ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES, ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT

PATRAM 2010
16th International Symposium on the Packaging and Transport of Radioactive Materials

PACKING FOR RADIOACTIVE WASTE TRANSPORT

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3rd – 8th October, 2010, International Maritime Organization, London, UK

IP-2 PACKAGES

Requirements:

Packing for radioactive waste has to satisfy the requirements established by national and international regulations for the interim storage, transport and final disposal

Regulations:

- IAEA Safety Standards Series N° TS-R-1. Regulations for the safe transport of Radioactive Material. 2009 Edition
- UNI 11193:2006 – Manufatti di rifiuti radioattivi condizionati - Metodi di prova per la qualificazione dei processi di condizionamento per manufatti appartenenti alla Categoria 2

The qualification of the packages has been based upon the waste form, the container and the package. The waste form complies with the requirements for the disposal, while the packaging and the package complies with the specifications for the handling, interim storage and the final transport.

IP-2 PACKAGES

Conditioning Processes

LIQUID WASTE drum: 200 liters drum, final result of the conditioning process of liquid radioactive waste (the resultant sludge from the volume reduction treatments of the liquid waste) mixed with cement mortar.

OVERPACK SOLID WASTE drum: 380 litres drum, final result of the conditioning process of the solid radioactive waste, compressed in pellets, or of sealed sources, in a concrete matrix.

Solid waste

- ✓ super-compaction of 220 litre drums
- ✓ overpack filling with compacted drums and with concrete matrix
- ✓ weight, external dose and contamination controls
- ✓ overpack labelling and storage

Liquid waste

- ✓ sludge, produced by the liquid treatment plant, and dosed water transferred in drum
- ✓ concrete mixing to a perfect homogenisation
- ✓ stop mixer, supply pipes disconnection and package removal; package weighing and labelling

IP-2 PACKAGES *WASTE FORM*

TEST	*ACCEPTABILITY*	*TEST RESULT*
Compression test	$R_c \geq 5$ N/mm^2	$R_c = 60$ N/mm^2
Thermal cycling test	No cracks or damaged surfaces $R_c \geq 5$ N/mm^2	No cracks or damaged surfaces at the end of the thermal cycling test $R_c = 62$ N/mm^2
Radiation resistance test (10^6 Gy)	No cracks or damaged surfaces $R_c \geq 5$ N/mm^2	No cracks or damaged surfaces at the end of the irradiation exposure $R_c = 74$ N/mm^2
High temperature resistance test	Absence of structural failure or deformation	The specimens show no structural failure and are stackable
Water permeability test		Total impermeability
Free liquids test	No liquid inclusions	Total absence of free liquids and uniform distribution of concrete in the voids
Biodegradation resistance test	No cracks or $R_c \geq 5$ N/mm^2	No cracks or damaged surfaces R_c (bacteria) = 64 N/mm^2 R_c (mold) = 60 N/mm^2
Immersion resistance test	No bumps or damaged surfaces $R_c \geq 5$ N/mm^2	No bumps or damaged surfaces at the end of immersion $R_c = 67$ N/mm^2
Gas generation test (Radiolysis 10^6 Gy)		Presence of hydrogen with magnesium waste

IP-2 PACKAGES *PACKAGING*

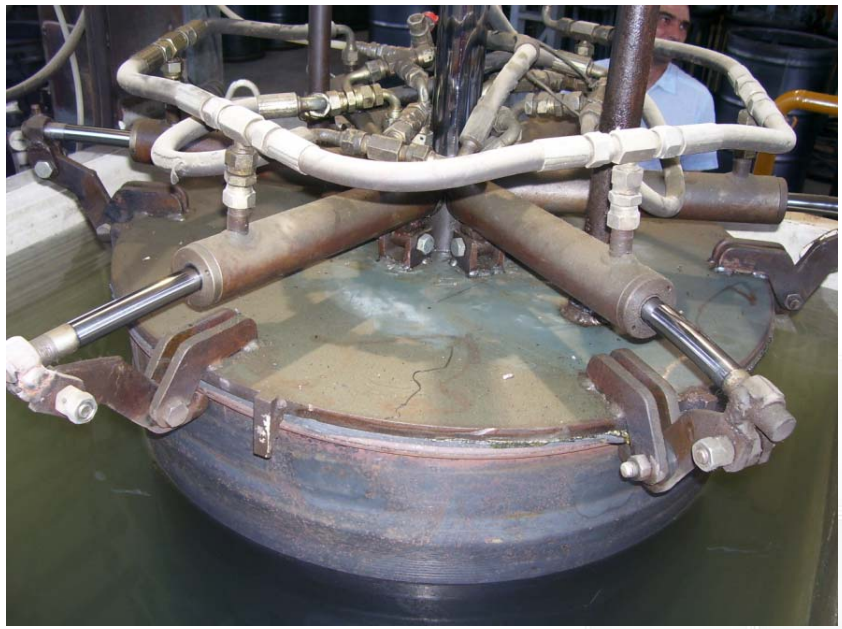
First check at the supplier

Checking sampling depends between 10% - 100%

If there are anomalies the sampling rate increases

Preliminary checks:

- ✓ identification of the steel sheets
- ✓ dimensional checks
- ✓ welds inspection
- ✓ leaking control by pressurizing air
- ✓ leaking control by immersion of the empty packaging in water
- ✓ coating cycle control and film thickness
- ✓ functionality check (liquid waste drum agitator)



IP-2 PACKAGES *PACKAGING*

The coating treatment includes a pre-treatment with nano-technology, application of zinc oxide and polyester coating for a thickness of 200 micron

ANALYSIS	*NOTES*	*ANALYSIS ASSESSMENT*	*ISO 4628 ASSESSMENT*
Blistering	No evidence of blistering Density=0, Size=0	**< 2(S2)**	**3(S3)**
Rusting	Edge rusting is allowed	**Ri 0**	**Ri 1**
Cracking	No evidence of cracking	**0(S0)b**	**2(S3)b**
Flaking	No flaking up to 1 mm	**< 1(S1)a**	**2(S2)a**
Chalking by tape method (Fig. 2)	No evidence of chalking (absence of coating on tape)	**Rate 0,0**	**Rate 1,0**
Delamination and corrosion on the scribe	Absence of delamination around a scribe	**Grade 1** Very slight	**Grade 2** slight
Filiform corrosion	Absence of filiform corrosion around a scribe	**L1/M1**	**L3/M2**
Other notes	Corrosion in the scribes and the edges is allowed		

Neutral salt spray test:

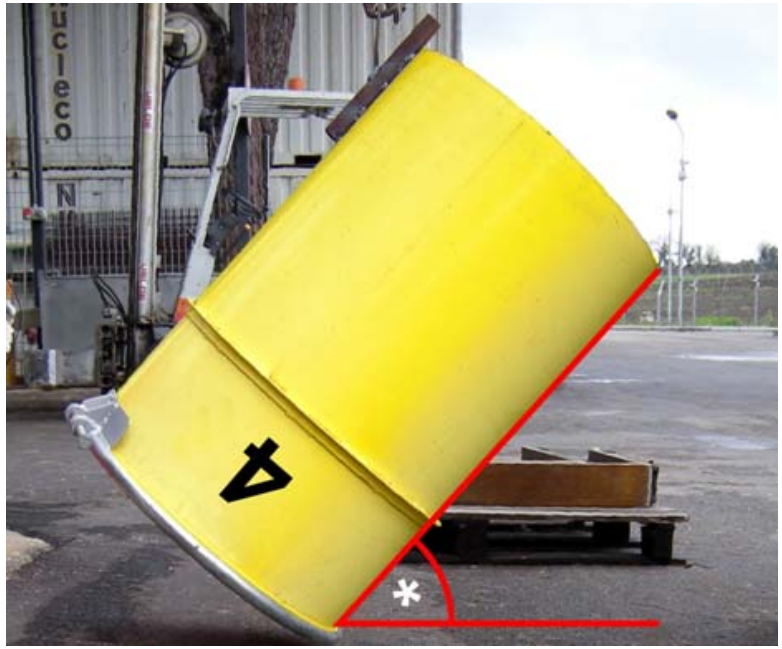
Test Conditions:

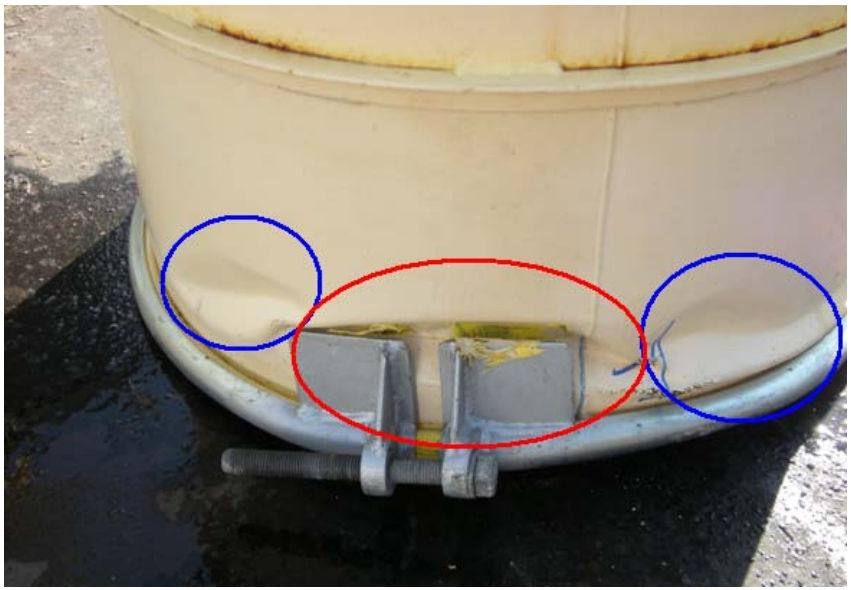
- Industrial Enviroment (real: countryside)
- High Durability

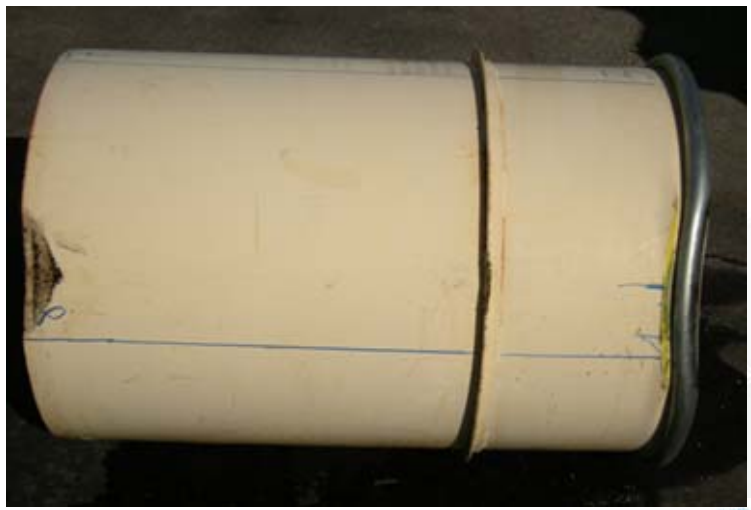
Time test: 720 h

IP-2 PACKAGES *PACKAGE*

The **free drop tests** onto a flat target, horizontal surface with a steel thickness of 40 mm, shows that there are no evidence of openings and loss of simulate radioactive contents. Several falls with different orientation (60°, 26°, 54°, 48°) assured us that we have found the most damaging free drop.







IP-2 PACKAGES *PACKAGE*

The bar of the **penetration test** didn't break the drum in every impact point, even close to closure system.

In the future we shall use the same packages as Type IP-3 for LSA-III too, so we performed the free drop test, the stacking test and the penetration test

The specimens are not deformed by the load in **stacking test**.

SPENT HIGH ACTIVITY SOURCES

Objective ⇨ Design a shielding and containment system for spent γ high activity sources, limited to ^{60}Co and ^{137}Cs

SPENT HIGH ACTIVITY SOURCES
CONDITIONING

The **choice** of a shielding materials for spent high activity sources was limited by:

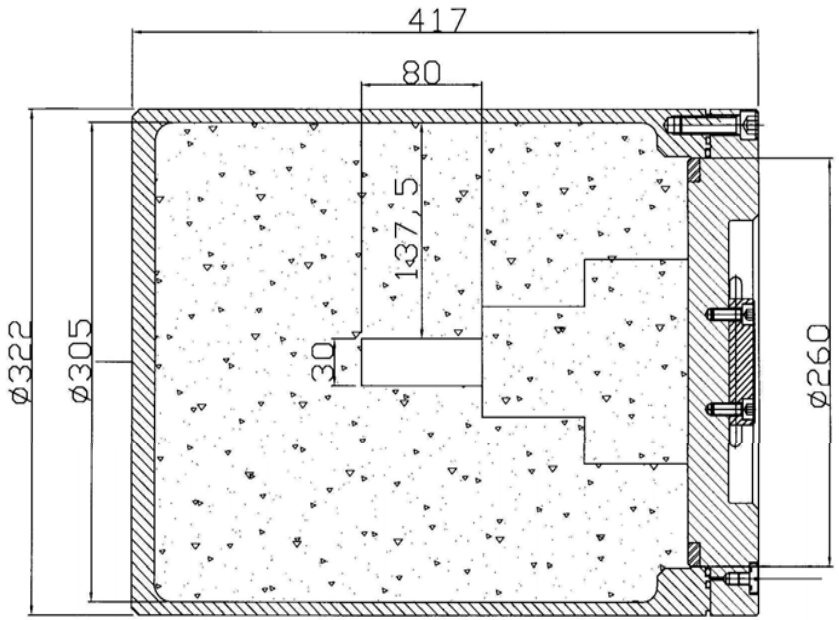
- ✓ *Dimensions*
- ✓ *Allowed mass content of the external components*
- ✓ *Costs*

Two design of the containment system for γ spent high activity sources available for transport and for disposal have been chosen:

- ⇨ *Lead containment system*
- ⇨ *Lead-Tungsten containment system*

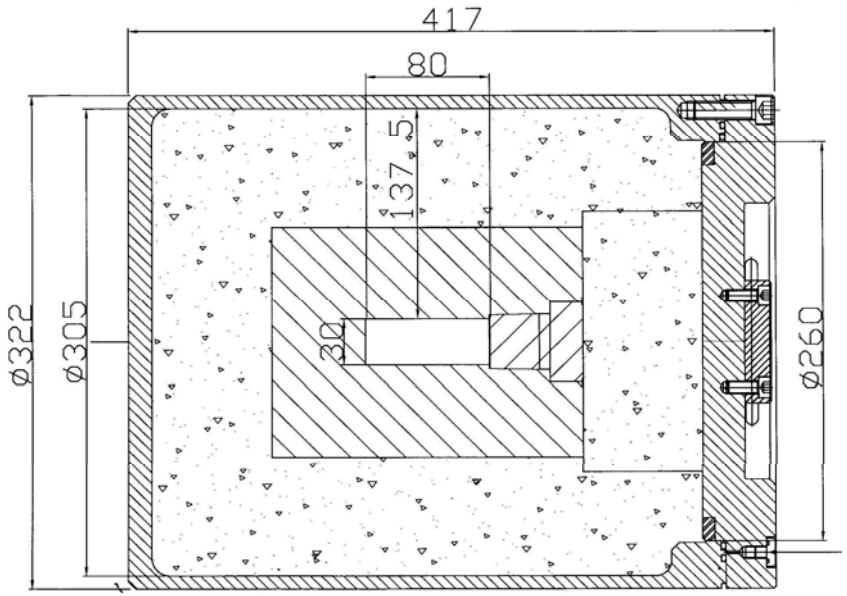
SPENT HIGH ACTIVITY SOURCES
CONDITIONING

Pb containment system



The container is totally realized in lead surrounded by a AISI 304 stainless steel liner with thickness of 17 m

Pb-W containment system

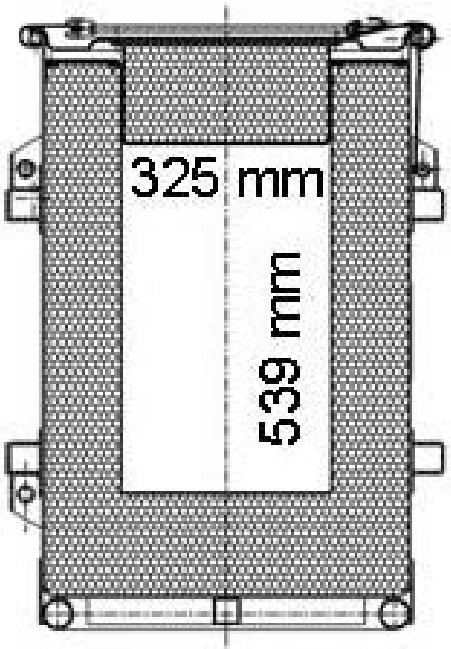


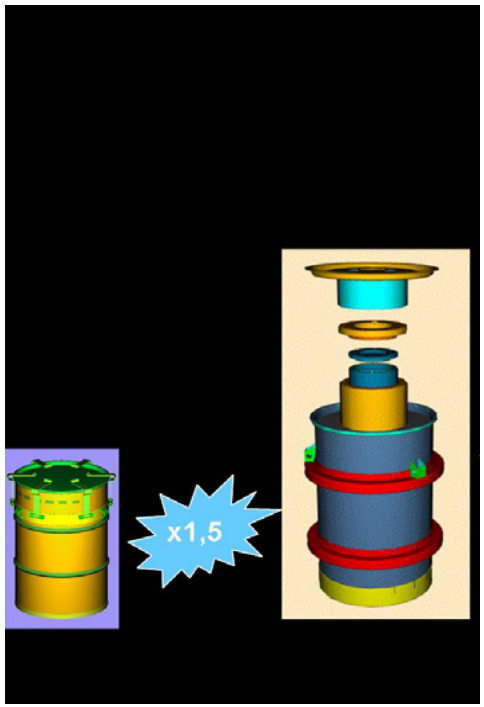
The new containment system is composed by a primary shield realized in tungsten, followed by a secondary shield of lead.

SPENT HIGH ACTIVITY SOURCES
CONDITIONING

The containment systems (lead or lead-tungsten) were inserted in an another component to form a package ⇨ ***CF66***

CF66 mechanical protection and thermal shielding system





Approved as Type B (U) by the National Competent Authority (ISPRA)

SHIELDING CALCULATION

Objective ➡ Evaluate the maximum activity, in TBq, allowed by the shielding thickness of Pb or Pb-W containment system.

Design parameter:

Equivalent Dose Rate ➡ **2 mSv/h** *On the outer surface of the shielding*

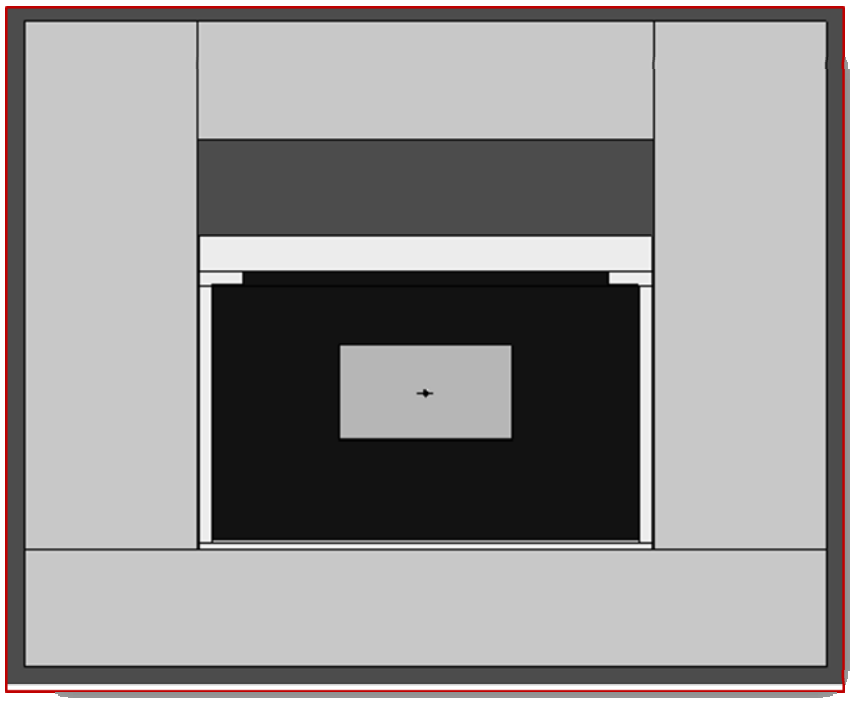
Equivalent dose rate allowed by international standards for the transport of nuclear material

SHIELDING CALCULATION

The evaluation of the maximum activity, for a fixed thickness of lead shielding, for ^{60}Co and ^{137}Cs was performed by using:

➡ ***MCNP: Monte Carlo N-Particle Transport Code (Version: 4C)***

a computer transport code for neutrons, photons and electrons.



The user creates an ***input file***

- ✓ *Materials description*
- ✓ *Geometry characterization*
- ✓ *Location and specification of the source*
- ✓ *Tallies desired*
- ✓ *Variance reduction techniques*

SHIELDING CALCULATION

*Maximum activity of ^{60}**Co** in **Pb** containment system*

Dose contact CF66	Activity allowed
2 mSv/h	**19.30 TBq = 521.62 Ci**
lateral surface	**8.86 mSv/h**
upper surface	**0.97 mSv/h**
lower surface	**0.47 mSv/h**
upper surface CF66	**0.185 mSv/h**
lower surface CF66	**0.118 mSv/h**
dose at 1 m from CF66	**0.14 mSv/h**

*Maximum activity of ^{137}**Cs** in **Pb** containment system*

Dose contact CF66	Activity allowed
2 mSv/h	**173529.8 TBq = 4690 kCi**
lateral surface	**8.54 mSv/h**
dose at 1 m from CF66	**0.13 mSv/h**

SHIELDING CALCULATION

*Maximum activity of ^{60}**Co** in **Pb-W** containment system*

Dose contact CF66	Activity allowed
2 mSv/h	**183.2 TBq = 4951.3 Ci**
lateral surface	**8.90 mSv/h**
upper surface	**0.85 mSv/h**
lower surface	**0.41 mSv/h**
upper surface CF66	**0.16 mSv/h**
lower surface CF66	**0.12 mSv/h**
dose at 1 m from CF66	**0.14 mSv/h**

*Maximum activity of ^{137}**Cs** in **Pb-W** containment system

Dose contact CF66	Activity allowed
2 mSv/h	**3991936 TBq = 107890 kCi**
lateral surface	**6.51 mSv/h**
dose at 1 m from CF66	**0.15 mSv/h**

ITALIAN γ HIGH ACTIVITY SOURCES

Nuclide	Activity (GBq)	Unit	Number
^{137}Cs	50000	ASL	2
^{60}Co	4500	Private	5
^{60}Co	32000	Hospital	1
^{137}Cs	100000	Private	2
^{137}Cs	60000	University	2
^{137}Cs	120000	Hospital	2
^{60}Co	14000000	Private	1
^{137}Cs	45000	Hospital	3
^{137}Cs	1000	Industry	1
^{137}Cs	15000	Private	1
^{60}Co	6000	Private	1

CONCLUSION

- ✓ *The experience gained for many years in waste treatment and tests on industrial drums can assure an easy transport and acceptance to the final disposal……*
- ✓ *The design of a new packaging for disused sources is just one step to comply with the European Directive on High Activity Sources*

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