Conditioning Procedure for Spent Cs-137 Sealed Sources in Egypt

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ABSTRACT

It is the duty of the Hot Laboratories and Waste Management Center, Egyptian Atomic Energy Authority to mange the radioactive waste generated from any user for radioactive materials in Egypt. The most hazardous or dangerous radioactive waste we collect is spent radioactive sealed sources that have to be managed safely to protect human, workers and environment from any undue burden for radiation. Through the Integrated Management Program Of Radioactive Sealed Sources In Egypt, IMPRSS all spent Cs-137 sources with low activity will be retrievable conditioned in 200 L drum with special lead shield to keep the surface dose rate lower than 200 merm/h according to US regulations and IAEA guidelines. Using this procedure the EAEA will condition about 243 sources in 9 drums.

INTRODUCTION

Although the immediate objective of conditioning is to facilitate interim storage, it should also facilitate transport when the disposal facility is off-site. However, the most important thing is to produce a package likely to be suitable and acceptable at a final disposal site. Therefore it is very important to follow international guidance and regulations for the conditioning and disposal of radioactive wastes. For these reasons, the conditioning-process involves:

- ✓ The production of a package type that is recognized in and conforms to IAEA transport regulations [1] and
- ✓ The use of an immobilization matrix (cement mortar) that is already widely accepted in many countries for interim storage and disposal sites

It may be considered that a package that is safe to transport through the public sector will be also suitable for interim storage at a secure site. The method of conditioning described in this short report is based on the Type A package as defined in IAEA transport regulation [1]. A Type A package is defined as a packaging, tank or freight container containing an activity up to the A2 value or up to A1 if the contents meet the definition of “special form” radioactive material.

“Special form” radioactive material means an in-dispersible, solid radioactive material or sealed capsule containing radioactive material. It may be expected that many sealed sources meet these requirements and thus are classed as special radioactive material [2]. To be considered “special form”, the sealed source must have a certificate from the manufacture company. This documentation must include an expiration date if it has been withdrawn or expired without extension. In this case, the source cannot be considered “special form” so the IAEA recommends the use of A2 values for Type A containers. A list of the values of A1 and A2 are given in Table I for radionuclides commonly used in Egypt.

Table I. Activity Level for Sealed and Unsealed A1/A2 of Some Radionuclides

Radionuclide	A1/ Ci	A2/ Ci	Specific activity Ci/g
Cs-137	54.1	13.5	87
Co-60	10.8	10.8	1100
Am-241	54.1	5.41×10^{-3}	3.4
Sr-90	5.41	2.7	140
Ir-192	27	13.5	9200
Kr-85	541	270	390

SRSS Acceptance Criteria for Conditioning

There are some conditions and waste acceptance criteria for any source will be conditioned by this method:

1. Only Cs-137 sources will be approved to be conditioned by this method.
2. All Cs-137 sources must have a leak test record with the test results not exceeding 0.005 μCi. If it cannot pass the test, the operator has to perform the leak test according to IAEA guidance (see Appendix I).
3. The total activity in each drum is not exceeding 5 Ci per drum.
4. Only the 200 L drum is approved for use in this method.
5. The density of the cement mortar is not less than 2.35 g/cm^3 and the density of lead is not less than 11.3 g/cm^3
6. The drum's surface dose rate is not to exceed 2mSv/h (200mrem/h).

Quality Assurance

Quality assurance means all those planned and systematic actions necessary to provide adequate confidence that an item, process or service will satisfy given requirements for quality that means the operator (HLWMC) has to make all actions and safety measures necessary to keep the contamination level, surface dose rate, transportation index, personnel certification, documentation and record keeping within the IAEA, EAEA and/or US standards. The operator has to develop organization and responsibility structure within the radioactive waste facility QAMP and also develop procedures for handling QAP1, recovery QAP2, conditioning QAP3, procurement QAP4, WAC for storage and disposal QAP5, instruments calibration QAP6, personnel training and certification QAP7, non-conformance, QAP8 and corrective actions QAP9 and record control QAP10. The radioactive waste facility leader may delegate his authority to another person but he still keeps the project responsibilities.

Conditioning Procedure

The conditioning procedure is based on the immobilization of the sources within a Type A package (mild steel 200 L drum) with concrete thickness of 20 cm. The sources encased within a special lead container are placed in the center of a 200 L drum filled with cement mortar. The activity in the package must not exceed the A1/A2 level as set out in the IAEA transport regulations. Conditioning in this way prevents unauthorized removal of the source. The bulk, weight and robust nature of the package also provide a barrier against the loss of containment of the radioactive material. Such a package would have a weight of about 450 kg and so removal and transportation would require the use of mechanical equipment e.g. fork lift [3].

Equipment and supplies required

- Special lead shield with a thickness of 5 cm, cap thickness of 5 cm and bottom thickness of 2 cm (shown below)

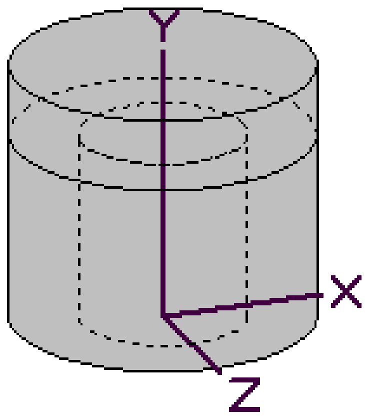


Fig.1 The design and dimension of lead shield
X = 10 cm
Y = 25 cm
Z = 10 cm

- 200 L drum free from rust spots or other defects (inside and outside)
- mold for preparing a cavity inside the drum and for the cap of the drum.
- cement mixer or even manual mixing
- Handling tools (e.g. Forceps, tongs 60 cm long with parallel grip 100 cm long.)
- A fork lift
- Labels for storage and transportation
- Plastic sheets to prevent against contamination during work

Procedure Steps

- Assemble all equipment and supplies required to proceed with the conditioning process as listed above.
- Open and visibly inspect the Type A 200 L drum for rust spots or other defects. Don't use the defected drums.
- Mix sufficient concrete to fill the drum to approximately half of its volume.
- Place the concrete mixture in the drum and shake the drum to assure that no void has been formed in the concrete.
- Insert the mold into the container and the container casket, place the cement mortar around the mold and then let the concrete set to harden. Ensure that the thickness of the concrete in the cavity section is not less than 15 cm and the cavity diameter is at least 18 cm.

- Using appropriate radiation protection and handling procedures, remove the sources from their shields and place them in the prefabricated lead shield as prescribed above. The maximum activity in prefabricated shield is 5 Ci for Cs-137.
- Place the prefabricated shield into the cavity in the drum.
- Install the drum head and bolt ring by screwing the closure device.
- Check the outside of the drum to ensure that no concrete has been spilled on the outside surface.
- Inspect the drum integrity and perform wipe tests (See app I) to determine presence of contamination on the drum. According to the IAEA safety series No. 6, “regulation of the safe transport of radioactive material” should be followed. These limits are summarized below.
- Post appropriate radiation labels on the drum to ensure proper identification for storage. Regulations for the safe transportation of radioactive material place a limit on surface radiation of 200 mrem/h (2msv/h) [4].

Table II. The maximum permissible level for contamination for α, β and γ

Contaminant	**Max. Permissible level**	
	Bq/cm^2	**µCi/cm^2**
Beta and Gamma emitters	**4.0**	**10^{-4}**
Alpha emitters	**0.4**	**10^{-5}**

The surface dose rate calculation using micro-shield software reveals that when lead shield of 5 cm thickness, concrete shield of at least 20 cm thickness, (density=2.35 g/cm^3) and the 200 drum thickness is 0.14 cm, the surface dose rate is **46 mrem/h**, see App. II. The Spent Radioactive Sealed Source (SRSS) inventory in Egypt reveals that there are 257 known and 148 unknown Cs-137 spent sources already stored at Inshas storage facility. One of the known sources has a high activity of 237 Ci so it is out of the scope of this conditioning method. According to this procedure, the 256 Cs-137 sources may be put into 9 drums without the surface activity of each drum exceeding 5 Ci.

Tables III. The Contents and Activity Levels of Waste Drums

Drum No.1		
Activity/Ci	**No. #**	**Total/Ci**
0.425	3	1.275
0.05	2	0.1
1	1	1
0.02	1	0.02
0.1	6	0.6
0.01	98	0.98
0.5	1	0.5
0.15	1	0.15
Total	**117**	**4.625**

Drum No. 2 to 7		
Activity/Ci	**No. #**	**Total/Ci**
1.5	18	27
0.5	2	1
0.5	1	0.5
0.5	2	1
Total	**23**	**29.5**

Drum No. 8		
Activity/Ci	**No. #**	**Total/Ci**
0.08	47	3.76
0.1	11	1.1
Total	**58**	**4.86**

Drum No. 9		
Activity/Ci	**No. #**	**Total/Ci**
0.25	1	0.25
0.1	6	0.6
0.01	1	0.01
0.1	6	0.6
0.1	6	0.6
0.1	6	0.6
0.1	1	0.1
0.03	7	0.21
0.1	6	0.6
0.09	3	0.27
0.08	7	0.56
0.1	6	0.6
Total	**56**	**5**

CONCLUSION

Through the IMPRSS project which reviewed the conditioning procedure in Sandia National Laboratories NM, USA and fund the conditioning operation, we conditioned about 117 spent Cs-137 sources till now and we are going to complete the rest of sources inside the 200 L drum and also develop the next phase to condition 134 small spent Co-60 sources. The most benefit we got from the conditioning procedures is to get the qualified and trained personnel capable to do the job with high experience with safety and security precautions

ACKNOWLEDGEMENT

The authors would like to thank the IMPRSS project which funds the conditioning procedure and also thank Sandia National Laboratories NM, USA for reviewing this procedure.

Appendix I: Leak Testing of Sealed Sources

(A) Each licensee who uses a sealed source shall have the source tested for leakage periodically. The licensee shall keep a record of leak test results in units of microcuries and retain the record for inspection by the EORP office for three years after the leak test is performed. When the sources are declared as spent, the licensee must approve by documentation that the last leak test conformed with regulatory standards and did not exceed 0.005 microcurie.

(B) The wipe of a sealed source must be performed using a leak test kit or method approved by the Regulatory body according to Egyptian guidance and regulations. The wipe sample must be taken from the nearest accessible point to the sealed source where contamination might accumulate. The wipe sample must be analyzed for radioactive contamination. The analysis must be capable of detecting the presence of 185 Bq (0.005 microcurie) of radioactive material on the test sample and must be performed by a person approved by the Chairman of Radioactive Waste Management Division, and Egyptian regulatory body.

(C) Sealed sources must be tested at the following frequencies:
Each sealed source must be tested at intervals not to exceed six months. In the absence of a certificate from a transferor that a test has been made within the six months before the transfer, the sealed source may not be used until tested.

(D) If a sealed source shows evidence of leaking by revealing the presence of more than 0.005 microcuries, then after a confirmatory recount, a second swipe should be performed. If the test results are positive, the source will be immediately withdrawn from use, decontaminated, and/or repaired or disposed of as appropriate. In the event of the detection of a leaking sealed source, a report will be filed to Chairman of Radioactive Waste Management Division describing the source, the test results, and the corrective action taken.

(E) Each sealed radioactive source, except for Hydrogen-3 (tritium), with a half-life greater than 30 days and in any form other than gas, will be tested for leakage by means of a swipe test. This action must be taken prior to initial use and at six-month intervals in accordance with IAEA guidance. The leak tests, to be performed by a member of the Radiation Safety Office staff, will be capable of detecting the presence of 0.005 microcuries (185 Bq) of removable contamination. The results of all leak tests will be recorded in an appropriate record system in units of microcuries or Becquerel. Leak tests are required for sealed beta or gamma sources with an activity of 100 microcuries (3.7MBq) or greater, and for alpha sources with an activity greater than 10 microcuries (370 kBq).

(F) Special Case: Sealed Sources in Storage
Old or spent sealed sources that are not being used may be placed in an appropriate sealed container and placed in a long-term storage vault. Sources not in use will be transferred to the radioactive waste management division. They are responsible for storage and record-keeping. Stored sources need only be inventoried once every year and must be leak-tested before being put back into use. However, a single swipe of the storage vault is still required on a six-month interval. This provision is to minimize needless radiation exposure during the swipe testing of unused sealed sources. A special record of all such sources will be maintained and reviewed each six months.

Test Procedure:

- Verify each source's serial number.
- Swipe each source and/or container.
- Obtain alcohol or other effective solvent.
- Moisten a piece of filter paper, or other suitable material of high wet strength and absorbent capacity, with this solvent.
- Wipe all external surfaces of the source thoroughly.
- Count each swipe using a liquid scintillation counter, gas-flow proportional counting system or equivalent detection equipment.

Appendix II: Shielding Calculations

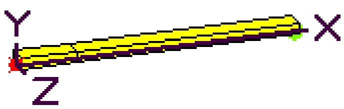
MicroShield v6.02 (6.02-00229)
Sandia_National_Lab

Page	:1	**File Ref**	: EAEA conditioning of Cs-137 without container thickness
DOS File	:Case1	**Date**	: 10-28-2004
Run Date	: October 28, 2004	**By**	: Yasser T. Mohamed
Run Time	: 5:06:07 PM	**Checked**	:
Duration	: 00:00:00		

Case Title: Case 1
Description: Case 1
Geometry: 1 - Point

Dose Points

A	X	Y	Z
# 1	25 cm	0 cm	0 cm
	9.8 in	0.0 in	0.0 in



Shields

Shield N	Dimension	Material	Density
Shield 1	5.0 cm	Lead	11.3
Shield 2	20.0 cm	Concrete	2.35
Air Gap		Air	0.00122

Source Input : Grouping Method - Actual Photon Energies

Nuclide	curies	becquerels
Ba-137m	4.7300e+000	1.7501e+011
Cs-137	5.0000e+000	1.8500e+011

Buildup : The material reference is - Shield 2
Integration Parameters

Results

Energy MeV	**Activity Photons/sec**	**Fluence Rate MeV/cm²/sec No Buildup**	**Fluence Rate MeV/cm²/sec With Buildup**	**Exposure Rate mR/hr No Buildup**	**Exposure Rate mR/hr With Buildup**
0.0045	1.817e+09	0.000e+00	1.005e-23	0.000e+00	6.889e-24
0.0318	3.623e+09	0.000e+00	2.803e-22	0.000e+00	2.335e-24
0.0322	6.685e+09	0.000e+00	5.375e-22	0.000e+00	4.326e-24
0.0364	2.433e+09	0.000e+00	2.995e-22	0.000e+00	1.702e-24
0.6616	1.575e+11	9.597e+02	2.619e+04	1.861e+00	5.077e+01
Totals	**1.720e+11**	**9.597e+02**	**2.619e+04**	**1.861e+00**	**5.077e+01**

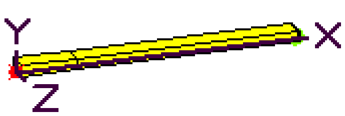
MicroShield v6.02 (6.02-00229)
Sandia_National_Lab

Page	:1	**File Ref**	:Cs-137 for EAEA with container thickness
DOS File	:Case1	**Date**	: 11-30-2004
Run Date	: November 30, 2004	**By**	: Yasser T. Mohamed
Run Time	: 10:31:36 AM	**Checked**	: Sandia National Laboratories
Duration	: 00:00:00		

Case Title: Case 1
Description: Case 1
Geometry: 1 - Point

Dose Points

A	**X**	**Y**	**Z**
# 1	25.14 cm	0 cm	0 cm
	9.9 in	0.0 in	0.0 in



Shields

Shield N	**Dimension**	**Material**	**Density**
Shield 1	5.0 cm	Lead	11.34
Shield 2	20.0 cm	Concrete	2.35
Shield 3	.14 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input : Grouping Method - Actual Photon Energies

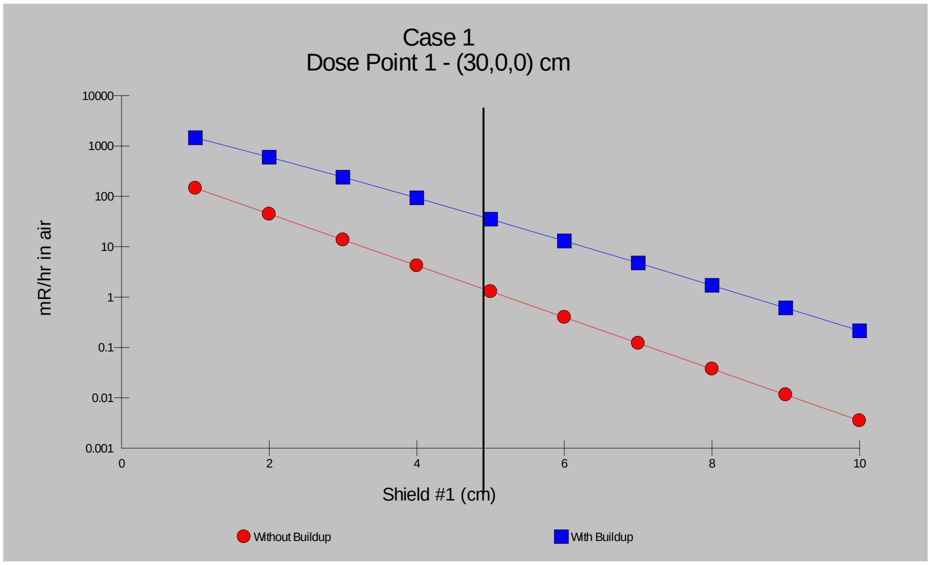
Nuclide	curies	becquerels
Ba-137m	4.7300e+000	1.7501e+011
Cs-137	5.0000e+000	1.8500e+011

Buildup : The material reference is - Shield 2
Integration Parameters

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	1.817e+09	0.000e+00	9.939e-24	0.000e+00	6.812e-24
0.0318	3.623e+09	0.000e+00	2.772e-22	0.000e+00	2.309e-24
0.0322	6.685e+09	0.000e+00	5.315e-22	0.000e+00	4.278e-24
0.0364	2.433e+09	0.000e+00	2.962e-22	0.000e+00	1.683e-24
0.6616	1.575e+11	8.580e+02	2.380e+04	1.663e+00	4.614e+01
Totals	**1.720e+11**	**8.580e+02**	**2.380e+04**	**1.663e+00**	**4.614e+01**

Relationship between the lead shield thickness and surface dose rate



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