IAEA Regional Workshop
„Safety Considerations of Disposal of Disused Sealed Sources in Near Surface Facilities“

Security of Radioactive Waste

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Overview

- **Background**
- **Measures to achieve waste security**
- **Approach to develop guidance:**
  - starting point: categorisation of sources
  - additional scenarios developed for security of wastes
- **Waste categories**
- **Relating Waste Classes and Types to Security Categories**
- **Modifiers**
- **Conclusions**

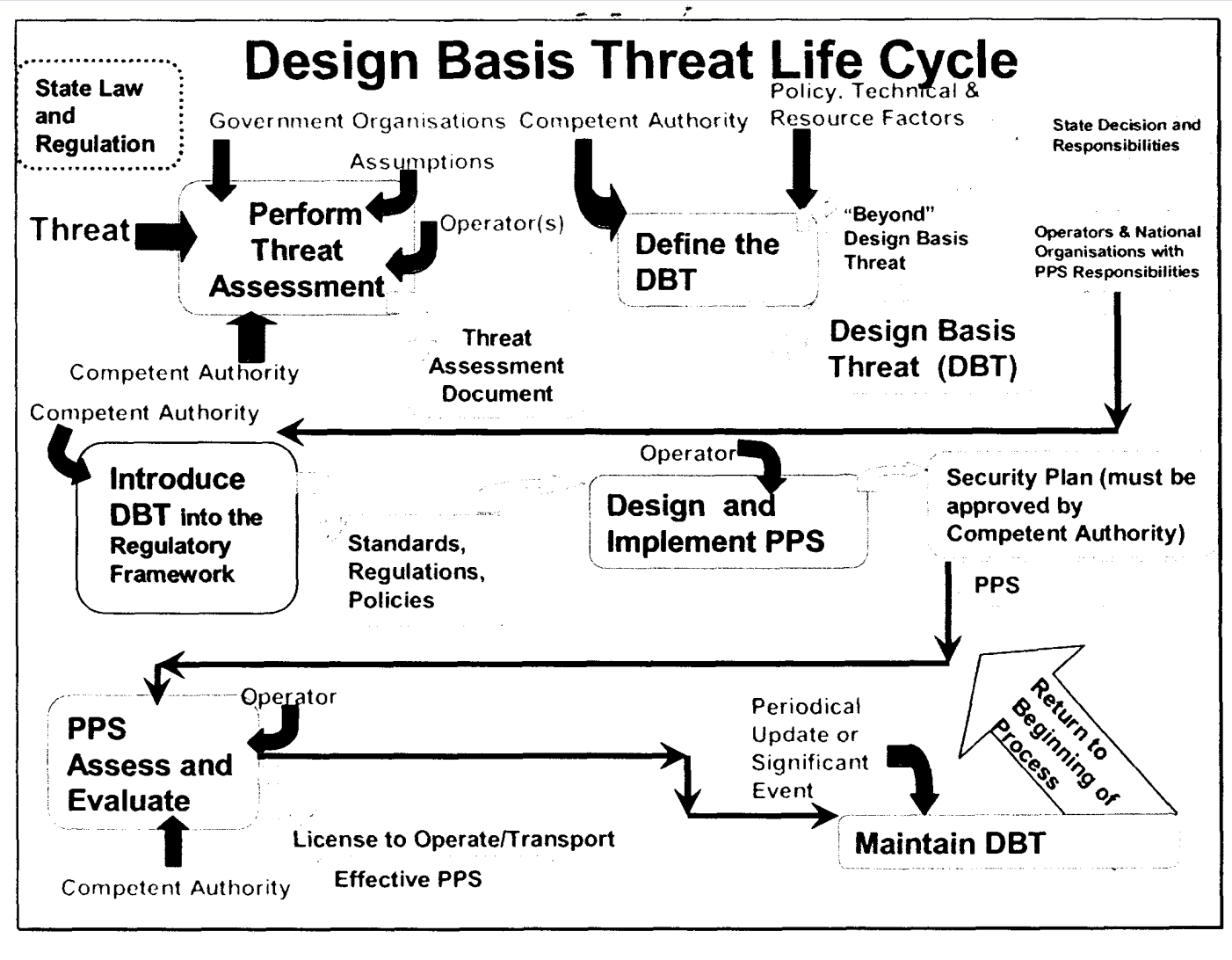
Background

Nuclear material and nuclear facilities	**INFCIRC/225/Rev.4 The Physical Protection of Nuclear Material and Nuclear Facilities 1999**
Radioactive Sources	**Interim guidance (for comment) on the security of radioactive Sources, TECDOC –1355 June 2003**
Radioactive Waste	**???**

Background

Nuclear material and nuclear facilities	**Non-Proliferation** **Sabotage** **Unauthorised removal**
Radioactive Sources	**Malevolent use** **Unauthorised use** **(Prevent deterministic effects)**
Radioactive Waste	**???**

Basis: Design Basis Threat (DBT)



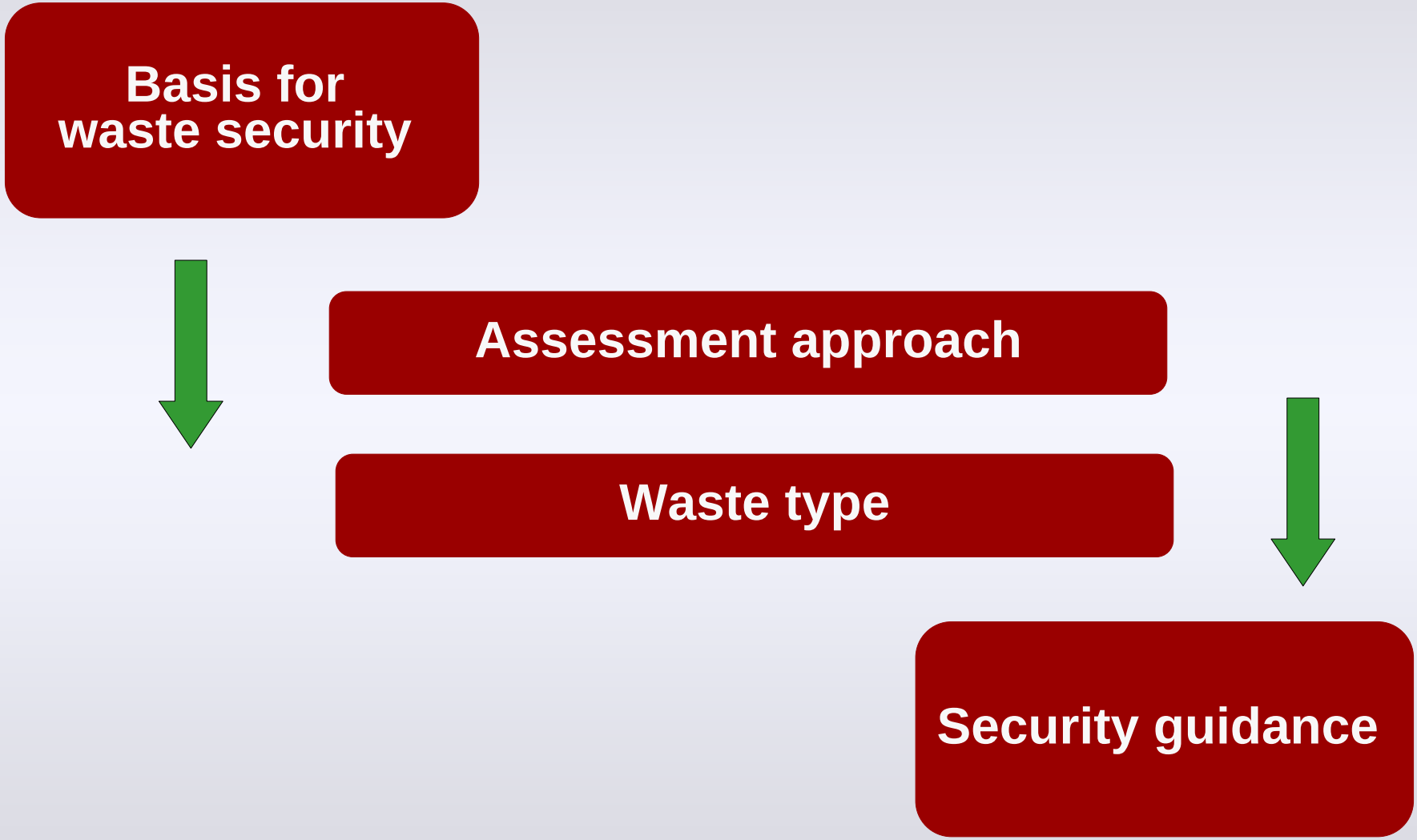
General Measures to Achieve Waste Security

- **Categorization of waste in order to implement adequate and consistent security measures based on potential consequences**
- **Appropriate treatment/storage/disposal of waste to minimize the potential and consequences of malicious acts**
- **Management of waste only within an authorised, regulated, legal framework**
- **Management of the security of personnel and information**
- **Measures to minimize the acquisition of radioactive waste by those with malicious intent**

Specific Measures to Achieve Waste Security

- **Deter unauthorized access to the waste**
- **Detect any such attempt or any loss or theft of waste**
- **Delay unauthorized access**
- **Provide timely response to counter any attempt to gain unauthorised access**
- **Measures to minimize acts of sabotage**
- **Efforts to recover any lost or stolen waste.**
- **Mitigation and emergency plans in case of release of radioactivity**

Approach to Develop Guidance



Starting Point: TecDoc 1344 (Categorisation of Sources)

- **Dangerous source: could, if not under control, give rise to exposure sufficient to cause severe deterministic effects**
- **Severe deterministic effect: is fatal or life threatening or results in a permanent injury that decreases the quality of life**
- **Concept of dangerous sources:**
  - Used for decisions,allocation of resources and public warnings
  - Must be realistic – not overly conservative
  - Must be understandable by the public

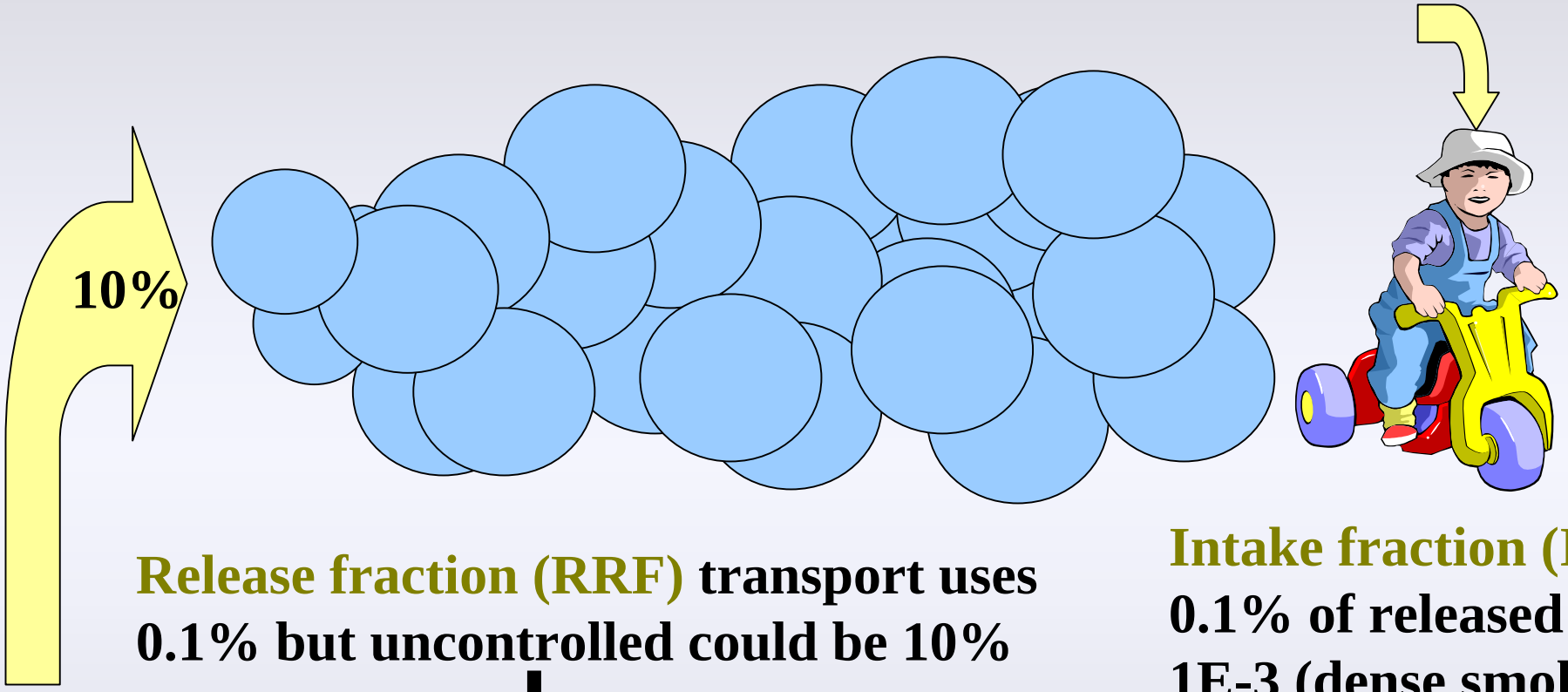
Dosimetric Criteria

- **Internal - BSS Acute dose (approach lethal or injurious threshold)**
  - Low Let
    - 1 Gy to the bone marrow
    - 6 Gy to the lung
    - 5 Gy to the thyroid
  - Hi Let
    - 25 Gy to lung in 1 yr
- **External - contact - tissue necrosis**
  - 25 Gy at a depth of:
  - 1 cm for most parts of the body in 10 hours
  - 0.3 cm for the hand in 1 hour
- **External – where contact is not reasonable**
  - 1 Gy in about 100 hours to bone marrow
  - Approaching lethal threshold with supportive treatment
  - 10 mGy/h

Exposure Routes

- **Non-dispersible**
  - Contact dose to tissue (gamma dose, beta dose, bremsstrahlung)
  - Bone marrow dose from shine
- **Dispersible**
  - Intake (acute bone, lung and thyroid dose)
    - inhalation during fire
    - ingestion (inadvertent or intentional contamination)
  - Contact dose to tissue
  - Bone marrow dose from shine

Inhalation



Release fraction (RRF) transport uses 0.1% but uncontrolled could be 10%

Intake fraction (IF) 0.1% of released 1E-3 (dense smoke)

Dispersible – release 10% (1E-1)

RRF X IF = Uptake faction (1E-4)

Examples Dangerous Source D Numbers (TBq)

Radionuclide	D1 Non Dispersible	D2 Dispersible
Sr 90 / Y 90	4	1
Ir-192	0.08	20
Am-241	1	0.06
Natural U Dep U	unlimited	unlimited (caution on chemical toxicity)

TecDoc 1344 Categories

Category	Examples	Risk
1 (> 1000 X D)	Irradiators Teletherapy	Extremely dangerous to the person and nearby
2 (1000 – 10 X D)	Radiography Hi brachytherapy	Very dangerous to the person and nearby
3 (10 – 1 X D)	Fixed gauges Well logging	Dangerous to the person and nearby
4 (1 - 0.1 X D)	Moisture density gauges	Unlikely to be dangerous
5 (> 0.1 X D)	Lo brachytherapy Tritium signs Depleted U	Not dangerous

Considerations for Waste Security

- **Many and diverse waste forms**
- **Immobile to highly dispersible**
- **Unauthorised diversion and sabotage to be considered**
- **Apart from deterministic effects, social and economical disruptions and long-term health effects are taken into account**
- **Possible effects:**
  - deterministic effects to individuals
  - large area contamination
  - contamination of buildings, train stations etc.
  - contamination of municipal water supplies

Additional Scenarios Considered

- **Contamination of a large area of 1 km^2 caused**
  - by a RDD or other dispersion mechanisms or
  - by an explosion or fire in a facility where radioactive wastes are stored (e.g. by explosives, an intentional plane crash, or sabotage).
- **Contamination of the water tank of a municipality serving 2000 people**
- **Insertion of dispersible radioactive material into the ventilation system of a large building or into a subway station**

Basic parameters used for assessment	
100 kg of wastes dispersed	annual dose criterion: 10 mSv

Derivation of Hazard Criteria

Nuclide	Level for Scenario		Limiting pathway	Overall Level	D value	Ratio Level / D	Hazard criterion
	A large area [TBq]	B water tank [TBq]		[TBq]	[TBq]		[TBq]
Fe-55	6.6E+02	6.1E+00	water tank	6.1E+00	8.0E+2	0.008	6.1E+00
Co-60	4.3E-01	5.9E-01	large area	4.3E-01	3.0E-2	14.2	3.0E-02
Mo-99	6.2E+02	3.3E+00	water tank	3.3E+00	3.0E-1	10.8	3.0E-01
Ra-226	1.0E-01	9.8E-04	water tank	9.8E-04	4.0E-2	0.025	9.8E-04
Pu-238	2.4E-01	8.7E-03	water tank	8.7E-03	6.0E-2	0.145	8.7E-03

Waste Classification (SS 115-G-1.1)

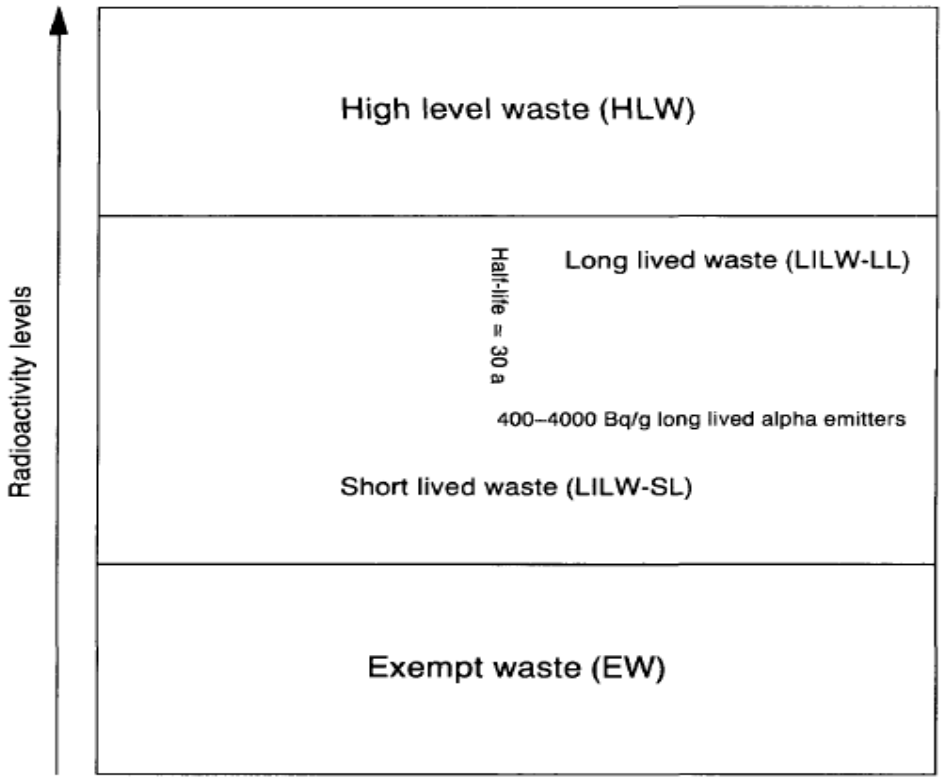


FIG. 1. Revised waste classification system.

Waste Categories

WASTE	TYPE	GENERAL
HLW	>10^{16} Bq/g	High level waste usually consists of spent fuel or the arisings from the reprocessing of spent fuel. Can be in the form of fuel rods, liquid or vitrified waste. Some high intensity sources can also fall into this category.
ILW	>10^{6} Bq/g >10^{3} Bq/g [a] > 2 mSv/h contact dose	4000 Bq/gm [a] is typically the limit in a near surface facility. Is usually a by product of fuel processing of which the largest part is the residual fuel cladding which may be either stored directly or encapsulated in cement. Other sources can be the ion exchange media use in cleaning, effluents and pond water.
LLW	10 – 10^{6} Bq/g <10^{3} Bq/g [a]	Surface disposal of LLW is typically limited to 4000 Bq/gm [a] The majority of this waste will consist of protective clothing and materials used while dealing with TRU materials.
Mines Tailings	Few Bq/g	These usually consist of high volume low level wastes that arise from the processing of metal ores usually at facilities near to the mines.
NORM	Few >10^{3} Bq/g [a]	E.g. scales from some oil industry pipelines, fly-ash from coal fired power stations and various forms of thorium. Some of these materials can have levels of activity that would take them into the classifications shown above.

Examples for Different Waste Classes

High-Level Wastes

Glass
Liquid
Evaporator Bottoms
Calcine

Intermediate-Level Wastes

Ion-Exchange Resins
Zeolites
Bitumen
Disused Sources
TRU Waste
Pu-contaminated Material
Sludge
Dry Salt
Fuel Cladding

Low-Level Wastes

High-Integrity Container Wastes
Compacted Waste
Delay and Decay Wastes
Incinerator Ash

Other Radioactive Wastes

Uranium Mill Tailings
NORM

Relating Waste Classes and Types to Security Categories (Basis: 100 kg)

Nuclide	Level for Scenario		Limiting pathway	Overall Level	D value	Ratio Level / D	Hazard criterion
	A large area [TBq]	B water tank [TBq]		[TBq]	[TBq]		[Bq / g]
Fe-55	6.6E+02	6.1E+00	water tank	6.1E+00	8.0E+2	0.008	6.1E+07
Co-60	4.3E-01	5.9E-01	large area	4.3E-01	3.0E-2	14.2	3.0E+05
Mo-99	6.2E+02	3.3E+00	water tank	3.3E+00	3.0E-1	10.8	3.0E+06
Ra-226	1.0E-01	9.8E-04	water tank	9.8E-04	4.0E-2	0.025	9.8E+03
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Security Categories (Basis: INFCIRC/225/Rev 4)

Category 2

Category 2 radioactive waste should be stored within a *Secure* Area:

Access to and the number of access points should be kept to a minimum

The area should be surrounded by a substantial physical barrier providing a relevant delay of attempts to gain entry unauthorised entry by climbing or penetration

Clear zones should be provided on both sides of the physical barrier to allow for surveillance and detection

There should be relevant contingency plans to provide for unauthorised intrusions. Guards and other personnel should be trained in the implementation of such plans and their effectiveness should be periodically exercised

A system for detecting intrusion should be installed on or close to the physical barrier to give the earliest possible warning of interference with the barrier or attempts to enter the area

The intruder detection system should alarm at a Security Control Room from where guards or a suitable force can be respond to the event

The trustworthiness of persons allowed unescorted access to the area should be verified by a formal process

Vehicles, persons and packages entering or leaving the area should be searched

The entry of private vehicles into the Secure Area should be minimised

Staff should be subject to periodic security awareness briefings

Stringent control should be maintained of persons being issued

Security Categories (Basis: INFCIRC/225/Rev 4)

Category 3

Category 3 radioactive waste should be stored within a *Designated* Area:

Access to radioactive waste storage areas should be kept a minimum

If the areas are not within an enclosed site consideration should be given to the provision of a fence or other physical barrier around the facility

There should be provision for detecting unauthorised intrusion and for appropriate action by a response force

There should be relevant contingency plans to provide for unauthorised intrusions. Guards and other personnel should be trained in the implementation of such plans and their effectiveness should be periodically exercised

There should be provision for detecting unauthorised access into the area or facility

The trustworthiness of persons allowed unescorted access to the areas should be verified by a formal process

Staff should be subject to periodic security awareness briefings

Security Categories (Basis: INFCIRC/225/Rev 4)

Category 4

Category 4 radioactive waste should be stored within an *Assigned* Area:

Access to the area should be controlled

There should be a means of detecting an unauthorised intrusion into the area in which the radioactive waste is stored

Alarm indications should be investigated as soon as possible

Category 5

Category 5 radioactive waste should be stored in an area which is controlled and managed in accordance with approved safety and industrial standards:

The radioactive waste materials or facilities should be subject to periodic inspection

Only authorised persons should be allowed access to the area.

Basic Security Categories for Wastes

TYPE OF WASTE	FACILITY OR WASTE MANAGEMENT ACTIVITY	SECURITY CATEGORY INDEX VALUE
High-level Radioactive Waste	Treatment or Storage Geologic Disposal	2 4
Intermediate-level Radioactive Waste	Treatment or Storage Disposal	3 4
Low-level Radioactive Waste	Treatment or Storage Disposal	4 5
Other Wastes: including NORM and mining and milling waste	Treatment or storage Disposal	4 5

Modifiers

- **Attributes that could effect the security level, examples:**
  - dispersability
  - transportability
  - volume and quantity
  - waste form and package
- **Refinement possibly warranted, e.g.:**
  - subdividing into more groups
  - consideration of additional factors like accessibility and probability of malevolent event
  - ranking of factors and attributes

Example for Use of Modifiers

Waste	Initial Security Category	Description	Positive Modifiers	Negative Modifiers	Adjusted Security Category
ILW	3	SOLID	v		4
ILW	3	LIQUID		v	2

Conclusions

- **Proposals to be refined, in particular with respect to**
  - hazard criteria
  - assignment of security categories
  - use of modifying factors
- **Review by Technical Meeting**
- **Guidance to be published by IAEA**