EVALUATION OF A NEUTRON-PHOTON SHIELD FOR TRANSURANIC (TRU) WASTE CONTAINERS

M. Gallegos, R. Ruby, E. J. Sullivan, R. J. Wishau
Los Alamos National Laboratory

ABSTRACT

The Los Alamos National Laboratory (LANL) Operational Health Physics Group, with the support of the Nuclear Materials Technology Waste Management Group, has developed a wrap-around shield for use with 0.208 cubic meter (55 gallon) drums containing transuranic (TRU) waste. The shield or "drum cover" as it is called, is innovative in its ability to attenuate both neutron and photon radiation associated with TRU waste.

This poster presents information on the design, fabrication and field use of the drum cover. Design details to be presented include the composition of the shield including the materials used, thicknesses, weight, dimensions and fastener arrangement. Information on the source supplier for the shield materials, the fabrication vendor and the drum cover cost are provided.

Shielding data show the unique effectiveness of the drum cover and its ability to reduce neutron and photon radiation exposures as low as reasonably achievable (ALARA). These data include x-ray testing of the assembled shield materials, as well as field experience reports on the drum cover using TRU waste containers and neutron source drums.

The poster includes discussion and photographs of recent field uses for the drum cover, user experience and acceptance of the drum cover and suggestions for future use and enhancement of the drum cover design.

INTRODUCTION

Various operations at Los Alamos National Laboratory result in the generation of transuranic (TRU) waste. TRU waste refers to waste materials containing elements with atomic numbers greater than 92 and containing more than 3.7 kBq of alpha emitting TRU per gram of waste. A standard container for TRU waste is a 55 gallon steel drum. These drums are prepared at LANL for disposal at the Waste Isolation Pilot Plant (WIPP) the underground TRU waste repository near Carlsbad, New Mexico USA.

Several organizations at the Laboratory are involved in the preparation, packaging, characterization, temporary storage, and monitoring of these TRU drums prior to their transfer to the WIPP. These organizations include the Waste Management and Environmental Compliance group (NMT-7) and the Risk Reduction and Environmental Stewardship Division Characterization (RRES-CH) group. In the course of their work these groups will occasionally encounter TRU drums with higher than usual radiation levels. Personnel will then shield the drums to reduce the radiation dose rates to levels that are As Low As Reasonably Achievable (ALARA) thereby reducing their radiation doses.

This poster provides information on the design, testing and field use of drum covers that were developed to shield the TRU waste drums.

THE DRUM COVER

Design

Recently, the NMT Waste Management and Environmental Compliance group decided to develop its own TRU drum shield. This decision resulted following an unsuccessful search to find an existing shield product that would be effective for both neutron and photon radiation.

The waste management personnel provided design goals for the shield. These goals included:

- Effectiveness in shielding both neutrons and photons
- Easy to install and remove
- Provide a separate shielded lid for the top of the drum
- Provide a contamination-resistant durable outer layer
- Be light in weight so that one person could install the shield
- Shield fastens tight around the drum

Radiation protection personnel provided design specifications for the shield's materials and capabilities considering the radiation associated with TRU waste. The shielding materials and thicknesses were a design consideration because a good photon shield is usually a poor neutron shield and vice versa. In the case of TRU waste, the neutrons are mainly spontaneous fission neutrons and the photons are low-energy x-rays or gamma photons. The gamma photons are dominated by the 60 keV emissions from the buildup of Americium-241 produced by the decay of Plutonium-241.

Supply Central Ltd. of Albuquerque, NM served as the product vendor who procured materials, fabricated and delivered the drum covers to LANL. The finished design includes the shield material that is encased in a waterproof easy-to-clean jacket of yellow Herculite™80. The shield wraps around 55 gallon drums and is cinched tight using Velcro™ straps and two cam-tightened buckle belts. The drum cover also comes with a shielded lid.

The shielding is comprised of two materials shown in a sectional view in the photograph in Fig. 1. The neutron shield is made of a 7 mm thick sheet of borated polyurethane material. This shield is made by ThermoElectron RMP Corp. and is marketed under the product name Borated FLEX™ Panel No. 227a. This flexible product is 9 weight percent boron and has a high hydrogen content, and is self-extinguishing when exposed to flame. The photon shielding consists of two 0.175 mm sheets of composite lead vinyl fabric glued to each side of the FLEX panel.

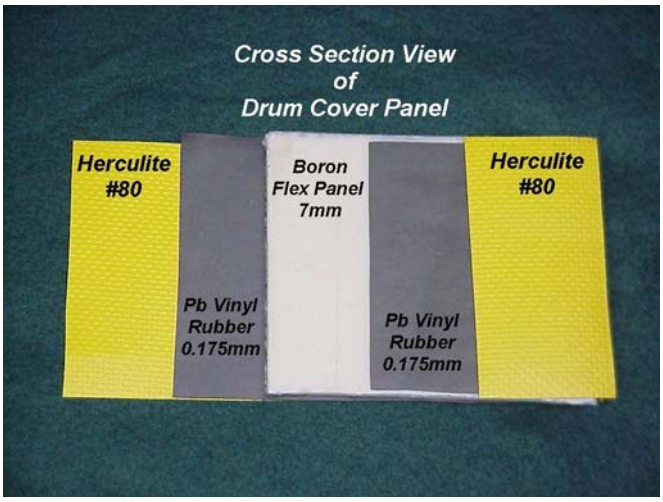

Fig. 1.

In the photograph in Fig.2 the drum cover is shown installed on a 55 gallon TRU waste drum. The drum cover measures 89 cm high by 203 cm in length and weighs 22.7 kg. The removable shield lid is of similar composition and weighs 8.6 kg and measures 66 cm in diameter with 15 cm side flaps.

Fig. 2.

Shield Effectiveness

Several tests were performed to evaluate the effectiveness of the drum shield. The tests were made using shield material samples and using the full size shield installed on typical TRU drums. The tests were performed using simple radiation attenuation methods and standard commercially available radiation protection field instruments.

Neutron Shielding Test Results

Table I presents neutron shielding results. Measurements were taken using a TRU drum and the drum cover in shielded and unshielded configurations. The type of instrument and the manufacturer and model are shown. The attenuation factor is the ratio of the shielded dose rate to unshielded dose rate. A ratio of 0.81 equates to a 19% reduction factor.

Table I Neutron shielding test results

Neutron Instrument/ Manufacturer	Detector type	Unshielded (μSv/hr)	Shielded (μSv/hr)	Ratio
Test 1				
SWENDI-II / ThermoElectron	Helium-3 counter tube	30.2	24.5	0.81
PDM-303 / ALOKA Co. Ltd.	Solid-state proton recoil	35.7	25.8	0.72
Test 2				
Bubble detector / BTI™	Superheated liquid vapor bubble	670 μSv	428 μSv	0.63

The neutron reduction ranged from 19 % to 36 % for the measurements listed in Table 1 showing that the drum cover is partially effective in shielding neutrons.

Photon Shielding Test Results

Two types of effectiveness tests were performed to evaluate the drum cover's ability to shield photons. The first was to expose x-ray film using standard diagnostic x-ray equipment and the second was using active and passive dosimetry and commercially available radiation protection field instruments.

For the x-ray testing shielded film was exposed and developed to determine the degree of effectiveness of the shield. A diagnostic x-ray machine (General Electric™ Model DXD350) set to 80 kVp, 100 mA and 1/20 sec was used to expose shielded film. Optical densitometer readings for the shield sample indicated a transmission of less than 10% at this energy (or an attenuation of 90%).

The x-ray test results were confirmed using lithium fluoride type thermoluminescent dosimeter (TLD) chips placed in unshielded and shielded geometry. The TLD results indicated an average transmission factor (ratio) of 0.1 or attenuation of greater than 90 %.

A third photon shielding test used a 55 gallon drum containing TRU waste and radiation protection field instruments. Using the drum cover unshielded and shielded radiation measurements were taken from both the side and top of the TRU waste drum. These gamma photon measurements were made with a ThermoElectron SHP300A energy compensated low-level GM probe. Photon shield effectiveness test results are shown in Table II.

Table II Photon shielding test results

Location of Reading	Unshielded (μSv/hr)	Shielded (μSv/hr)	Ratio
Top(through the shield lid, drum 1)	594	75.5	0.13
Side (middle of drum 1)	1052	136	0.13
Side (drum bottom)	133	12	0.09

These measurements indicated that for the predominant TRU waste photon energies the drum cover is very effective in reducing the photon absorbed dose [1]. Reduction ratios indicate an 87 % to 91% reduction in the photons passing through the shield.

User Experience with Drum Covers

Los Alamos National Laboratory organizations including NMT-7 and RRES-CH have used the drum covers in their work with TRU waste containers. Interviews were conducted with a number of personnel in these organizations to learn about their experiences and acceptance of the drum cover as an ALARA tool for their work. In general users are satisfied with the shield performance, and the total weight of the drum cover. The drum cover is somewhat awkward to handle when working alone and preferably two people would install the drum cover onto a drum. A drum cover rating summary was prepared from interviews with the user groups and is shown below as Table III.

Table III Drum cover rating summary

Drum Cover Features	Excellent	Good	Average	Poor	Comments
Fit and tightness on the drum		X			
Ease of use of tightening belt		X			
Function of Velcro™ strap		X			Some straps have torn requiring repair
Ease of handling and lifting			X		Somewhat difficult for one person to handle
Effectiveness in shielding neutrons			X		
Effectiveness in shielding photons	X				
Cost effectiveness at unit price of $ 1395			X		
Ease of cleaning	X				
Ease of storage when not in use			X		Needs a large size shelf or storage cart

CONCLUSION

The drum covers have proven to be effective in shielding personnel from radiation when working with TRU waste drums. The drum cover has satisfactorily met its design goals for weight and ease of installation. The drum covers were rated as excellent in their fit on the drums and their ability to be cleaned. Overall, the users are pleased with their performance. The drum cover is gaining acceptance with the users, and they have shown to be a worthwhile ALARA tool for reducing personnel radiation exposures.

REFERENCES

1 R. J.Wishau, J. M. Castro, R. L. Huchton, "Evaluation of a Neutron-Photon Shield for Transuranic Waste Containers", LA-UR-02-467, Los Alamos National Laboratory (2002).