16 - Field Packaging of Sources for Transport

SAND2011-2089P
Defense Nuclear Nonproliferation

Search and Secure Workshop

Course Content

- Field management of "found" sources to:
  - Identify
  - Characterize
  - Package
  - Transport to storage
- Includes discussions of:
  - Radiological protection and safety
  - Information gathering
  - Selection of packaging
- Practical exercise:
  - Packaging a source

Search Plan

- Search plan should include:
  - Sources potentially in search area
  - Actions to take upon initial location of source
  - Plans for consolidated packaging operation when all searches are complete
- Assumptions
  - Sources, once located, will be identified and characterized
  - Packaging will be completed when all search teams are done and all sources to be managed are located
- Work plan has three phases
  - Initial search and response to located sources
  - Determination of packaging needs
  - Packaging & preparation for transport

Initial Search and Response

- **STOP** – back off, obtain assistance as needed to ensure safety
- Take measurements – dose rates contamination monitoring
- Control access – use barriers
- Identify source/device
- Read data on labels/markings
- Identify radionuclide and original activity
- Record all information - take pictures
- Once source has been located and marked/barricaded – further handling can be planned – take time to use proper precautions

Initial Response - Cautions

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- Maintain exposure as low as possible
- Use rakes or shovels *carefully* to locate sources while maintaining distance
- ***BEWARE*** - contamination from sealed sources is rare but it can't be ruled out without testing

Initial response is complete when sources have been located, identified, and characterized.

Radiological Precautions
Initial Search and Response

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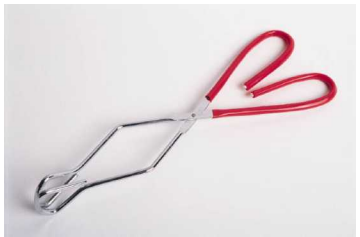
- Use an ion chamber when you need to accurately measure the dose rate off a source
- Measure dose rate at 1 meter – estimate contact dos rates using the inverse square law
- Check for contamination by field swipe testing with a paper and tongs and testing the paper with a contamination meter in a low background area
- Check any shield (or shutter) on the device to determine if open, closed, or damaged



Rev 05/09

Determine Packaging Needs

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- Determine options for storage of the source:
  - long term or temporary storage in a national storage facility
  - source segregation, packaging, marking and labeling requirements for storage
  - Method of transportation to national storage facility

Container Selection

- type of package required for the radionuclide and activity
- volume considerations
- requirements for placement in storage
- dose rate determinations
  - HVL/TVL of shielding materials
  - Use of Specific Gamma Ray Constants

Formulas

- **HVL and TVL – estimates or calculations**

For # of TVL use $D_2=D_{1/}(10^n)$ or $x=\log (D_2/D_1)/\log (10)$

For # of HVL use $D_2=D_1(2^n)$ or $x=\log (D_2/D_1)/\log (2)$

- **Dose Rate estimates based on a known amount of activity and Gamma Ray Constants**

Dose Rate {D} = (Gamma Ray Constant {G} mSv/hr/MBq @ 1 m) X (Activity {A} MBq) = mSv/h @ 1m or D = G X A

- **Inverse Square Law**

$D_2 (r_2^2) = D_1 (r_1^2)$

Example 1

Search activities locate a 18.5 GBq (0.5 Ci) Cs-137 source. The source is a cylinder, encapsulated in stainless steel and is about 3 cm thick and about 10 cm long (special form).

You have a concrete lined drum with a cavity in the center for placement of the materials to be packaged.

1. Question: Is this drum sufficient packaging without exceeding the limits on dose rate at contact (2 mSv/hr or 200 mrem/hr) with the drum?

2. Question: Will the Transportation Index (TI) exceed the limit of 0.1 mSv/hr (10 mrem/hr) at 1 meter?

Drum and Source Data

18.5 GBq (0.5 Ci) ^{137}Cs
Drum diameter: 57 cm
Diameter of center hole: 14 cm
Wall thickness of concrete: 21.5 cm

Solution 1

Known's: inverse square law: $D_2 (r_2^2) = D_1 (r_1^2)$

*Distance from drum center to drum surface = 28.5 cm (7cm center to edge of concrete + 21.5 cm concrete)

*TVL concrete for Cs-137 = 22 cm

*G=Gamma Ray Constant Cs-137 =1.00 X 10-4 mSv/h/MBq at 1 m

1000 MBq = 1 GBq

A. First find the dose rate off the 18.5 GBq Cs-137 source unshielded at 1 meter:

Dose rate from Cs-137 18.5 GBq at 1 meter = (1.00 x 10-4 mSv/h/MBq {G})X(1000 MBq/GBq)X(18.5 GBq) = **1.85 mSv/h at 1 m**

B. Correct the dose rate using the Inverse square law to what it would be at the outside of the drum (28.5 cm)?

Known's: D_1 =1.85 mSv/h r_1 = 100 cm r_2 =28.5 cm D_2= ?

$D_2 = (r_1^2)X(D_1)/r_2^2)$

$D_2 = ((100^2)\ X(1.85mSv/h))/(28.52)^2$

D_2 = 22.8 mSv/h dose rate unshielded at outside of drum

Solution 1 (continued)

C. Calculate the shielded dose rate at *surface* of the concrete drum

Known's: Dose Rate using TVL's: $D_2 = (D_1)/(10^x)$

*X= 21.5 cm of concrete/22 cm TVL or ~0.98 TVL

*D_1 = 22.8 mSv/h dose rate at surface of unshielded drum

*D_2 = ?

$D_2 = (22.8 \text{ mSv/h})/ (10^{0.98})$

D_2= 2.4 mSv/h dose rate at surface of shielded drum

EXCEEDS LEGAL LIMIT of 2 mSv/hr surface

D. Calculate the shielded dose rate *at 1 meter* from the concrete drum and determine the TI value

Known's: $D_2 = D_1 (r_1^2)/ (r_2^2)$

* D_1 = 2.4 mSv/h * r_1 = 1 cm off surface of drum *r_2 = 100 cm off drum *D_2 =?

$D_2 = (2.4 \text{ mSv/h})(1)^2 / (100)^2 =$ 0.0002 mSv/hr or 0.02 mrem/hr

Shielded dose rate @ 1 m = 0.0002 mSv/hr or 0.02 mrem/hr

Transport Index (TI) = 0.02 **DOES NOT exceed the legal limit of TI of 10.**

Example 2

The national authority has located another drum with both concrete and lead shields……

Given the data below – will this be sufficient for packaging and transport of the source?

Known's:

^{137}Cs 18.5 GBq (0.5 Ci)

Drum diameter: 57 cm

Diameter of central hole: 13 cm

Wall thickness of concrete: 18.5 cm

Wall thickness of lead: 3.5 cm

Outer diameter of lead shield: 21 cm

Inner diameter of lead shield: 14 cm

Question: What is the estimated dose rate at the *surface* of drum and at *1 meter* from the surface of the concrete and lead drum?

Solution 2

Known's: Dose rate formula using TVL $D_2 = (D_1)/(10^x)$

***TVL concrete for Cs-137 = 22 cm * TVL lead for Cs-137 = 2.1 cm**

A. As previously calculated the dose rate at the surface of the drum from the unshielded source was 22.8 mSv/h. What is the surface dose rate with the addition of the concrete and lead?

18.5 cm of concrete = 18.5 cm/22 cm ($TVL^{concrete}$) = **0.84 TVL = $X^{concrete}$ ***
3.5 cm of lead = 3.5 cm/2.1 cm (TVL^{lead}) = **1.67 TVL= X^{lead} ***
D_1 = 22.8 mSv/h $D_2 = (D_1)/(10^x)$
$D_2 = (22.8 mSv/h)/ (10^{0.84 + 1.67)}) = 0.07$
D_2 = 0.07 mSv/h shielded dose rate at surface of drum Meets Legal Limit ! (2mSv)

B. Shielded dose rate at 1 m off the drum?
Known's: inverse square law: $D_2 (r_2^2) = D_1 (r_1^2)$
- D_1 = 0.07 mSv/h *r_1 = 1 cm *r_2 = 100 cm *D_2 = ?
- $D_2 = (0.07 mSv/h)(28.5^2)/(100^2)$ = **0.00001 mSv/h at 1 meter or 0.001 mrem/h dose rate at 1 meter off lead and concrete shielded drum**

Transport Index (TI) = 0.001 Meets Legal Limits! <10 mrem/h or 0.1 mSv/h)

Source Handling and Packaging

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- **Source handling**
  - Never touch bare source with hands
  - Handle only after contamination levels and dose rates confirmed
  - Long handled tools, shielded enclosures and hot cells may be needed!
  - Limitations on field handling determined by national authorities
- **Segregation of sources in the field**
  - Type of source – alpha, beta-gamma, neutron
  - Collection into inner containers for placement in transport/storage container – later retrieval
  - Multiple containers due to segregation requirements of storage facility

Source Handling and Packaging Considerations

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- Preparation and use of containers and placement of sources must not preclude later retrieval or further conditioning
- Concrete lined drums with cavity for source placement
- Inner containers to allow retrieval from drum and storage of many sources
- Dunnage – holds source in position within container
- Use only approved containers from qualified suppliers
- Consider anticipated duration of storage and conditions– humidity, temperatures, etc

Demonstration
Package Loading and Closure

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- **Source to be packaged**
  - Meets conditions for use of Type A container
  - Swipe tested and free of contamination
  - Fully characterized and documentation available
  - Requirements of storage facility identified
- **Type A 5-Gallon Drum**
  - Certification document review – weights of particular concern, weight loading, closing instructions and torquing
  - Inserts and dunnage identified – shielding verified

Demo-Package Loading and Closing #2

- Open drum and prepare contents
- Discuss each item in drum and its use
- Prepare drum and transfer source
  - Dunnage in place
  - Inner container identified, marked and staged
  - Movement of source to container planned
  - Closure of inner container and placement in drum planned
  - Use of long handled tool
  - Move source, close inner container, place inner container into drum

Demo-Package Loading and Closing #3

- Close drum – torque to specifications
- Label and mark
- Final surveys – radiation dose rate at and 1 meter and for contamination
- Move drum to a staging area for loading
- Check tools and equipment for contamination
- Complete the shipping manifest

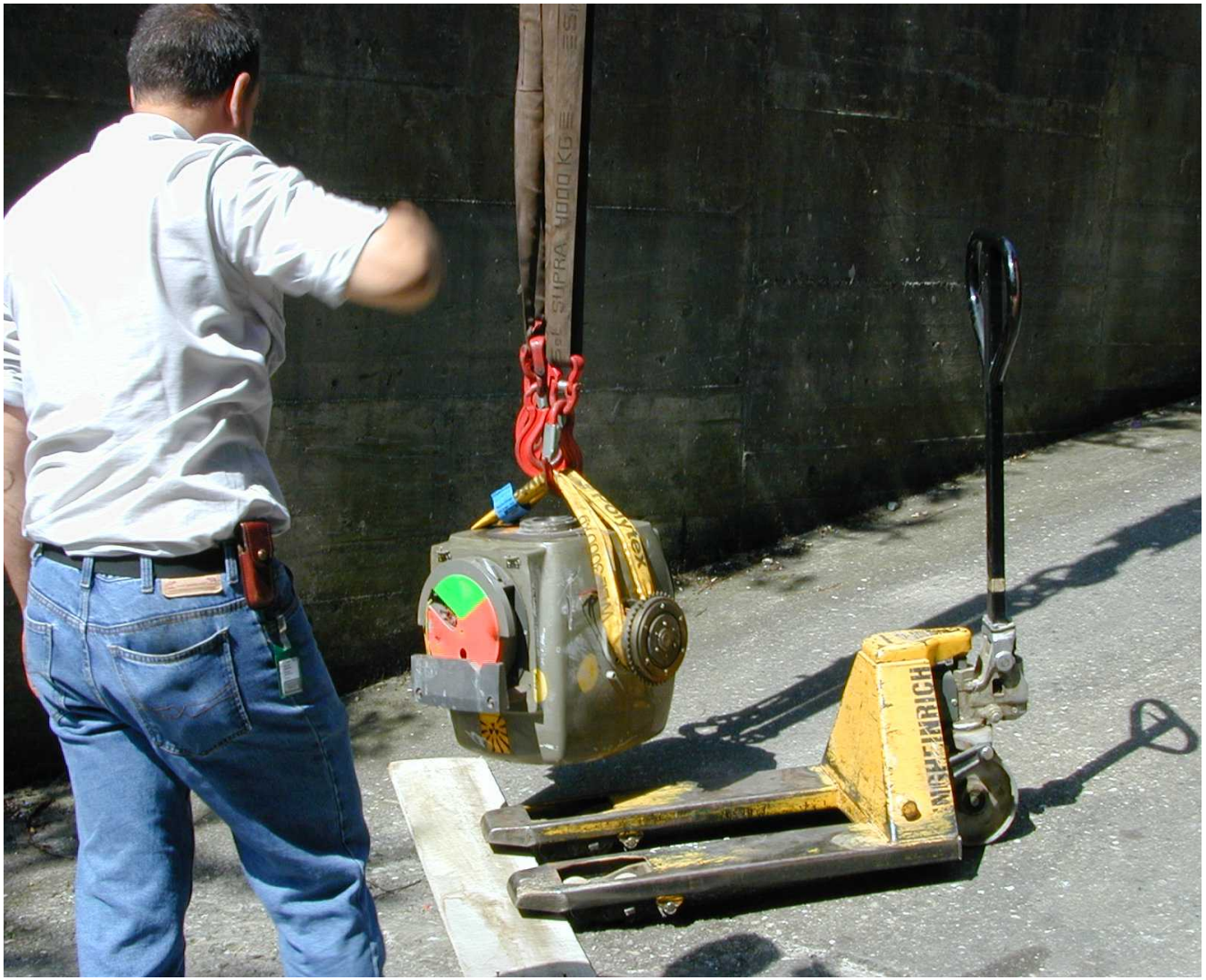
200 Litre Drum
Concrete Lined and Shielded

Concrete lined drum with cavity for placement of sources/inner containers

Where is a shielded top for the center?

Transport packages

Teletherapy head to be transported



Teletherapy head being loaded

Teletherapy head in overpack

Labelled drum in storage

Storage of conditioned Radioactive waste and sources

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Summary

- Field packaging of sources for transportation is the final step of the search and secure operation
- Radiological protection – both minimizing exposure and controlling contamination essential
- Packaging details will depend on the availability of containers and the type of transportation selected by the national authority
- Plan and execute according to a plan
- Be flexible – plans change based on real conditions!