

- Geopolymer Camp 2014 –

Materials for Development of Containers for Radioactive Waste Management

(July 8, 2014, St.Quentin)

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Radioactive Waste Management - ARTE TV (2013)

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Centrales nucléaires, démantèlement impossible ?

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Réalisateur : Bernard Nicolas
Producteurs : ECLECTIC PRESSE, ARTE France

Sortir progressivement du nucléaire pour choisir des énergies renouvelables, dépasse largement un simple débat électoral. C'est l'avenir de la planète, de ceux qui y vivront après nous, qui va se jouer dans les années qui viennent.

DVD à la carte	6,99 €	+ 6€ / DVD gravé > Plus d'infos	ACHETER
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La galerie photos
Centrales nucléaires, démantèlement impossible ?



Waste Acceptance Criteria (IAEA)

WAC LINKS/HIERARCHY



Sum of Radioactivity Fractions

$$\sum_i \frac{A_i}{T_i} < 1$$

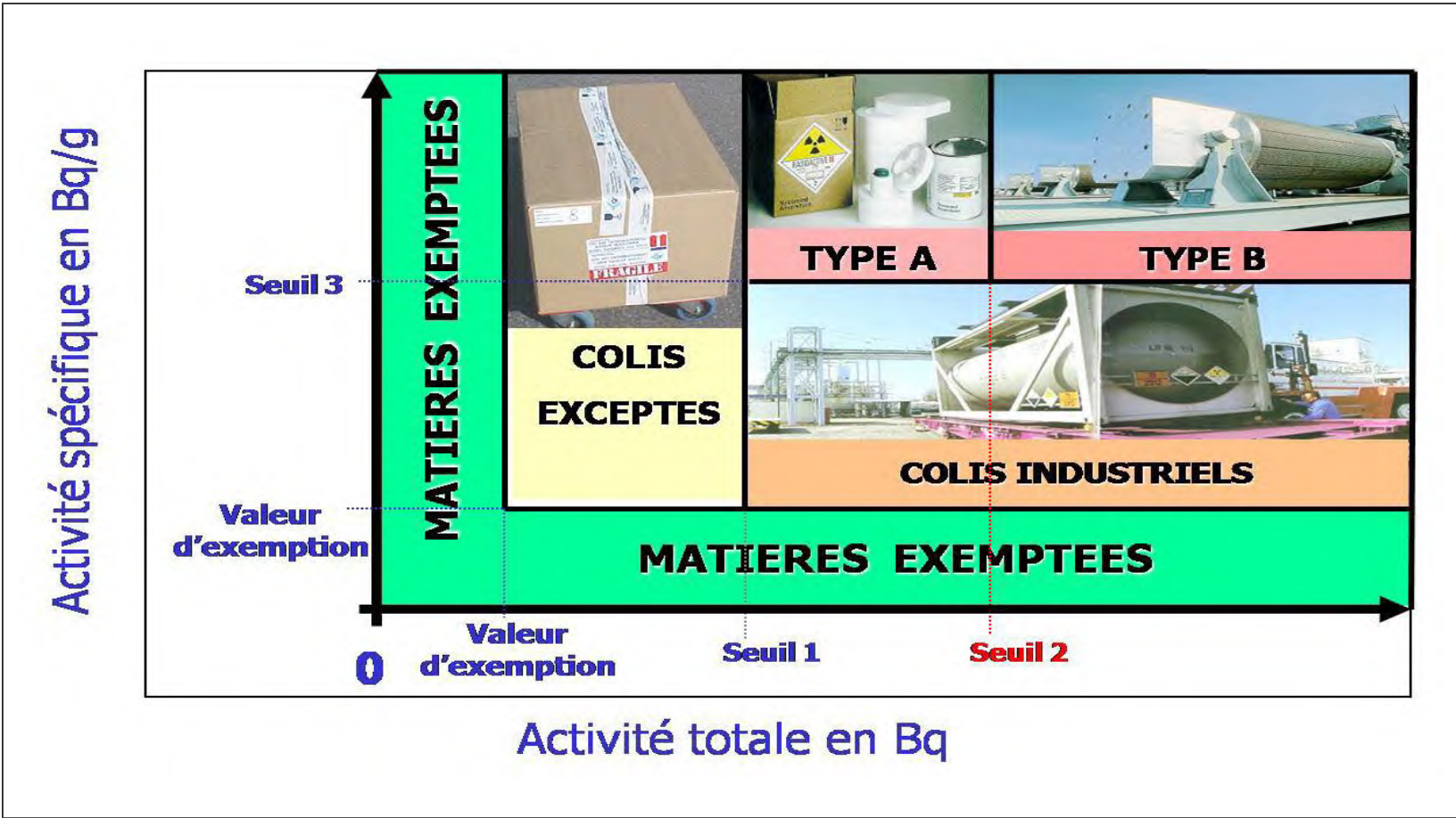
Where:

A_i = activity of radionuclide i that is present in a package (TBq)

T_i = transport security threshold for radionuclide i (TBq)

SAMPLE CALCULATION OF A SUM OF RADIOACTIVITY FRACTIONS OF NUCLIDES			
Radionuclide	Package Inventory/ TBq	Transport Security Thres hold/TBq	Contribution to Sum of Fr actions
Fe-55	3	8000	0.0004
Co-60	0.1	0.3	0.3333
Ni-63	6	600	0.01
Total (< 1)			0.3437

Radioactive Waste Packaging (France)



Packaging Requirements (France)

		LSA (Bq/g)		Transport Requirements		
		$\beta\gamma$ (Max./Aver.)	α (Max./Aver.)	Surface Contamination (Bq/cm ²)		Contact Dose (mSV/h)
				$\beta\gamma$	α	
VLLW		< 100 / 2	< 10 / 1	< 4	< 0.4	< 2
LLW	unsolidified	< 37,000	$\sum\alpha < 185$ <30 Yrs			
	solidified	Limit by nuclide	$\sum\alpha < 3,700$			
	combustible	< 20,000	<50			

Status of LLW Containers for D&D

	Background	Status	Remark
Korea	<ul style="list-style-type: none"> Based on American (W) system (drum) 	<ul style="list-style-type: none"> Concrete box for disposal Metal container for transport 	<ul style="list-style-type: none"> LLW/ILW repository built Sea transport D&D container to develop
Japan	<ul style="list-style-type: none"> similar to Korea 	<ul style="list-style-type: none"> D&D waste from JPDR 	<ul style="list-style-type: none"> a dozen containers
USA	<ul style="list-style-type: none"> Private respon. LLW Based on drum 	<ul style="list-style-type: none"> D&D waste container (B-25) developed Soft-sided bag for D&D 	<ul style="list-style-type: none"> Long-distance transport (Andrews Repository) disposal in concrete
UK	<ul style="list-style-type: none"> BNFL/Nirex system Extensive use of ISO containers 	<ul style="list-style-type: none"> ISO containers for Drigg Increasing use of soft bags for D&D wastes 	<ul style="list-style-type: none"> NDA policy to introduce competitive market for various containers for ILW
France	<ul style="list-style-type: none"> Centralized system Drums/boxes 	<ul style="list-style-type: none"> l'Aube/Morvillier : Soft bags for D&D waste 	<ul style="list-style-type: none"> Most container affiliated to Areva/EdF Concrete overpack for ILW
Germany	<ul style="list-style-type: none"> Konrad repository to be opened 	<ul style="list-style-type: none"> Konrad repository to open 	<ul style="list-style-type: none"> 14 types of containers
Sweden	<ul style="list-style-type: none"> American (W) drum ISO containers 	<ul style="list-style-type: none"> Standardized D&D waste containers (4 different types) 	<ul style="list-style-type: none"> SFR repository extension Sea transport

Container for LLW Waste Management

TC01 & TC03 Designs

Type IP-2

Contents - Solid LSA-II

Groutable Disposal
Container

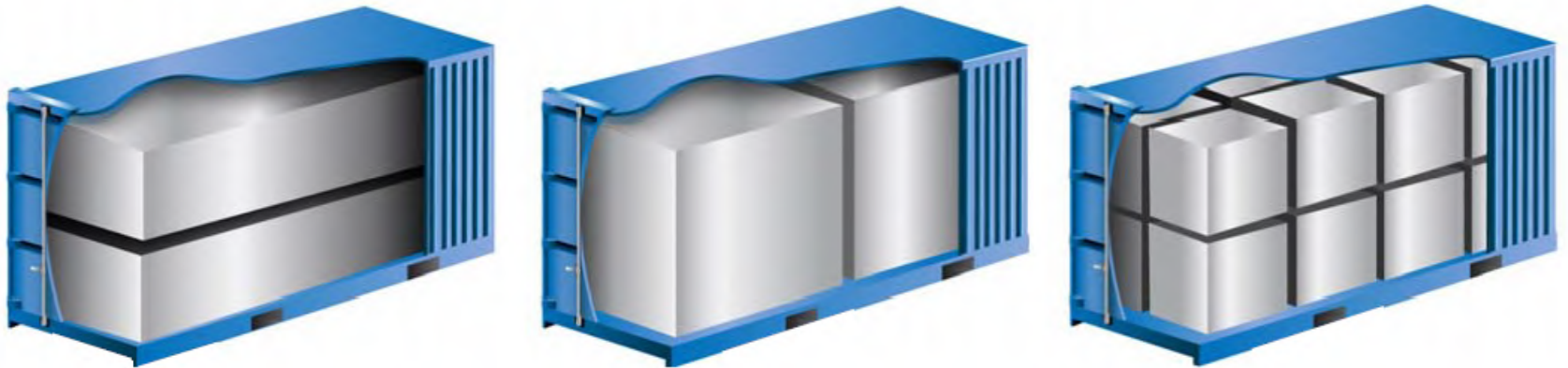
Max Gross Mass - 35te



Waste Packaging Concept (UK)

Waste Package = Disposal Package
in Reusable Transport Containers

- Reusable container to be returned for reuse
- Disposal package to be disposed of permanently in repository



UK NDA/LLWR Reusable Container

TC02 Waste Boxes

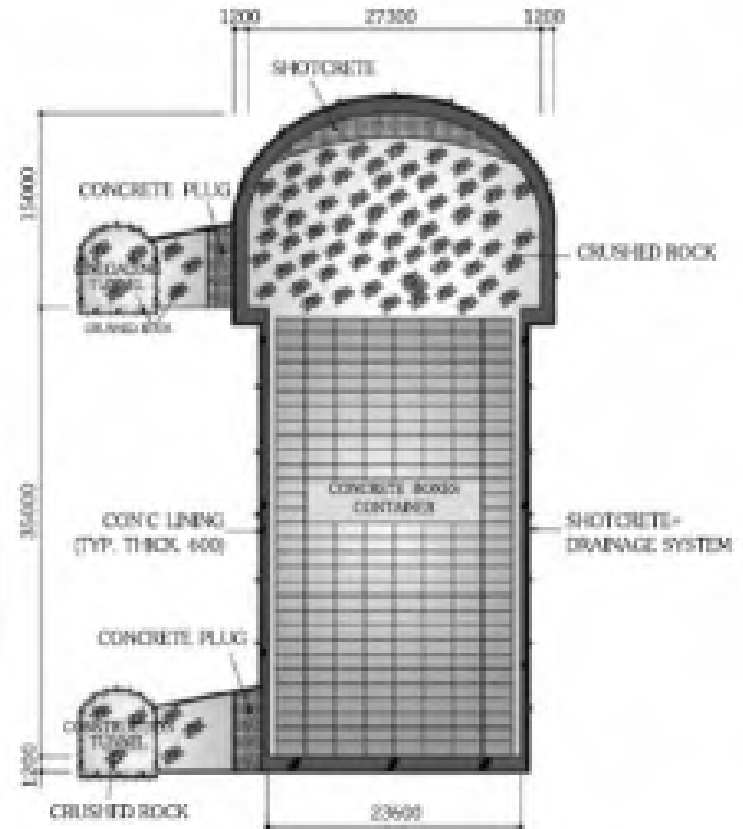
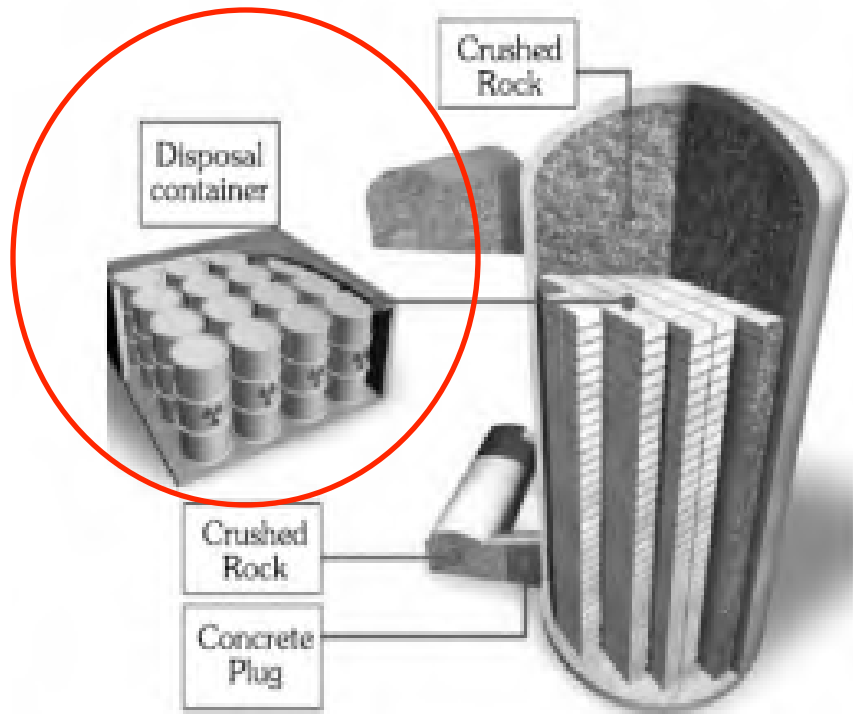


To minimise the hold up
time of the licensed
package

Drums in Transport Container



Gyeongju Repository (Korea)



Radioactive Waste Containers in Sweden (SFR Repository for LLW)

Waste packaging used for LILW in SFR • 220 litres steel drums



- cubical steel box with side length 1,2 m
- concrete box with side length 1,2 m
- concrete container (1,3 x 2,3 x 3,3 = 10 m³)
- ISO standard freight container.

Containers for Konrad Repository (Germany)

No.	Type	Dimension (mm)			Volume (m ³)
		L	W	H	
• 1	• Concrete canister – I	1,060		1,370 (1)	1.2
• 2	• Concrete canister – II	1,060		1,510 (2)	1.3
• 3	• Ductile Cast Iron (DCIC)-I	900		1,150	0.7
• 4	• Ductile Cast Iron (DCIC)-II	1,060		1,500 (3)	1.3
• 5	• Ductile Cast Iron (DCIC)-III	1,000		1,240	1.0
• 6	• Steel Container – I	1,600	1,700	1,450 (4)	3.9
• 7	• Steel Container – II	1,600	1,700	1,700	4.6
• 8	• Steel Container – III	3,000	1,700	1,700	8.7
• 9	• Steel Container – IV	3,000	1,700	1,450 (4)	7.4
• 10	• Steel Container – V	3,200	2,000	1,700	10.9
• 11	• Steel Container – VI	1,600	2,000	1,700	5.4
(1) H= 1,510 + hook 90 = 1,460 mm					
(2) H = 1,370 + hook 90 = 1,600 mm					
(3) KfK Type, H= 1,370 mm, Volume = 7.2 m ³					
(4) KfK Type, Stacking H= 1,400 mm, Volume = 7.14 m ³					

B-25 Boxes (North Coast Fabricators, CA)

<http://www.northcoastfabricators.com/fabrication/b-25-box>



B-25 Boxes fabricated in our shop
2 week turn around on your first order
Production capacity is 1/day

Carbon Steel construction
Seal Lock clip closures
Interior: L 71-3/4" x H 46" x W 47"

MHF Services

<http://www.mhfservices.com/Durable-Packaging.asp>

Inter-modals and Sea-lands



ISO Standard Containers

Les conteneurs ISO : deviennent le standard pour les déchets solides LSA

► **Conteneurs ISO 20' ½ hauteur ou pleine hauteur en tant que:**

- ◆ Colis excepté
- ◆ IP-1
- ◆ IP-2



- ◆ **Avantage : équivalence réglementaire ISO ⇔ IP-2, facilité de transport et de manutention, transport multimodal, internationalement reconnu**

Soft-Sided Bags for VLLW/LLW



Soft Bags for VLLW/LLW



Andrews Repository (Texas, USA)



FEDERAL WASTE FACILITY

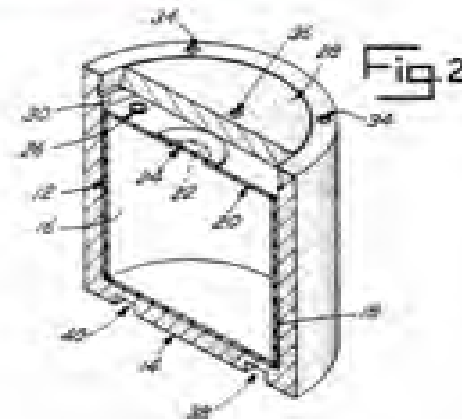
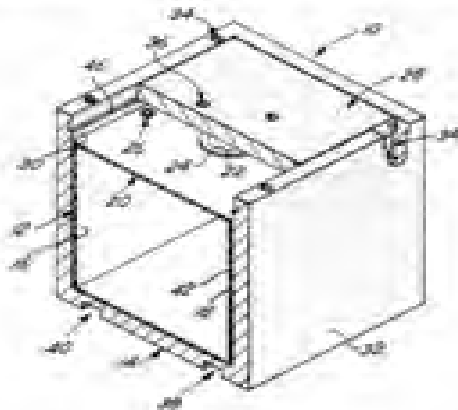
Combination of Containers

US Patent

5225114 (1993)

Multi-purpose Container for LLW (Chem-Nuclear)

The concrete outer shell 14 is typically made through a precasting process, and is metal reinforced. The concrete may be reinforced with epoxy coated wire mesh or reinforcement bar. The concrete may also have various additives admixed into it during the concrete blending procedure. Such additives may include various high range water reducing agents, or pozzolanic materials such as fly ash and silica fume (**= Geopolymer ?**). The concrete may also be reinforced, for instance, with amorphous metal fibers obtained from SOGEFIBRE of France. Such fibers are generally produced by quenching a liquid metal jet onto a cooled wheel that is rotating at a high speed. The resulting metal fibers are noncrystalline in structure, and thus highly corrosion resistant.



Concrete Containers (SOGEFIBRE)

TS SPÉCIAUX ET CONTENEURS EN BÉTON

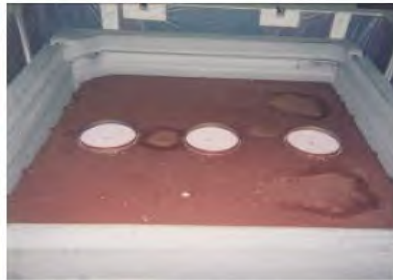
LA PRÉFABRIC



PROTÉGER

Sogefibre Concrete Container

2. Functions and applications

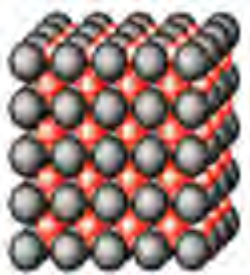
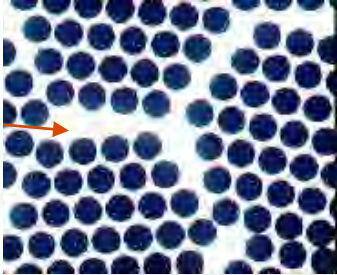
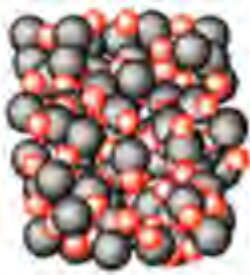

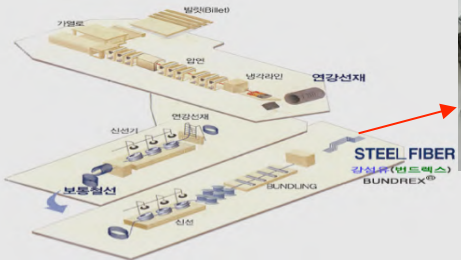

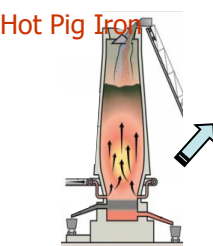
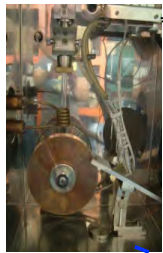



- ▶ Different types of waste packaging methods are used in the CBF-K container:

- bare drums
- bulk heterogeneous solid waste
- cement-solidified liquid or powder waste

- ▶ The CBF-K container meets radioactive waste package specifications calling for durable concrete containers

Comparative Features

	Conventional Steel Fiber	Pig Iron Based Amorphous Fiber
Atomic Structure	 	 
Manufacturing process	  <p>Steel Fiber</p>	  <p>* Melt Spinning Method</p>  <p>Amorphous Fiber</p>
	<p>Iron making , Iron → Steel making , Steel → C. casting → Wire hot rolling → Wire cold rolling (Drawing) → Cutting → Bundling → Steel Fiber</p>	<p>Iron making , Iron → PFC → Amorphous Fiber</p>
CO ₂ Emission (ton/ton)	2.28 (1.25)	1.83 (1)

Conclusions

- **Containers for Radioactive Waste Management**
 - Conventional steel drums may not be adequate performance
 - Better designs with new materials may be desirable
 - Advanced materials may come up for better performance
- **The ISO container as an option**
 - Compliance with transport requirements
 - Disposal requirements ? (→ concrete)
- **Concrete material for disposal container**
 - Armophous fibre reinforced concrete (Sogefibre, Posco,...)
 - Geopolymer (?)