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WIPE SAMPLING – REVIEW OF THE LITERATURE

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ABSTRACT

Methods for characterization of solid, non-compactable radioactive wastes contaminated in the surface are developed aiming at estimating the waste radioisotopic inventory for regulatory compliance and operational purposes. The wastes of interest here are mainly composed of plastic, metallic, or other materials parts originated in the decommissioning and maintenance operations of nuclear facilities. One way of measuring surface contamination is the indirect method of wiping the contaminated surface and counting the wipe, a common method of detecting non-fixed contamination in the radiation protection routine. The wipe sampling is an important tool in controlling the quality of the workplace in nuclear and radioactive facilities. Although radioprotection regulations establish quantitative limits, the practice in the radiation protection routine is to use wipe sampling as a qualitative measurement. To produce useful quantitative results for inventorying radioactive wastes, a quantitative approach must be adopted. A previous paper presented by the authors in the last INAC Conference discussed alternative wipe materials and protocols. The method of wipe sampling underwent small changes since it started to be used but still is the object of study, as it is attested by many recent papers and patents on the subject. This article consists of a literature review. Results of a survey in the literature about wipe sampling techniques that can be applied to waste characterization are presented.

1. INTRODUCTION

Wipe sampling is a method of monitoring to evaluate the level of removable radioactive contamination, in surfaces of workplace and pieces of equipment in nuclear facilities, for radiation protection purposes. It is a tool for radioactive contamination monitoring for regulatory compliance and quality control in hospital radiopharmacies, nuclear medicine clinics, nuclear power plants, other nuclear fuel cycle facilities, and radioactive research laboratories. It is used for characterizing surface contamination for the following reasons: decommissioning operational areas, evaluating the effectiveness of clean-up of spills, evaluating compliance with housekeeping levels in operational areas, characterizing pieces of equipment for release from control.

Wipe tests uses a disc of an absorbent material like paper, cloth, glass fiber filter etc, which are wiped with firm pressure over the contaminated surface to be monitored, removes part of the contaminant that is subsequently assayed by an appropriate method. The contaminants can then be identified and their concentrations determined.

In this paper, we discuss available published literature on wipe sampling aiming at using this review to base further research on application of wipe sampling for characterizing non compactable radioactive wastes, composed of large pieces of equipment, for release.

Since its birth in 1925, the radiological protection has been searching for techniques of radiation control and safety to assure a safe work with radioactive sources. The monitoring is one of such techniques and aims at verifying the efficacy and effectiveness of radiological protection practices and detecting deviations from planned paths. The monitoring of surface contamination is part of this control to avoid or limit internal and external exposures. Wipe sampling and wipe tests coexist with other direct methods of surface monitoring like surveys with pancake probes, passive measuring with dosimeters, and other methods of sampling like adhesive tape and even the destructive methods of laser ablation.

2. METHODOLOGY

The methodology of the present study consisted of a search of published literature related to wipe sampling in national and international collections available on line, using Boolean expressions and internet searching engines. Extensive internet searching was used in a first, broad scope search, using keywords such as ‘wipe sampling’ or ‘swipe’ and ‘smear test’.

Example of Boolean expressions used in this search is (wipe OR swipe OR smear) AND (sample OR sampling OR test).

References from the International Nuclear Information System (INIS), the Energy Citation Database (ECD), the Nuclear Science Abstracts (NSA), and the Nuclear Science References (NSR) spanning from 1943 to the present were examined. Literature published in the Web was searched for using the Google Search Engine. Data bases in the libraries of IPEN and CNEN were also used, as the Biblioteca Digital Memória (Digital Memory Library) of CNEN, which provided published reports since 1956. Keywords in Portuguese, English, French and Spanish were used to retrieve documents. The search words were: Portuguese: ‘teste de esfregaço’; English: ‘wipe test’; French: ‘frottis’; Spanish: ‘prueba de frote’, and other terms related to surface contamination.

Retrieved documents included books, journal papers, technical reports, regulations, standards, operational procedures, and operation manuals of equipment. They were briefly examined and assorted to further reading or discarded.

3. RESULTS

3.1 Radiation protection

Since the modern radiation protection philosophy was adopted, the use of ionizing radiation in medicine, industry and research, emphasis is given in limiting the detriment of radiation effects and limiting the risk of exposures for the sake of getting the benefits of these applications [1]. Untrained workers, ill designed equipment, mistakes and unfortunate events can cause spills, airborne radioactivity and contamination. In the past, contamination with radioactive substances was given less attention. The famous example of contamination of the

young workers of a factory in New Jersey in early XX Century with radium paint is solely one [2-3]. Even in the middle seventies of last century, one of the authors witnessed extensive contamination with radium paint in a luminous dial clock factory.

The safety measures against the risk of contamination with radioactive substances, radium in this case, were basically caring in the manipulation and appropriate shielding. It was believed that these precautions were enough to avoid the 'skin burnings' that were considered for a long time the main hazard. However, the effects of theses exposures appear later and were severe [3].

Instruments to monitor ionizing radiation were developed, for instance, the Geiger-Muller counter in 1928, which was then improved to specific applications, like monitoring alpha radiation emitted by surface contamination plutonium, during the Manhattan Project [4]. An array of instruments was created to monitor air, surface, area and personnel contaminations, for instance the ionization chamber adapted to detect alpha particles, in 1944, although without agreement among universities, laboratories and the ICRP [5] on the limits for surface contamination that should be adopted. The criterion was the potential radiological risks of the incorporated radionuclides by inhalation or by contact with the skin. [3, 5-6].

The smear test, was described as an abrasive technique where a piece of filter paper mechanically smeared the surface with uniform pressure collecting the contaminant for further analysis [7]. This technique was deemed quantitative, based on the belief that the fraction of the contaminant that is transferred to the smear, called transference fraction, was known and was constant, allowing to characterize the contamination [8-9].

However, obvious differences between the mode dust particles settled in and adhered to different surfaces were expected to cause deviations from the adopted value of transfer factor surface-wipe [7]. In 1964, experiments performed in the Oak Ridge National Laboratory, in Tennessee evaluated the transfer factor for different wipe materials and surfaces to compare with, including the adhesive tape sampling method.

The results confirmed a large variation in the fraction of the contamination that was transferred to the wipe, and showed that the adhesive tape transferred the contamination more uniformly and reproductively than the wipe, independently of the surface roughness and individual performing the test. In conclusion, the tests considered the wipe sampling not quantitative, though useful when used keeping in mind those limitations [10].

3.1.1 Radioactive contaminants

Concerns about radioactive contaminants arose during the Manhattan Project and increased after the war because of the large scale production of fissile materials and radioactive fission products. Over time, the production and use of radioisotopes for medical, research and industrial applications required more and more use of monitoring of surface contamination, because of the risk of internal contamination via skin contact, inhalation and ingestion [2].

3.1.2 Check of sealed sources

From 1959 onward, a regular check of leakage of sealed sources was required as a normal procedure for safe handling of sealed sources [11]. Brazilian regulations, for instance CNEN-NE-3.06 [12], require periodic assay of sealed sources by wipe sampling. The leakage of radium sources manufactured long before the nuclear age started massively producing sealed sources was an unnoticed problem.

Wipe sampling of shielding, packages and accessible ports and openings in sealed source packages is required before and after transportation, before dispatching and after receiving the cargo [13].

3.1.3 Monitoring of surfaces at workplace

There are many papers connecting wipe sampling with control of contamination in radioactive facilities, since early 1960's [2-3,5-7]. Although recognizing the lack of standardization in the procedures [14], it was used as a confirmation of results obtained by other methods, the fraction of the contamination present in the surface which was transferred to the wipe being called transfer factor [8], [9].

Wipe sampling surfaces in the workplace for control of contamination was required both as a precautionary measure and as a confirmatory measurement to assure that decontamination process achieved the release level [6].

The results of an investigation on the efficacy of the wipe sampling method realized in Oak Ridge National Laboratory, in early 1960's, showed that variations in surface properties induced large variations in the transfer factor. Roughness of the surface is the main factor [10]. Results showed that the adhesive tape method was more reproducible than the conventional method of wiping the surface with absorbent paper, cloth or gauze, with the conclusion that wipe sampling could not be quantitative but was useful as long as care was taken with the characteristics of the surface being assayed [10-13].

3.2 Wipe sampling in radioactive waste management

Wipe sampling is one of the methods recommended for waste characterization [1]. The measurement of surface contamination can be used to characterize the non-compactable radioactive wastes before treatment and to verify that candidate materials for release are below regulatory limits. These aims are particularly important in the management of wastes generated in the decommissioning of radioactive and nuclear installations.

In wipe sampling the surfaces of pieces of equipment and materials from decommissioning operations the problem of representativeness and reproducibility of results is even more difficult because of the variability in surface characteristics and sampling procedures [15], [16]. Underestimation of the concentration of activity can result in, for instance, releasing as if they were below regulatory limits, materials that should be kept under regulatory control, or otherwise, the overestimation of the activity concentration can lead some materials to be treated was radioactive wastes when actually they are not. Notwithstanding this, in many

cases it is the only available method that allows obtaining an approximation of the radioactive inventory of such wastes [11].

3.3 Comparison of sampling methods

Results of a study on sampling with sixteen different surfaces and sampling methods showed that adhesive tape is the best method to perform representative sampling independently of the area of the sampled surface – a change from 20 cm^2 to 200 cm^2 showed no loss of efficiency on counting the wipes [14].

3.4 Wipe sampling at IPEN

In 1959, with support from the IAEA, the Institute of Atomic Energy (IEA) commissioned the laboratory of dosimetry in the presently named IPEN. Wipe sampling was among the monitoring methods then used in the radiological protection procedures of the operational routine at the institute [17].

Presently, the Radioactive Waste Management Laboratory at IPEN uses wipe sampling regularly, as a means of monitoring surface contamination of waste packages for regulatory purposes and start using it as tool for screening and characterization of wastes [18].

3.5 Standardization of surface contamination monitoring

Radioactive and non-radioactive contamination of surfaces are monitored by means of wipe sampling [2,19-20] with accuracy of results depending on the factors already mentioned, as quality of surface, wipe material, procedures etc. [15-16]. Some improvements are reported in the methods [21-22].

The ISO Standards 7503-1 and 7503-2 [23] establishes values for the transfer factor to be used in radioactive contamination sampling between 0.05 to 0.5, depending on the surface smoothness. A value of 0.5 should be used in sampling glass, stainless steel and smooth surface plastics; 0.1 should be used in permeable surfaces like concrete and wood; and 0.05 for other kinds of surfaces.

A large laboratory in USA chose to establish an internal standard [24] to guide the use of wipe sampling in its operations in order to achieve a higher degree of accuracy and repeatability. A study on the performance of wipe sampling conducted by Chavalitnitkul [25], Stephen Billets [26].

A Literature Review of Wipe sampling Methods for Chemical Warfare Agents and Toxic Industrial Chemicals, indicated that personal variations in performing wipe sampling caused by the pressure applied during sampling as well as the lack of a consistent sampling area resulted in large differences in the transfer factor, which varied from 31% to 212%, the later value being the result of inaccuracy in reporting the sample area besides the other factors [26].

3.6 Final remarks

The retrieved literature showed that surface contamination and its control and monitoring concerned laboratory safety personnel since the beginning of the nuclear technology development and reflected concerns on safety in other areas of occupational risks too.

The method of wipe sampling underwent small changes since it started to be used but still is the object of study, as it is attested by many recent papers and patents on the subject [26]. The wipe sampling, smear sampling or swipe sampling, the names by which are know the technique of measuring the degree of contamination, or only the presence or not of contamination, is an important tool in controlling the quality of the workplace in nuclear and radioactive facilities.

REFERENCES

1. International Atomic Energy Agency. *Governmental, Legal And Regulatory Framework For Safety*, Safety Standards Series No. Gsr Part 1, General Safety Requirements IAEA, Vienna (2010).

2. S. Ness, *Surface and dermal monitoring for toxic exposures*. Van Nostrand Reinhold, New york, EUA (2010).

3. B. C. Hacker, *The Dragon's Tail: Radiation Safety In The Manhattan Project, 1942-1946*. University Of California Press, 1987. Available At: http://books.google.com.br/books (2010).

4. "The Internet Encyclopedia Of Science. Geiger-Müller Counter." http://www.daviddarling.info/encyclopedia/g/geiger-muller_counter.html. (2010).

5. G. W.; Spangler, C. A. Willis, *Permissible Contamination Limits.* Surface Contamination: Proceedings Of A Symposium *Held At Gatlinburg*. Tennessee Editor: Fish, B. R. Symposium Publications Division, (1964).

6. H. J. Dunster, *The Concept Of Derived Working Limits For Surface Contamination.* Surface Contamination: Proceedings Of A Symposium Held At Gatlinburg Tennessee. Symposium Publications Division, (1964).

7. B.R. Fish; G. W. Walker; Roysterjr. ; J. L. Thompson, *Redispersion Of Settled Particulates.* Surface Contamination: Proceedings Of A Symposium Held At Gatlinburg Tennessee. Symposium Publications Division, (1964).

8. R.T. Brunskill, *The Ralationship Between Surface And Airbone Contamination.* Surface Contamination: Proceedings Of A Symposium Held At Gatlinburg Tennessee. Symposium Publications Division, (1964).

9. J. R. Prince; C. H. Wang, *A Method For Evaluation Surface Contamination Of Soft Beta Emitters.* Surface Contamination: Proceedings Of A Symposium Held At Gatlinburg Tennessee. Symposium Publications Division, (1964).

10. G. W. Royster; B. R. Fish, *Techniques For Assessing Removable Surface Contamination.* Surface Contamination: Proceedings Of A Symposium Held At Gatlinburg Tennessee. Symposium Publications Division, (1964).

11. "Martin Division Nuclear. Thermoelectric Generator Safe Handling Procedures. Usa: U.S. Atomic Energy Commission," http://www.osti.gov/energycitations/servlets/purl/4225733-nnbhkn/. (2010).

12. Comissão nacional de energia nuclear. Requirements for radioprotection and safety in radiotherapy services. CNEN, Rio de Janeiro, 1990. CNEN-NE-3.06.

13. "Health-Physics Monthly Information Report," http://www.springerlink.com/content/tf5405y91qcknqfr/fulltext.pdf (2010).

14. "Health Phisics Division 1961. Studies Of Surface Contamination," http://www.osti.gov/energycitations/servlets/purl/966959-9PPBby/ (2010).

15. B-K.Seo; B-J.Lee; K-W. Lee; J-H. Park, *Development Of An Automatic Smear Sampler And Evaluation Of Surface Contamination. Radiation Protection And Dosimetry*, **Vol. 112**, No. 2 287-290 (2004).

16. A. E. O. Barbieri; R. Ferreira; R. Vicente, "Wipe Sampling For Characterization Of Non-Compactable Radioactive Waste". *INTERNATIONAL NUCLEAR ATLANTIC CONFERENCE*. Rio de Janeiro, (2009)

17. C. Mcfarland, *Determination Of Beta-Particle Counting Efficiency For Wipe-Test Samples.* Radioactivity & Radiochemistry. **Vol. 8**, No. 3 (1997).

18. "National Committee For Nuclear Energy**.** Reports," http://memoria.cnen.gov.br/doc/pdf/relatorios/relatorio1979.pdf. (2010)

19. Berthold Technologies. *Wipe Test.* Berthold Technologies Gmbh. Bad Wildbad, Germany (2006).

20. J. Floeckher, Swipe Assays. *Application Note, Packard Bioscience Company.* Meriden, Connecticut. (200?).

21. R. W. Schroder, *Surface Contamination :* Proceedings Of A Symposium Held At Gatlinburg Tennessee. Symposium Publications Division, (1964).

22. G.W. Wright, *Discussion Of Challenges Encountered During The Collection And Submission Of Wipe/Leak Test Samples.* Journal Of Radioanalytical And Nuclear Chemistry, **Vol. 264**, No. 2 351-355 (2005).

23. International Organization For Standardization, *Evaluation Of Surface Contamination – Part I: Beta-Emitters(Maximum Beta Energy Greater Than 0,15 Mev) And Alpha-Emitters* ISO7503-1. Geneva, (1988).

24. Brookhaven National Laboratory. *Surface Wipe Sampling Procedure.* Industrial Hygiene Group, Upton, Ny, (Field Procedure No. Ih75190) (2007).

25. C. Chavalitnitkul, And L. Levin, *A Laboratory Evaluation Of Wipe Testing Based On Lead Oxide Surface Contamination.* American Industrial Hygiene Association Journal. Vol. 45(5):311-317.That Was Reviewed By Billets (1984).

26. J. R. Verkouteren, J. L. Coleman, R A. Fletcher, W.J. Smith, G. A. Klouda; G. Gillen. *A Method To Determine Collection Efficiency Of Particles By Swipe Sampling*. Meas. Sci. Technol. 19 115101 (2008).