

Modular Design of Processing and Storage Facilities for Small Volumes of Low and Intermediate Level Radioactive Waste including Disused Sealed Sources

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Background (1)

- A number of IAEA Member States generate relatively small quantities of radioactive waste and/or disused sealed sources
- Many of these Member States do not have facilities for processing and storing their radioactive wastes - notably in those countries with small quantities of generated radioactive wastes.
- In other Member States the existing waste processing and storage facilities (WPSF) are in need of varying degrees of upgrading.
- IAEA supports these Member States to manage their radioactive wastes in a safe and cost-effective manner
- Wide variation in the needs of these Member States because of the wide variation in the types and quantities of radioactive waste.

Background (2)

- Therefore the IAEA has developed a modular design approach for a Waste Processing and Storage Facility (WPSF)
- WPSF based on a variety of modules for different waste stream treatment and conditioning processes as well as for storage.
- Each module can be constructed locally or pre-fabricated and delivered as skids then combined with other modules to meet the country specific needs.
- Similarly for storage, different storage module concepts are available ranging from simple storage cabinets up to a purpose designed storage building.
- Modular WPSF design is elaborated in a substantial Design Engineering Package

Design Engineering Package Content

- Overview of the technical and regulatory requirements for setting up WPSF.
- A description of typical wastes generated in these Member States.
- Identification of the preferred processing and storage options
- Waste management decision flowcharts
- Design and specification information for each of the process or storage modules.
- Guidance on the integration of the modules to provide a complete waste management capability.
- Operating guidelines for a modular WPSF

Design Engineering Package

Modular Design of Processing Facilities



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Design Engineering Package Content:

Waste Processing

- Waste types and quantities
- Waste processing technologies
- Waste management decision flowcharts
- Waste processing modules - design and specification information
- Example procurement specifications

Waste Types and Quantities (1)

Matrix Cross Ref.	Waste Stream	Annual Quantity to be Processed	Waste Origin and Waste Type
A	Low Volume Aqueous Liquid	Typically up to 0.5m ³	Laboratories, Hospitals etc.
B	High Volume Aqueous Liquid	Typically in the range 0.5 -10m ³	Laboratories, Hot cells, Research reactor spent fuel storage pool, Decontamination, Sump and rinsing collection etc.
C	Organic Liquid	Typically less than 0.3m ³	Scintillation solutions, Oil (from pumps etc), Extraction solvent etc.
D	Compactable Solid	Typically less than 20m ³	Paper, Cardboard, Plastics, Rubber, Gloves etc.
E	Non-Compactable Solid	Typically less than 5m ³	Glassware, metallic items, scrap etc. Disused sealed sources are included is a separate waste stream
F	Ion Exchange Resins	Typically less than 0.5m ³	Research reactor tank and spent fuel storage pool, as secondary waste from treatment by ion exchange etc.
G	Sludge	Typically less than 0.5m ³	Secondary waste from evaporation and chemical treatment etc.

Waste Types and Quantities (2)

Matrix Cross Ref.	Waste Stream	Annual Quantity to be Processed	Waste Origin and Waste Type
H	Disused Sealed Source - Short Lived Isotope (half- life ≤30 y)	Large variation of number of sources, for the reference case 20 should be used	Medical, industrial and research applications etc.
J	Disused Sealed Source - Long Lived Isotope (half-life > 30 y)	Large variation of number of sources, for the reference case 20 should be used	Medical, industrial and research applications etc.
K	Biological (Carcasses)	Typically up to 0.5m ³	Medical applications and research. Type: Animal carcasses, tissues and body fluids
L	High Activity Disused Sealed Source	Typically 1 or 2 sources per year	Medical, industrial and research applications etc.

Waste Processing Technologies (1)

Cross Ref.	Waste Stream	Liquid and West Solid Waste						Solid Waste			
		Chemical Treatment	Ion Exchange	Reverse Osmosis	Cross-flow Filtration	Filtration	Solidification	Encapsulation	Low Force Compaction	Unshielded Booth	Mobile Hot Cell
A	Low Volume Aqueous Liquid						A6				
B	High Volume Aqueous Liquid	B1	B2	B3	B4	B5	B6				
C	Organic Liquid				B4	B5	A6				
D	Compactable Solid								D2	D3	
E	Non-Compactable Solid							E1		D3	
F	Ion Exchange Resins						A6				
G	Sludge						A6				
H	Disused Sealed Source - Short Lived Isotope (half- life ≤ 30 y)							E1		D3	
J	Disused Sealed Source - Long Lived Isotope (half-life > 30 y)							E1		D3	
K	Biological (Carcasses)							E1			
L	High Activity Disused Sealed Source										F1

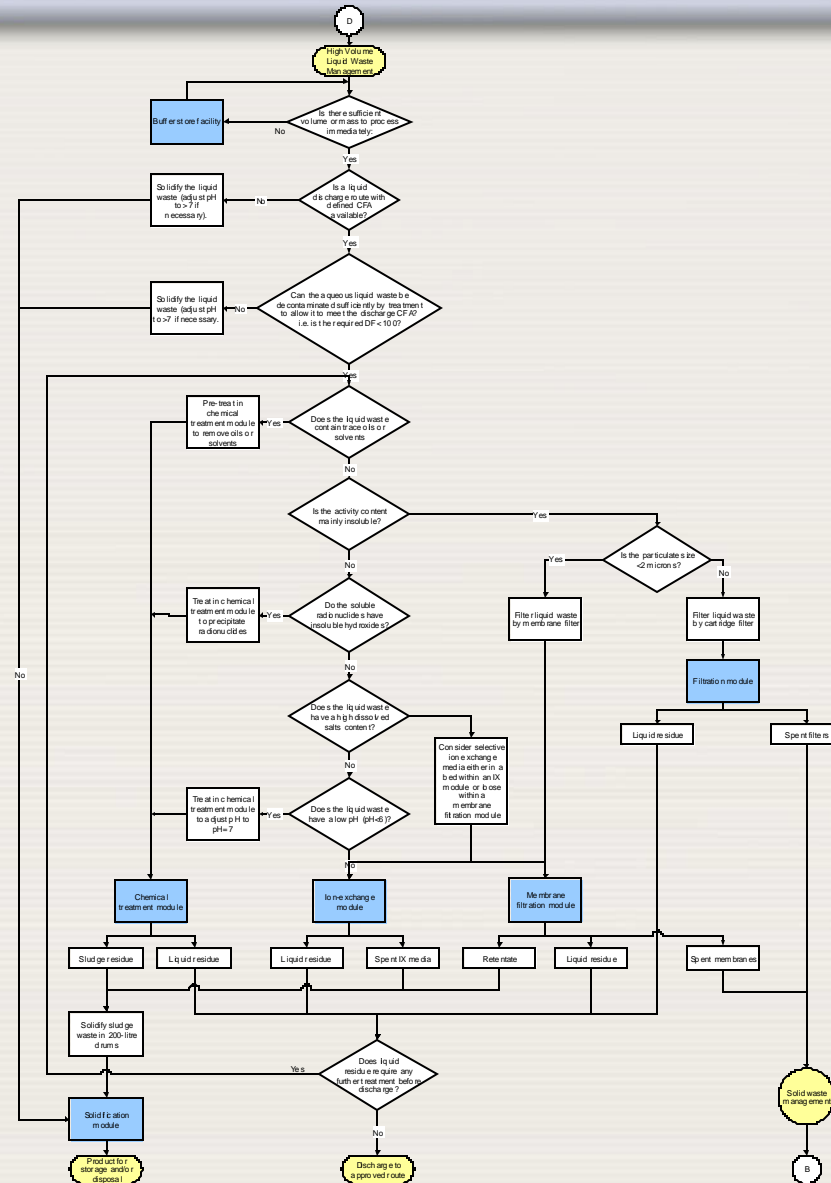
Waste Processing Technologies (2)

Process Module		Principal Waste Stream	Other Waste Streams That Can Be Processed By The Module
B1	Chemical Treatment	High Volume Aqueous Liquid	
B2	Ion Exchange	High Volume Aqueous Liquid	
B4	Membrane filtration	High Volume Aqueous Liquid	Organic Liquid
B5	Filter	High Volume Aqueous Liquid	Organic Liquid
B6	Solidify	High Volume Aqueous Liquid	Sludge (large volumes) Ion Exchange Media
C1	Chemical Treatment	Organic Liquid	
C6	Solidification	Organic Liquid	Sludge (small volumes) Low Volume Aqueous Liquid Ion Exchange Media (small volumes)
D2	Low-Force Compaction	Compressible/Compactable	
D3	Unshielded Booth	Compressible/Compactable	Non-Compactable Disused Sealed Source (low dose rates)
E1	Encapsulate	Non-Compactable	Disused Sealed Source Biological wastes
-	Hot Cell	Disused Sealed Sources	

Waste Management Decision Flowcharts

- Radioactive Waste Management Strategy
- Radioactive Waste Categorisation
- Solid Waste Management
- Low Volume Liquid Waste Management
- High Volume Liquid Waste Management
- Organic Liquid Waste Management

Waste Management Decision Flowcharts: e.g. High Volume Liquid Waste Management



Design and specification information (1)

- General Module Specification Sheet
 - Functional requirements
 - Summary description
 - Estimate of costs
 - Support requirements – services, storage, staff, equipment
- Interface Specification Sheet
 - Equipment details - sizes, weights
 - Service requirements – electricity, water

Design and specification information (2)

- Module Specifications
 - General
 - Basis of Design
 - Process Flow Diagram
 - Equipment lists
 - Equipment description
 - Process Description and Operation

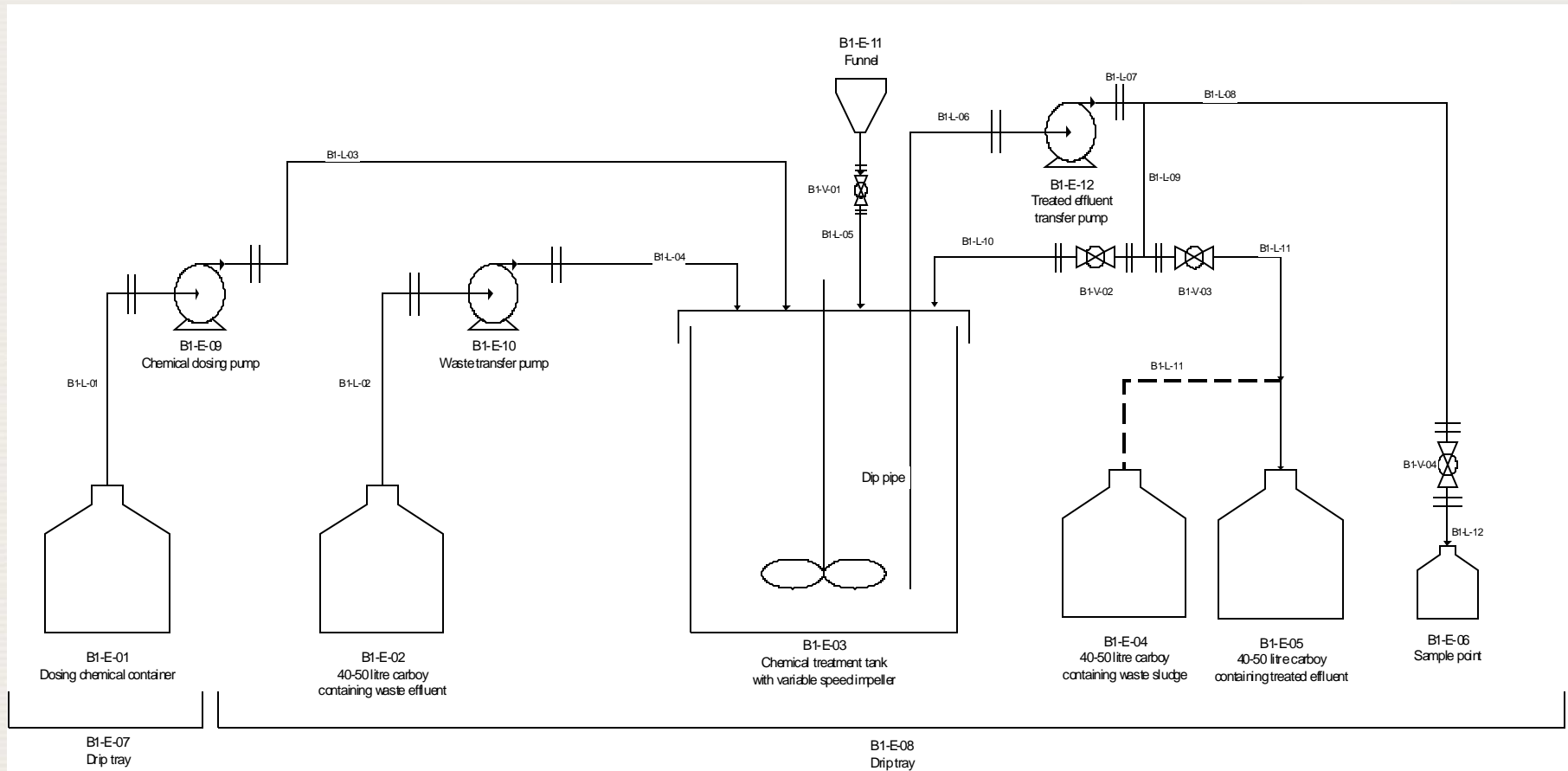
Example Module Specification Information: *Chemical Treatment - Module B1*

Treatment of high volume aqueous waste

- Treat aqueous waste in batches.
- Produce a small volume of sludge containing the radionuclides.
- Bulk volume of the aqueous waste either discharge immediately, or further "polishing" before discharge.

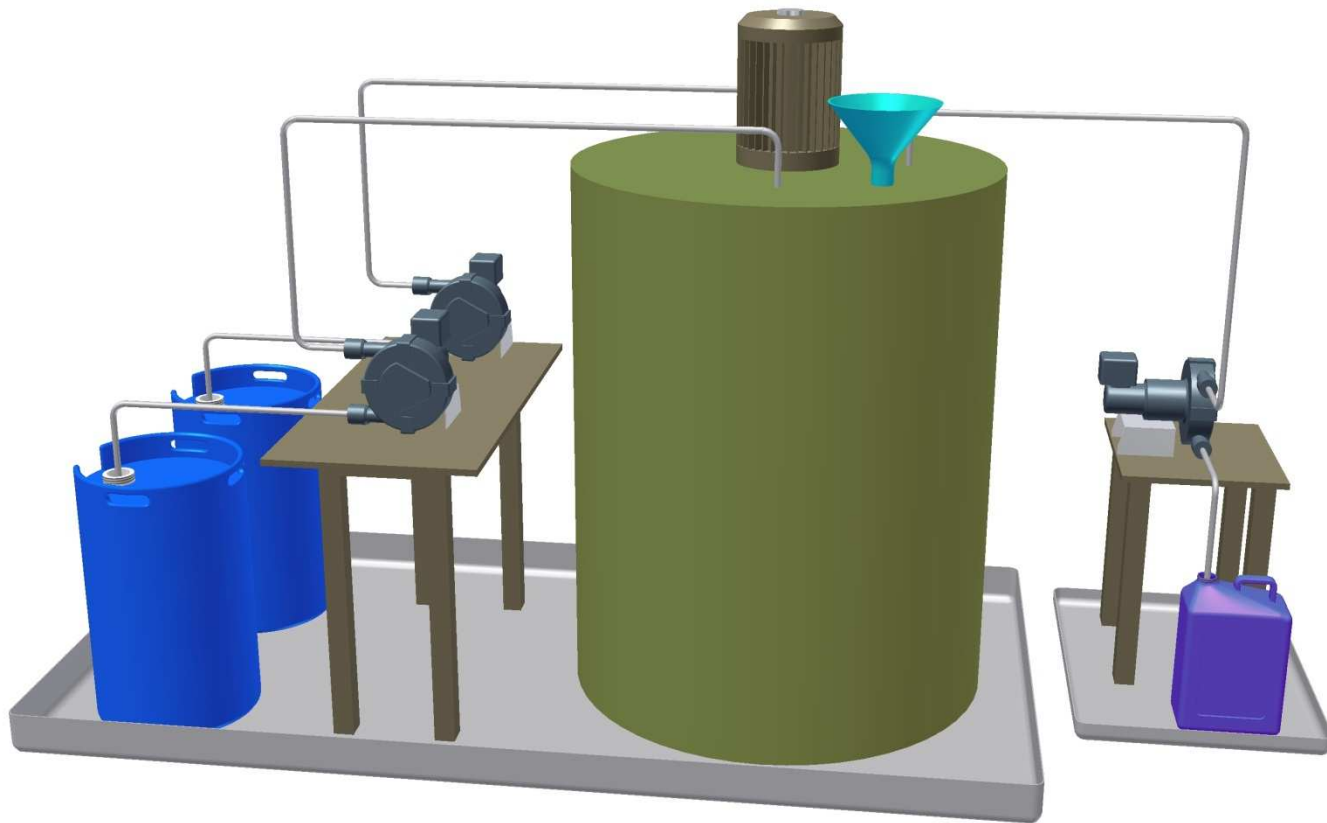
Example Module Specification Information:

Chemical Treatment - Module B1



Example Module Specification Information:

Chemical Treatment - Module B1



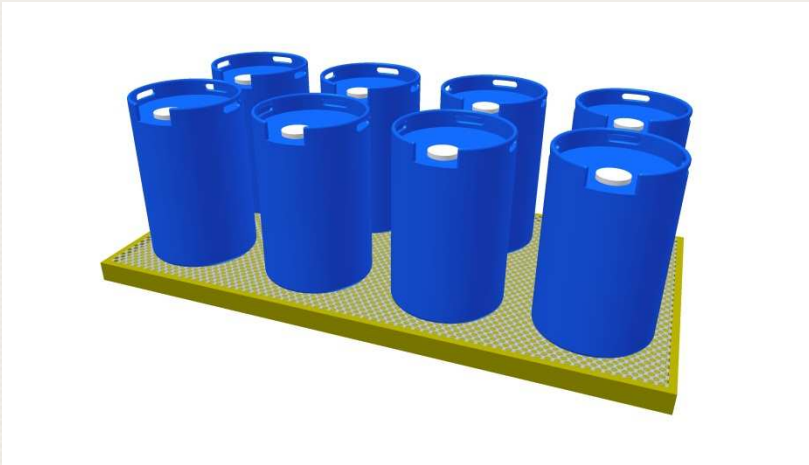
Example Module Specification Information: *Chemical Treatment - Module B1*

UN Group I certified container
for liquid waste



Example Module Specification Information:

Chemical Treatment - Module B1



Example Module Specification Information:

Chemical Treatment - Module B1

Equipment List				
Displayed Text	Description	Material	Model	Flowrate
B1-E-01	Dosing chemical tank	Plastic or stainless steel	40-50 litre plastic carboy	
B1-E-02	Waste effluent container	Plastic	40-50 litre carboy	
B1-E-03	Chemical treatment tank	Stainless steel or plastic	Covered roof, agitation	
B1-E-04	Treated effluent container	Plastic	40-50 litre carboy	
B1-E-05	Treated effluent container	Plastic	40-50 litre carboy	
B1-E-06	Sample container	Plastic or glass	Laboratory beaker	
B1-E-07	Drip tray	Plastic or stainless steel		
B1-E-08	Drip tray	Plastic or stainless steel		
B1-E-09	Chemical dosing pump	Plastic or stainless steel	0.1 cu.m/h peristaltic (flanged)	0.1m ³ /hr
B1-E-10	Waste transfer pump	Plastic or stainless steel	1.0 cu.m/h peristaltic or diaphragm (flanged)	1m ³ /hr
B1-E-11	Funnel for dosing solid chemicals	Plastic or stainless steel	Standard industrial	
B1-E-12	Treated effluent transfer pump	Plastic or stainless steel	1.0 cu.m/h peristaltic or diaphragm (flanged)	1m ³ /hr

Example Module Specification Information:

Chemical Treatment - Module B1

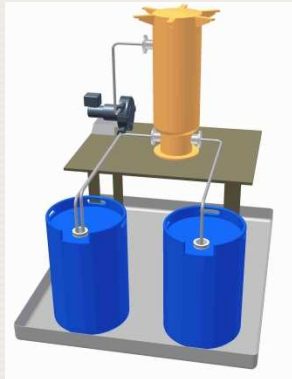
Pipeline List				
<i>Displayed Text</i>	<i>Description</i>	<i>Line Size</i>	<i>Design Pressure</i>	<i>Design Temperature</i>
B1-L-01	Chemical dosing pump feed line	5-15mm	2 bar	Ambient
B1-L-02	Waste transfer pump feed line	15mm	2 bar	Ambient
B1-L-03	Chemical dosing line	5-15mm	2 bar	Ambient
B1-L-04	Waste transfer line	15mm	2 bar	Ambient
B1-L-05	Solid chemical dosing line	25mm	Atmospheric	Ambient
B1-L-06	Variable height dip pipe	15mm	2 bar	Ambient
B1-L-07	Treated effluent transfer line	15mm	2 bar	Ambient
B1-L-08	Treated effluent transfer line	15mm	2 bar	Ambient
B1-L-09	Treated effluent transfer line	15mm	2 bar	Ambient
B1-L-10	Treated effluent return line	15mm	2 bar	Ambient
B1-L-11	Treated effluent transfer line	15mm	2 bar	Ambient
B1-L-12	Sample point	15mm	2 bar	Ambient

Example Module Specification Information:

Chemical Treatment - Module B1

<i>Valve List</i>			
<i>Displayed Text</i>	<i>Description</i>	<i>Line Size</i>	<i>Valve Class</i>
B1-V-01	Funnel delivery valve	25	Ball valve (flanged)
B1-V-02	Treated effluent return valve	15mm	Ball valve (flanged)
B1-V-03	Treated effluent isolation valve	15mm	Ball valve (flanged)
B1-V-04	Sample point isolation valve	15mm	Ball valve (flanged)

Other examples of processing modules



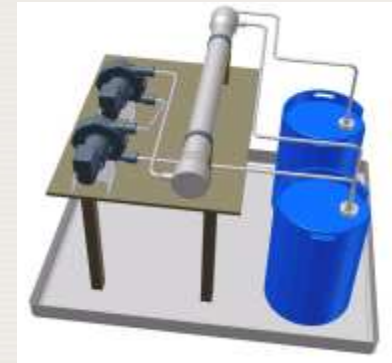
Filtration



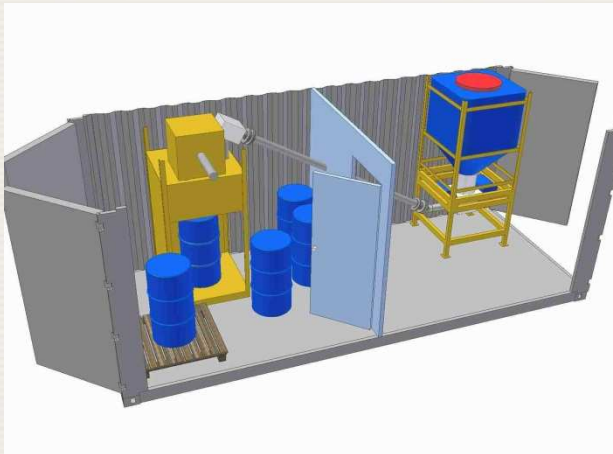
Ion exchange



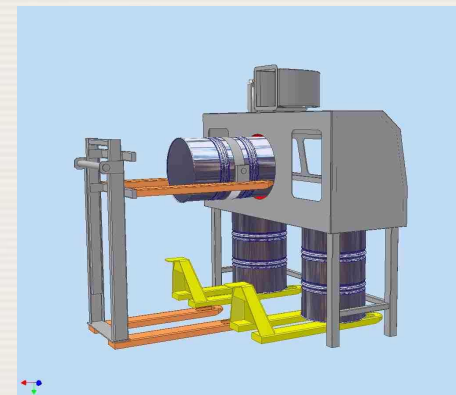
Cross flow
filtration



Reverse Osmosis



Solidification



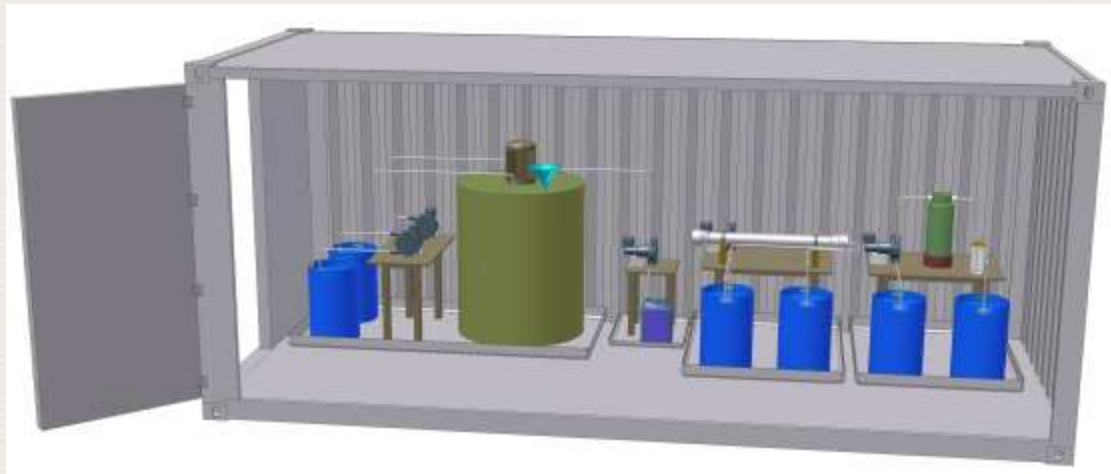
Unshielded booth

Process module integration

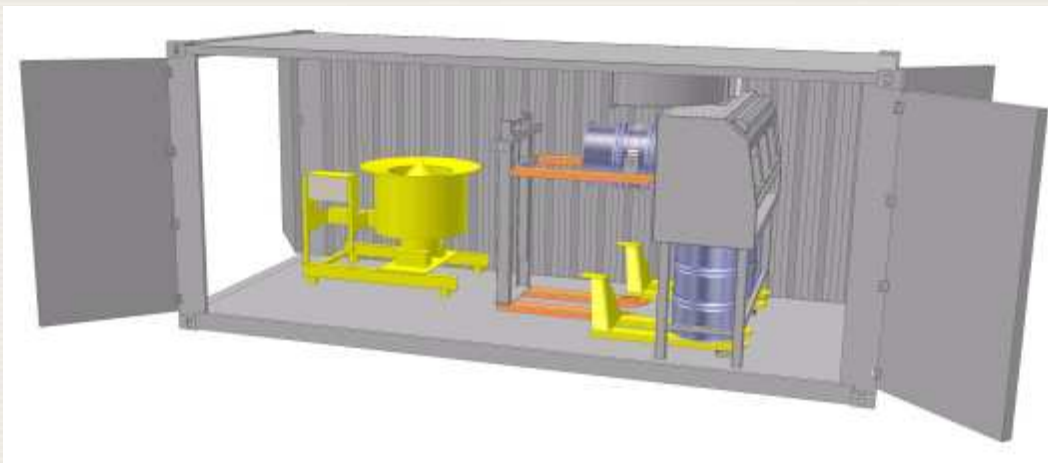
Integration can involve physical co-location and sequential operation of the process modules with the benefits of:

- Minimising double-handling of waste and hence reduced dose uptake by the operators.
- More efficient and effective use of staff and resources as wastes can be processed in short campaigns.
- Reduced interim storage of un-conditioned or incompletely treated waste because waste streams are processed from their raw form to final conditioned form in one campaign

Examples of module integration (1)

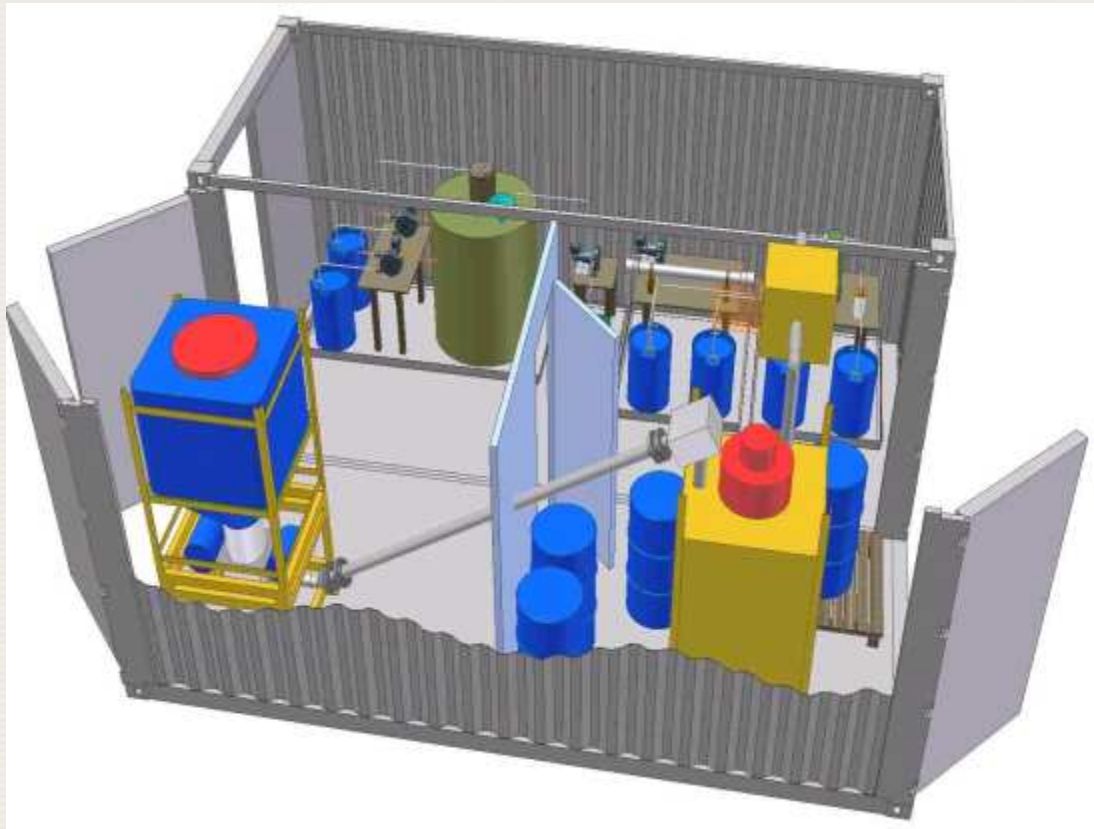


- Chemical treatment
- Filtration
- Ion exchange



- Solid waste sorting
- Encapsulation

Examples of module integration (2)



- Chemical treatment
- Cross-flow filtration
- Ion exchange
- Solidification of sludge and IX media

Procurement Specifications

The aim of the specification is to provide a clear definition of:

- The scope of work required
- The technical requirements
- How the work must be done
- How the contractor must demonstrate that he has met the technical requirements
- Any information the contractor needs to do the work

Design Engineering Package

Modular Design of Storage Facilities



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Design Engineering Package Content:

Storage

- Waste types and quantities
- Storage options
- Storage decision flowcharts
- Storage design and specification information

Waste Package Characteristics

- 200-litre / 45-55 gallon waste drums
- Drum weight could vary:
 - 50 kg (in-drum compacted soft waste)
 - up to 400 kg for encapsulated and solidified wastes
- Low radiation dose rates to allow contact handling
- Drums are free of external contamination

Waste Package Quantities

- Number of packages could vary from 1 or 2 drums per year up approximately 30-40 drums produced each year.
- Plus Member States may have quantities of historical or legacy waste to be conditioned, packaged and stored.
- Number of packages and the rate at which they are received will determine the storage facility size and need for expansion.

Store Design Options

Wide variety of storage concepts are available:

- Shielded cabinet
- Concrete container
- Dedicated room
- Transport container
- Below ground tubes or vaults
- Purpose built industrial building
- Existing building

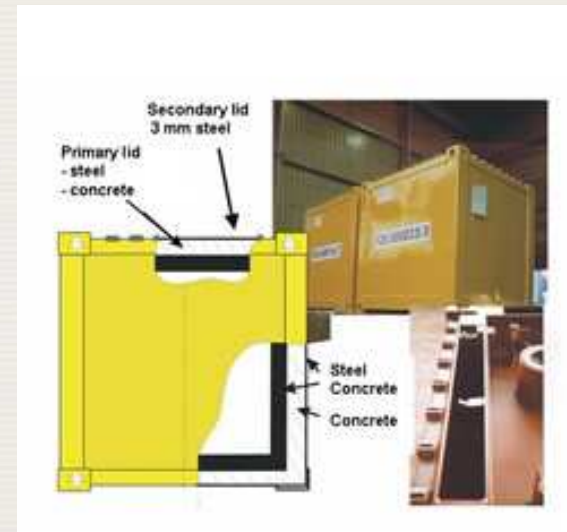
Store Design Options: *Shielded Cabinet*

- Ideal for storage of small waste packages in small quantities
- Can be located within an existing facility
- Can be locked to provide security



Store Design Options: *Concrete container*

- Widely used as transport, storage and disposal containers.
- Particularly suitable for higher dose rate waste packages as the box provides shielding
- Most, if not all designs have a removable lid for loading waste packages.
- Requires a crane and grab for handling waste packages and removal of the lid.
- Adds complexity and cost to drum handling.



Store Design Options: *ISO freight container*

- Widely available throughout the world
- Container Safety Convention certification.
- In wind and water tight condition.
- Fitted with a steel floor (or steel cladding of the existing wooden floor, sealed to the walls) to provide a decontaminable surface.
- Finished with a good paint finish outside and inside.
- Fitted with lock boxes on the doors to improve security.

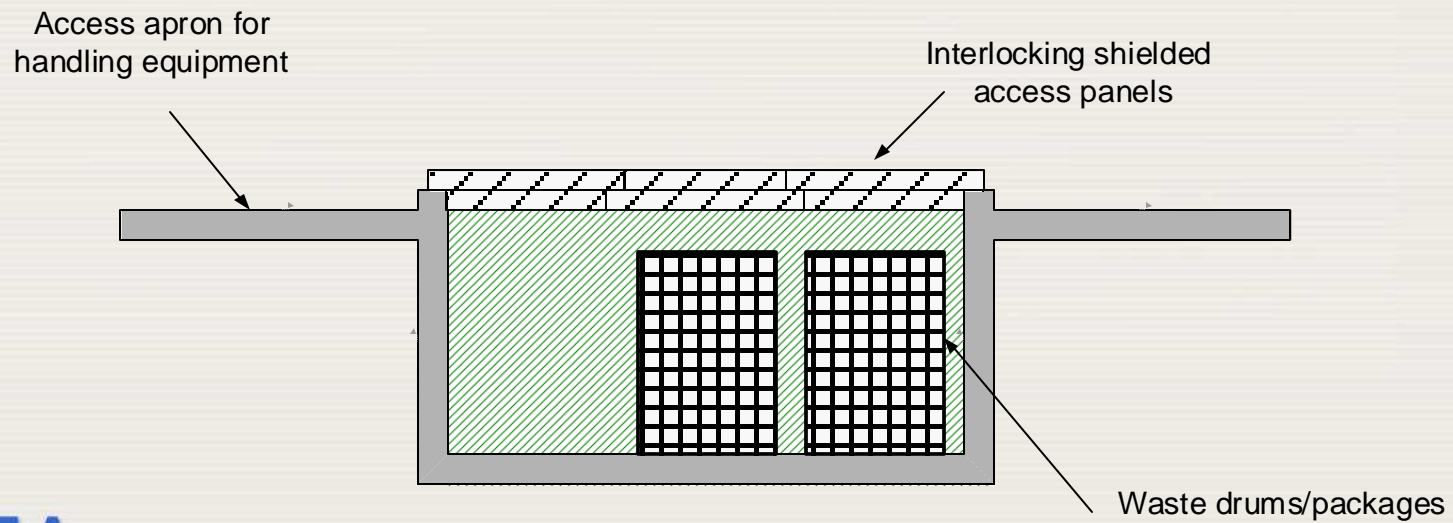


Store Design Options: *Dedicated room*

- Room in an existing facility may be suitable if waste volumes are relatively small.
- Need to consider :
 - Access into the room carrying drums with fork lift truck or pallet trucks will require a double door (normal personnel single doors not wide enough).
 - Access route to the room from where the waste drums (flat, smooth, width)

Store Design Options: *Concrete bunkers or trenches*

- Particularly suited to high dose rate wastes
- Construction challenge involving excavation and reinforced concrete retaining walls as well as consideration of access and drainage.
- Loading the bunker or trench with drums from above requires crane or and grab.



Store Design Options: *Purpose built industrial building*



Storage Decision Flowcharts (1)

- Storage Strategy
- Assessment of Existing Facilities for Storage
- Implementation of a New Storage Facility
- Store Specification and Design
- Store Design Requirements

Summary

The Design Engineering Package enables users:

- to select the optimum waste processing and storage modules to meet their needs, and
- to specify the requirements for procurement of individual modules and their integration into a waste processing and storage facility.

Publication

Design Engineering Package is planned for publication by the IAEA in 2012 and presented as:

- A Design Engineering Package Summary document.
- A supporting CD that contains:
 - Process module general specifications.
 - Process module interface specifications.
 - Design Engineering Package for process modules.
 - Sample technical specifications for design and construction of modular processing facility.
 - Design Engineering Package for storage modules.

Thank you
for your attention!

