levels may be averaged over 1 m² provided that the maximum activity in any area of 100 cm² is less than three times the values in this table.</p>			

There are no performance standards or other requirements for fixed contamination monitors such as the TCM-2. Therefore, the only criterion that the TCM-2 was evaluated against was MDA. Before beginning the evaluation, the TCM-2 was calibrated using the calibration procedure provided by Eberline in the TCM-2 operating manual.

The evaluation methodology used, the evaluation results, recommendations for use of the monitor, and criteria for release of objects from radiological control are described in ensuing chapters of this report.

2.0 METHODOLOGY USED TO EVALUATE THE TCM-2

The MDA of the TCM-2 is dependent on the background count rate, count time, and counting efficiency. In turn, the counting efficiency is dependent on source energy and the detector-to-source geometry. The background count rate was assumed to be about 1000 cpm (the background count rate in the 318 Building). The count time requested by the customer was 1 minute. Based on these parameters, the TCM-2 calculates a reliably detectable activity (RDA) that will cause an alarm with a given confidence level.

Because the background count rate was assumed to be 1000 cpm and the count time was given as 1 minute, the primary factor in determining the MDA was the counting efficiency of the instrument under various source/detector geometries. The count time may be increased if necessitated by a high-background count rate in the facility. The background during the evaluation was about 1000 cpm.

Because this evaluation calculated the MDA of the TCM-2 for mixed fission products, the evaluation was conducted using ^{99}Tc and $^{90}\text{Sr}(\gamma)$. The energies of these isotopes span the energies of the isotopes generally of interest when monitoring for mixed fission products. (Because ^{99}Tc is the more limiting isotope, most of the conclusions are based on the results from ^{99}Tc .)

The TCM-2 is operated with an RM-22 TB controller that establishes high-voltage supplies, performs calculations, and alarms as appropriate. The RM-22 simulator program, provided by Eberline and run on a personal computer, was used to determine the minimum efficiency required to achieve an RDA upper limit of 5000 dpm in 1 minute. The results of the calculations, shown in Figure 1, indicate that a minimum efficiency of about 4% is required to achieve a RDA of 5000 dpm.

The instrument efficiencies for $^{90}\text{Sr}(\gamma)$ and ^{99}Tc were measured for various configurations. For example, the efficiency of the detectors was measured using $^{90}\text{Sr}(\gamma)$ and ^{99}Tc point sources located at various distances from each detector. The efficiencies were measured for the surface of the source facing the detector and for the surface of the source perpendicular to the detector.

FIGURE 1. Counting Efficiency Required to Achieve an RDA of 5000 dpm in a Given Count Time

The efficiency of the bottom detector was measured with the metal screen and plastic tool tray in place.

To simulate simultaneous monitoring of several objects, the efficiencies were measured with two cardboard boxes placed side by side, with a ^{99}Tc source taped to the vertical surface of one box as shown in Figure 2. The efficiencies were measured with the boxes at varying distances from each other to quantify the effect of shielding from multiple objects.

These measurements were used to develop criteria for determining if the TCM-2 can be used to release various types of materials.

Not to Scale

FIGURE 2. Method Used to Determine Detector Efficiencies for Sources That Are Perpendicular to the Detector

3.0 RESULTS OF THE EVALUATION

The results of the measurements taken to measure detector efficiencies are shown in Figures 3 and 4. Based on these measurements, a surface that is parallel to a detector may be up to 6 inches from a top or side detector, and up to 3 inches from the bottom detector when the screen and tool tray are in place. A surface perpendicular to the detector should be within 2 inches of a top or side detector. The efficiency of the bottom detector with the screen and tray in place is too low to allow the surfaces perpendicular to the face of the detector to be monitored.

The results of the measurements made to simulate shielding from multiple objects are shown in Table 2. Based on these measurements, multiple objects such as small hand tools or bolts may be surveyed simultaneously if each object is not thicker than 1 inch and the objects are at least 1 inch apart. If the objects are thicker (up to 2 inches thick) the objects should be at least 3 inches apart. During surveys of multiple objects, the top detector should be moved as close as possible to the objects.

FIGURE 3. Efficiency of TCM-2 Detectors - Surface of source is parallel to detector. Bottom detector shielded with metal screen and plastic tray.

FIGURE 4. Efficiency of Top and Side Detectors - Surface of source perpendicular to detector.

TABLE 2. Efficiency of the TCM-2 for Detecting ^{99}Tc Contamination on Perpendicular Surfaces When Multiple Objects Are Surveyed

Bottom Detector, Screen and Plastic Tray in Place			
Distance Between Objects, inches	Distance Between Source and Detector, inches		
	1	2	3
	Efficiency for ^{99}Tc (cpm/dpm)*100		
1	1.6	0.6	0.3
2	1.8	1.3	0.7
3	1.9	1.3	1.0

Top Detector, No Screen or Plastic Tray			
Distance Between Objects, inches	Distance Between Source and Detector, inches		
	1	2	3
	Efficiency ^{99}Tc (cpm/dpm)*100		
1	4.2	1.7	0.5
2	6.3	3.0	1.6
3	7.0	3.9	2.1

4.0 RECOMMENDATIONS FOR USING THE TCM-2 FOR UNCONDITIONAL RELEASE OF OBJECTS

The RM-22 program uses the efficiency of the TCM-2 detectors to determine the RDA. Because the efficiency is dependent on the distance between the source and detector during calibration, this distance limits the maximum distance allowed between an object and a detector. The TCM-2 can be expected to reliably alarm when it detects activity at or below the RDA if the object surveyed is no further from the detector than the source was during calibration. Hence, if the TCM-2 were calibrated with a source 3 inches from the detectors, an object would have to be within 3 inches of the detectors to ensure that the survey was capable of meeting the required detection limit. Because the required sensitivity can be achieved with the calibration source 6 inches from the detector, which allows greater flexibility in using the monitor, it is recommended that the TCM-2 be calibrated with the source 6 inches from the detector.

The instrument should be calibrated using a beta source located 6 inches from the top and side detectors and 3 inches from the bottom detector. If the TCM-2 will be used with the metal screen and plastic tool tray, these should be in place during calibration so that the efficiency measured during calibration reflects the efficiency achievable in the field. The calibration source selected should represent the lowest-energy isotope expected in the facility, usually ^{137}Cs . Therefore, it is recommended that the TCM-2 be calibrated with ^{137}Cs . Strontium-90(Y) may be used; however, greater sensitivity will be achieved with the lower-energy source. Choosing a lower-energy source would help compensate for less-than-ideal geometry and surface conditions.

Because the HSRCM (1992) requires a 95% statistical survey for performing unconditional release, the instrument should be set up with a Sigma Factor of 4 and an RDA Confidence Level of 95%. With these parameters, the TCM-2 would have a 5% false alarm rate and a 5% probability of not alarming upon detection of a contaminated object; thus, it would meet the HSRCM requirement.

The instrument should be operated in Mode 2 with a maximum RDA of 5000 dpm and a count time of 60 seconds. The monitor will then adjust the actual RDA used to establish alarm set points to the lowest RDA achievable within the set count time. If the maximum RDA is not achievable within the set count time, the monitor will alarm upon detecting high background and the operator may increase the count time. Mode 2 is recommended because only in Mode 2 can the TCM-2 adjust the RDA to a value less than the maximum RDA of 5000 dpm. Having an RDA potentially less than 5000 dpm would compensate for less-than-ideal geometry and surface conditions.

To protect the bottom detector from contamination, the TCM-2 should be used with the plastic tool tray in place, which degrades the efficiency of the bottom detector. Therefore, unless the entire bottom surface of the object is within 2 inches of the tray (about 3 inches from the detector), the object should be turned over and surveyed a second time.

Over time, the tool tray can become contaminated. A contaminated tool tray would be indicated by an increased background and, possibly, by a high-background alarm. Periodically, while using the TCM-2, the tool tray should be checked for contamination. This is done by lowering the top detector to its lowest position and using it to survey the tool tray.

The top detector of the TCM-2 can be lowered and raised to accommodate objects of various sizes. Because the sensitivity of the instrument is improved by minimizing the distance between the object and a detector, the top detector should be lowered to be as close as practical to the object.

5.0 CRITERIA FOR RELATING OBJECTS MONITORED WITH A TCM-2

Based on the results given in Section 4.0, criteria were developed to help decide whether or not a TCM-2 may be used to unconditionally release objects. If an object meets the criteria listed below, the TCM-2 will be capable of detecting 5000 dpm or less of beta/gamma contamination on the object. In some cases, it may be necessary to survey an object twice, rotating it between surveys, to ensure that all surfaces are within the allowed distance from a detector.

The TCM-2 may be used to release objects that meet the following criteria:

- The object shall have a nonporous surface.
- The object shall be free of oil and dirt.
- The entire bottom surface of the object should either touch or be within 2 inches of the plastic tray. If not, the object should be turned over and resurveyed.
- Each surface of the object must be within 6 inches of a detector that is parallel to the surface or within 3 inches of a detector that is perpendicular to the surface (except for the bottom detector).
- The TCM-2 may not be used to release objects with potentially contaminated internal surfaces unless the internal surfaces are surveyed separately using a portable survey instrument.
- If multiple objects are surveyed simultaneously, each object should be less than 2 inches thick and the objects should be spaced a minimum of 3 inches apart.

6.0 REFERENCES

Eberline Instrument Corporation. 1990. Eberline TCM-2 Tool Contamination Monitor, Operating Manual. Eberline Instrument Corporation, Santa Fe, New Mexico.

Munson, L. H., G. J. Vargo, and D. H. Denham, eds. 1992. Hanford Site Radiological Control Manual. HSRCM-1, Pacific Northwest Laboratory, Richland, Washington.

DISTRIBUTION

No. of
Copies

No. of
Copies

OFFSITE

ONSITE

12 DOE/Office of Scientific and
Technical Information

20 Pacific Northwest Laboratory

D. M. Brehm, P7-78
R. F. Brich, A5-55
S. J. Davis, S6-81
J. E. Edmond, P7-01
D. M. Fleming, P7-01
R. J. Ford, L8-19
D. J. Foust, G7-40
T. J. Froelich, P7-01
B. C. Gibson, L8-19
R. W. Goles, P7-01
M. L. Johnson, P7-01
J. E. Kane, L8-19
A. P. Mileham, P7-78
K. L. Swinth, K3-55
Publishing Coordination
Technical Report Files (5)

END

**DATE
FILMED**

1/20/94