UNIVERSITY OF UTAH RESEARCH REACTOR WASTE MANAGEMENT

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ABSTRACT

For several decades, the University of Utah Nuclear Engineering Facility's source storage room has been used to store laboratory waste, used air filters, irradiated electronics, and several other radioactive samples from experiments over the years. Activity and radioisotope information for many of these items were either outdated or undocumented. The Utah Nuclear Engineering Program (UNEP) has recently developed a strong engineering safety culture. As part of this engineering safety culture new staff members assessed the concerns about the unknown items and waste occupying the source storage room. In order to determine the materials and items present as well as train UNEP students in methods applicable to the assessment of radioactive waste, a rigorous step-by-step procedure was developed. The aim of it is to assess, label and dispose of this waste. The protocol is built on the foundation of how cautiously to approach unknown materials, and determine the level of radioactivity and the elemental composition of the items. The identification of radioisotopes in items is determined with high-purity germanium detectors. This effort is benefiting both, the students assigned to participate in this project in learning and applying regulations and license requirements for waste management, as well as the facility at large in assessing, labelling, and cleaning old and forgotten waste items.

1. Introduction

UNEP has established and continues to build strong nuclear and engineering safety cultures by developing class and laboratory soft skills training and activities [1], [2], [3]. One area that has resulted in a concerted effort is the assessment and cataloguing of equipment and materials in the facility. Over the course of a few decades the UNEP source storage room served as a temporary radiological waste storage area. With new staff and an emphasis on the integration of a healthy and protocol-determined safety culture [4], [5], from 2009 the UNEP leadership notified it to be the *area for improvement*. This storage room contains waste coming primarily from laboratory waste bags, used air filters, contaminated laboratory equipment, activated electronic components and samples from various past experiments. UNEP staff identified these items to be sorted for waste disposal. The handling and disposal of radioactive waste is regulated by the State of Utah and the U.S. Federal Government [6], [7].

In general, all waste disposal services at the University of Utah are provided by the Radiological Health Department for all affiliated laboratories including UNEP's facility. Waste is to be separated by half-life, categorized by material and an arrangement

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must be made to schedule for take-away. Identification of radioisotopes and an approximate activity present are necessary [8]. This information is not available due to lost documentation and lack of labelling and historical data for the waste items located in the source storage room. While a few items had previously been labelled with this information, years of disuse called into question the accuracy of these measurements particularly for short-lived radioisotopes. A new procedure was thus developed to assess, label and categorize the items in a systematic and highly-organized manner. The identification of elemental radioisotope content is based on the high-purity germanium detectors for measuring activity and identifying radioisotopes. This procedure serves dual functionality as an improvement to the UNEP facility and as an educational opportunity for the students involved. This has allowed UNEP students to not only learn the theories of nuclear radiation in class but have a hands-on experience in real world problems and solutions associated with radioactive waste.

2. Procedure

The UNEP students were tasked with developing the plan to determine and segregate the waste. The basic procedure is defined as follows:

1. *Preparation* – ensures that actions taken are well documented and all detectors are functioning properly; the background readings are collected and are referenced for qualitative comparison to waste item counts:
    - Begin daily log, record date
    - Record serial number of Geiger-Müller survey meter and ensure it is within calibration date
    - Perform battery test with Geiger-Müller survey meter and record count rate of thorium lantern mantle (cpm)
    - Record background count rate (cpm) at designated measuring table
    - Record count rate (cpm) at the doorway of the source storage room
    - Perform background measurement with high-purity germanium detectors, saving background file for subtraction from later counts

2. *Swipe Test* (per waste item) – this procedure is a protective step in providing confidence that no dispersible radionuclides contamination will be spread into the rest of the facility when removed from the source storage room:
    - Swipe surfaces of waste item using laboratory wipes
    - Using Geiger-Müller survey meter, record count rate (cpm) of wipe at designated measuring table
    - If count rate does not exceed double background reading:
        i. Proceed to Frisk Survey
    - If count rate exceeds double background reading:
        i. Place item in a plastic bag
        ii. Proceed to Frisk Survey

3. *Frisk Survey* (per waste item) – collecting basic information documenting the item and providing a basis to determine the length of detection time using the high-purity germanium detector. This measurement is taken outside of the source storage room.
   - Remove item from source storage room and place on designated measuring table
   - Take a picture of the item with laboratory camera
   - Record image number and basic description of item
   - Label item by image number
   - Using Geiger-Müller survey meter, record count rate (cpm) of item directly
   - Proceed to High-Purity Germanium Detection

4. *High-Purity Germanium Measurements* (per waste item) – provides quantitative assessment of item radioactivity.
   - If Geiger-Müller count rate does not exceed double background reading:
     i. Perform a 1-minute count using high-purity germanium detector
     ii. If no prominent energy peaks exist in gamma spectrum:
        1. Designate as “clean” waste
        2. May be disposed of as non-radioactive waste
     iii. If prominent energy peaks exist in gamma spectrum:
        1. Proceed as if count rate were originally above double background reading
     iv. Save high-purity germanium detector spectrum file and record file name
   - If Geiger-Müller count rate exceeds double background reading:
     i. Record mass of item
     ii. Perform a 5-minute count using high-purity germanium detector
     iii. Identify and record prominent, contributing radionuclides
        1. If significant unidentified energy peaks exist, perform a recount with an extended count time as seen fit.
     iv. Calculate and record estimated activity for each radioisotope
     v. Save high-purity germanium detector spectrum file and record file name
     vi. Return to source storage room awaiting disposal.
     vii. Ensure proper tagging of information obtained is placed on waste.

High-purity germanium detection constitutes the finalized collection of radioisotope information regarding an item and the data collected determine how to dispose the waste item. Following this procedure, a spread-sheet of all processed items is created thus providing an electronic record for the item. An example portion of this spread-sheet is shown in Table 1.

Table 1: UNEP Waste Management Protocol: Waste Item Summary Form

Sample ID	1324		
Date	6/17/2016		
Description	Pipe Coupling		
Mass (g)	90		
Swipe (cpm)	80		
Frisk (cpm)	11000		
Count Time (min)	10		
Notes	Gamma Analysis 6/17/2016		
	Dry waste; Long-lived / Beta-gamma		
	Isotope	**Activity (µCi/g)**	**Total (µCi)**
	Co-60	2.38E-02	2.14

Using the entirety of information collected and the waste items summary, a higher-level decision is then made in regard to sorting the waste items per their content such as radioisotope and activity. For example, several items containing Co-60 isotope may be combined and disposed as one single waste item, simplifying thus the waste process. Table 2 shows an example of one of these combined waste item information sheets; these items are then sent to the Radiological Health Department for their terminal disposal. This includes a section summarizing the measured values which are used in providing conservative activity estimates as well as outlining the assumptions made.

3. Progress and Outcomes

Nearly 300 items have been processed comprising near the entirety of undocumented waste items. Clean items are removed or repurposed within the facility. Other items are either disposed as radioactive waste or are yet to be disposed. The clean-up project is successful in creating more useable space in the source storage room, as shown in Figure 1.

Table 2: UNEP Waste Management Protocol: Waste Disposal Summary Form

Waste Disposal Summary Sheet		
Major Isotopes	**Activity Estimate**	**Dose Rate:**
K-40	0.1 µCi	0.75 mrem/hr on contact
Co-57	0.1 nCi	
Co-60	5.5 µCi	
		Description of Items
		• Electronic components • Contaminated / Inseparable Packaging
Assumptions & Approximations Made:		
• Two items had Co-60 measurements at two magnitudes of activity higher than all other individual items. These two are used to approximate the total by rounding up from 3.04 µCi + 2.14 µCi to the value shown for the total. • A single item also has the most K-40 Activity by two magnitudes, and is rounded up from 7.54E-02 µCi to the value shown for total. • Co-57 is found in on only a single sample and rounded up to the value shown. • Individual items that were scanned are all of small enough size that they were treated as point source geometries in calculation of total activity.		

Fig 1: Comparison of UNEP source storage room: before waste procedure (left) and after waste procedure (right).

In addition to this assessment which utilizes the new waste management protocol, a new way of documenting waste items in the facility is as well established; additionally, this project served as an educational opportunity for UNEP students. It is important to state that in preparation to work in the facility, these students take a course in General Radiation Safety from the Radiological Health Department which introduces practical aspects of radiation and radiological laboratory techniques. Following completion of this course, students are responsible for the design of this procedure, which emphasizes the radiological safety aspects learned. In the waste disposal procedure, students gain hands-on experience working in a nuclear facility and applying basic principles from their nuclear engineering coursework. Use of the high-purity germanium detectors for radioisotope identification provides a basic understanding of the device operation and is similar in practice to those skills used in neutron activation analysis.

This same practice of allowing students to explore and expand their knowledge of principles and tools in nuclear engineering practices could be expanded to many different aspects of laboratory and facility maintenance.

4. Conclusion

In an ongoing process of improving UNEP's nuclear and engineering safety cultures, a procedure was developed and carried out by students to manage waste which had accumulated in UNEP's facility over several decades. This procedure emphasizes a cautious approach to unknown waste materials and includes a well-documented and thorough assessment of radioisotopes in preparation for their disposal. Using this procedure, nearly all legacy waste items have been processed and prepared for disposal from the facility. This project served to benefit UNEP in removing legacy waste and creating a formal procedure to be used in dealing with future waste items. Additionally, it provided students an opportunity to apply knowledge gained in nuclear engineering coursework, learn valuable radiological laboratory techniques and gain experience working in the facility.

5. Acknowledgement

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6. References

[1] Schow, R., Jevremovic, T., "Bridging the Nuclear Generation Practical Training Gap", The American Nuclear Society Winter Meeting, Washington DC, November 10-14, 2013.
[2] Schow, R., Jevremovic, T., "A Novel Paradigm in Training and Educating Nuclear Engineering Students About Effective Nuclear Safety Culture", NESTet Nuclear Engineering Science and Technology, Madrid Spain, November 17-21, 2013
[3] Schow, R., Jevremovic, T., "Enhancing Nuclear Safety Culture Training Through Knowledge Management and Emergency Response Exercises", NESTet Nuclear Engineering Science and Technology, Berlin Germany, May 22-26, 2016
[4] Jevremovic, T., "The Utah Nuclear Engineering Program and DevonWay are Developing One and Unique Approach to PLiM for Securing the Nation's Nuclear Future," 3rd International Conference on NPP Life Management (PLiM) for Long

Term Operations (LTO), IAEA CN-194, Salt Lake City, Utah, International Atomic Energy Agency (2012).
[5] Jevremovic, T., “Introducing the University of Utah Nuclear Engineering Facilities: Operational Protocols, Training Practices, Outreach Activities and Research,” National Organization of Test, Research and Training Reactors TRTR 2013 Annual Meeting, St. Louis, Missouri, September 23-26, 2013, TRTR.
[6] State of Utah Department of Environmental Quality, Division of Radiation Control, “Utah Radiation Control Rules (R313)”, March 2017.
[7] U.S. Nuclear Regulatory Commission (NRC), “10 CFR 20.2001-2008, 10 CFR 61, and 10 CFR 71”,
[8] University of Utah Radiological Health Department website “Radioactive Waste,” www.rso.utah.edu/using/radwaste/index.html, March 2017.