IAEA

The Abdus Salam
International Centre
for Theoretical Physics
www.ictp.it

Joint ICTP/IAEA Workshop on Radioactive waste management – solutions for countries without nuclear power programme

2 – 6 November 2015

(Miramare - Trieste, Italy)

The Workshop on radioactive waste management – solutions for countries without nuclear power programme is jointly organized by The Abdus Salam International Centre for Theoretical Physics (ICTP) and the International Atomic Energy Agency (IAEA).

Purpose

The Workshop aims to advise countries having small amount of waste from different research, medical, and industrial sources (institutional waste) which physico-chemical characteristics of radioactive waste should be considered and how to interpret them to effectively create infrastructure for safe collection, processing, storage and disposals of their radioactive waste, including intermediate level waste and spent fuel from research reactors, NORM and disused sealed sources.

Focus

This workshop will focus mainly on waste management professionals, both operators and regulators, from countries without nuclear power programme to create awareness of the technical inputs and physical and chemical waste characteristics necessary for establishing or upgrading national infrastructure for safe and efficient management of radioactive waste.

Organizers

Michael Ojovan (IAEA, Vienna)

Peter Ormai (IAEA, Vienna)

Local organizer

Claudio Tuniz (ICTP, Trieste)

United Nations Educational, Scientific and Cultural Organization

IAEA International Atomic Energy Agency

The Abdus Salam
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for Theoretical Physics

IAEA Activities Related to Radioactive Waste Predisposal Management

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Keywords
vitrification

Websites
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Biography

Michael I. Ojovan has been Visiting Professor in the Department of Materials of Imperial College London and Associate Professor in the Department of Engineering Materials of the University of Sheffield. He is currently Nuclear Engineer at International Atomic Energy Agency Headquarters in Vienna, Austria.
M. Ojovan has been awarded the degrees of DSc in Physical Chemistry and PhD in Solid State Physics. He is Fellow of the Russian Academy of Natural Sciences and Member of the Material Research Society and International Commission on Glass. He is also an Editorial Panel member for Journal of Nuclear Materials and International Journal of Corrosion. He has authored over 300 peer-reviewed scientific papers, has 42 patents, and published 11 monographs on nuclear materials including the second edition of "An Introduction to Nuclear Waste Immobilisation" by Elsevier (2005, 2014). He has been known for the two-exponential universal viscosity equation and the connectivity-percolation theory of glass-liquid transition.
For details see: http://www3.imperial.ac.uk/people/m.ojovan;
http://www.sheffield.ac.uk/materials/staff/mojovan;

International Atomic Energy Agency,
Vienna, Austria,
Nuclear Engineer, February 2011 – present
Visiting Professor of Imperial College London

The University of Sheffield,
Sheffield, United Kingdom
Assistant Professor, Department of Materials Science and Engineering, September 2002 – 2011, visiting academic at present.

Scientific and Industrial Association "Radon",
Moscow, Russian Federation
Deputy Director, Applied Research Centre, 1982 – 2002.

Michael I. Ojovan: Education

D.Sc. Physical Chemistry. Thesis "*Surface effects in nuclear waste forms*". Moscow Scientific Research Institute of Physical Chemistry. 1994.

PhD. Solid State Physics. Thesis "*Interaction of radiation with small particles*". Moscow Engineering Physical Institute. 1982.

M.Sc. Solid State Physics. Thesis "*Pulsed laser-beam deposited thin films*". Moscow Engineering Physical Institute. 1979.

B.Sc. Solid State Physics. Superconductivity. Moscow Engineering Physical Institute. 1978.

Outline

I. IAEA activities
II. Radioactive waste management
III. Radioactive waste predisposal
    1. Technical publications
    2. Networks
    3. Direct support
    4. Peer reviews
    5. Coordinated research projects
IV. On-going support activities

I. IAEA Activities

➢ Safety & Security

The IAEA works to protect people and the environment from harmful radiation exposure

➢ Safeguards & Verification

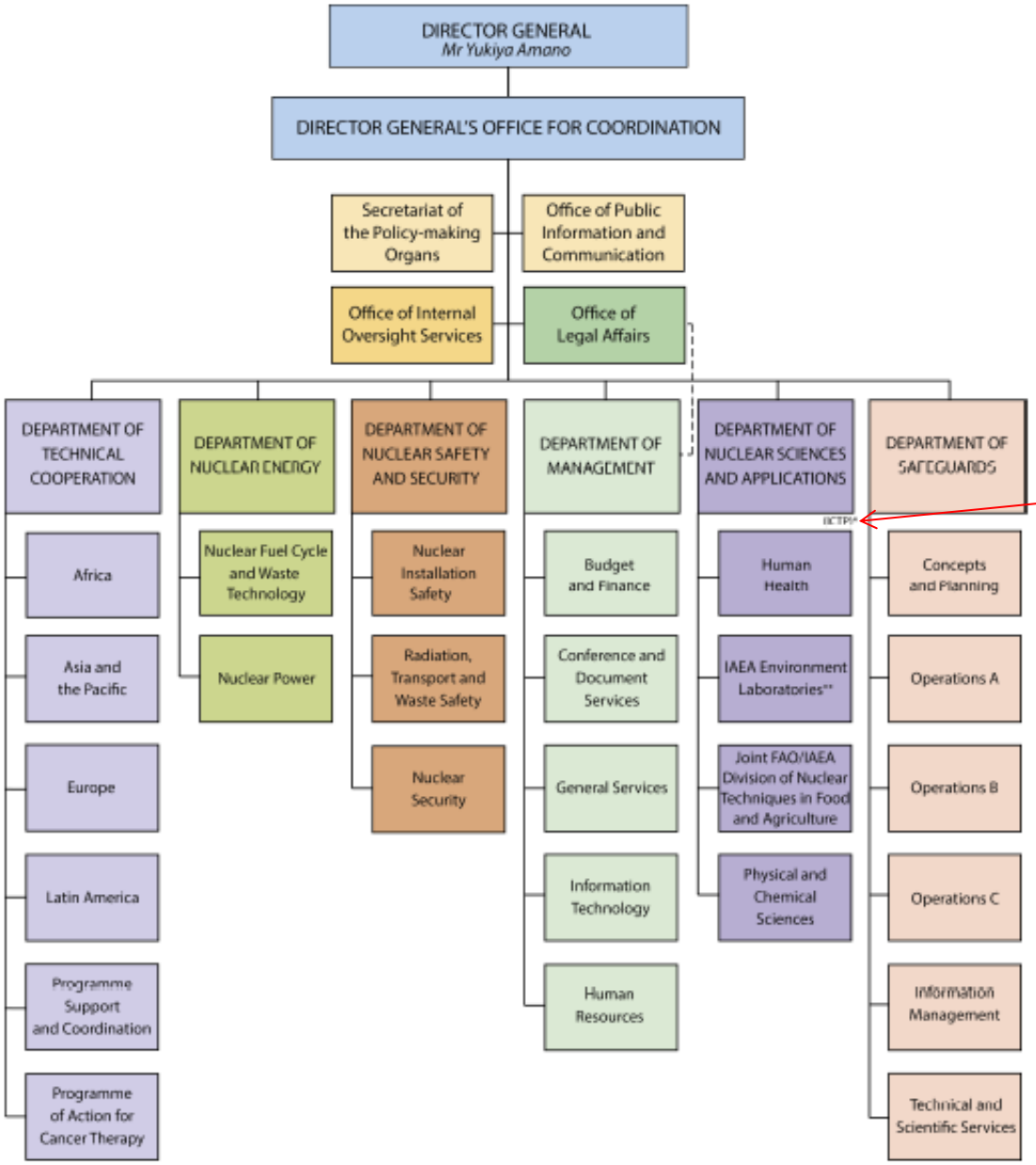
The IAEA works to prevent the further spread of nuclear weapons

➢ Science & Technology

The IAEA works to mobilize peaceful applications of nuclear science and technology. This includes radioactive waste processing and disposal technologies.

The IAEA works to mobilize peaceful applications of nuclear science and technology. This includes radioactive waste processing and disposal technologies.

- ***Developing*** **Standards and Guidance;**
- ***Providing*** **Reviews and Services;**
- ***Supporting*** **Capacity Building;**
- ***Promoting*** **Knowledge Networks;**
- ***Providing*** **a forum for communicating, increasing transparency, sharing lessons learned via workshops, meetings, and various media.**

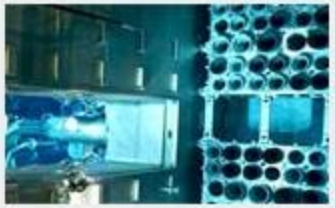


The Abdus Salam International Centre for Theoretical Physics

* The Abdus Salam International Centre for Theoretical Physics (ICTP), legally referred to as the "International Centre for Theoretical Physics", is operated as a joint programme by UNESCO and the Agency. Administration is carried out by UNESCO on behalf of both organizations.

IAEA Departments

Nuclear Applications



The Department of Nuclear Sciences and Applications helps countries use nuclear and isotopic techniques to promote sustainable development objectives in agriculture, human health, water resource management, marine environment and industrial applications. Read more →

Nuclear Energy

The Department of Nuclear Energy fosters the efficient and safe use of nuclear power by supporting nuclear programmes around the world, catalyzing innovation and building capability in energy planning, analysis, and nuclear information and knowledge. Read more →

Safety & Security

The Department of Nuclear Safety and Security works to provide a strong, sustainable and visible global nuclear safety and security framework, protecting people and the environment from the harmful effects of ionizing radiation. Read more →

Safeguards

The Department of Safeguards carries out the duties and responsibilities of the IAEA as the world's nuclear inspectorate, performing an indispensable role in global efforts to stop the spread of nuclear weapons. Read more →

Technical Cooperation

The Department of Technical Cooperation helps countries to improve their scientific and technological capabilities in the peaceful applications of nuclear technology, thus contributing to sustainable development. Read more →

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Department of Nuclear Energy

Fostering Sustainable Nuclear Energy for the Future

http://www.iaea.org/OurWork/ST/NE/Main/

Department of Nuclear Energy

- Nuclear Power
- » Nuclear Power Engineering
- » Nuclear Power Technology Development
- Nuclear Power Infrastructure
- International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)
- Nuclear Fuel Cycle & Waste Technology
- » Fuel Cycle & Materials
- » Research Reactors
- » Waste Technology
- Planning & Economic Studies
- International Nuclear Information System

Highlights

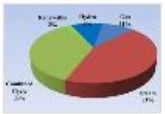
Statement at Nuclear Africa 2015 Conference

2015-03-19

"Technically and financially, access to nuclear power is no longer limited to developed countries," said IAEA Director General Yukiya Amano in his Statement at Nuclear Africa 2015 Conference on 18 March 2015. Read more...

IAEA Workshop Discusses Egyptian Public Awareness in Nuclear Power

2015-03-03



A three-day IAEA meeting recently held in Cairo focused on advancing stakeholder involvement in Egypt's nuclear power programme. Held under an IAEA Technical Cooperation project, the meeting from 17 to 19 February included nuclear communication experts from... Read more...

Experts Underscore Need to Strengthen R&D Data Sharing as Part of Post-Fukushima Action Plan

2015-02-24

The need to improve understanding and reduce uncertainty in phenomenon and models having bearing on safety by better sharing information on vital nuclear research projects was underscored at the IAEA's eighth International Experts

Deputy Director General
Mikhail Chudakov

About Us

- Our Role
- NE Organizational Structure
- SAGNE (members only area)

Upcoming Events

International Conference on Management of Spent Fuel from Nuclear Power Reactors

15 – 19 June 2015
Vienna, Austria

International Conference on Research Reactors: Safe Management and Effective Utilization

16 – 20 November 2015
Vienna, Austria

Navigation

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    - Environmental Remediation
    - Disused Sealed Source Management
    - Contact Expert Group
  - Research Reactors
- ARTEMIS Reviews
- Assurance of Supply for Nuclear Fuel
- Publications
- Meetings
- Information Systems
- Waste Management Networks

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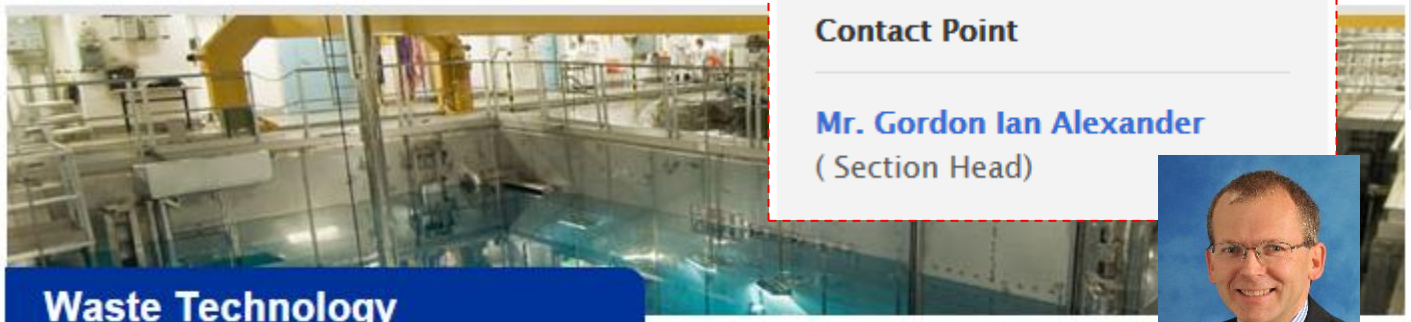

Waste Technology

Contact Point

Mr. Gordon Ian Alexander
(Section Head)

The IAEA promotes and develops two important aspects on radioactive waste management: universally applicable safety regime through the development of safety standards and application of safe and proven technologies in radioactive waste management.

To manage radioactive waste resulting both from the nuclear fuel cycle and nuclear applications, the IAEA's Waste Technology Section fosters technology transfer, promotes information exchange and cooperative research, as well as builds capacity in Member States by:

- Assisting to develope consistent policies and related strategies;
- Assisting with the predisposal and disposal stages of waste management;
- Helping to manage disused sealed radioactive sources;
- Assisting with planning and implementing decommissioning strategies and projects; and
- Supporting cleaning-up of legacy waste and environmental remediation actions of radiologically contaminated sites.

To adequately reflect and respond to the Member States' needs, the IAEA Programme on Radioactive Waste Management is developed in consultations with Member States; the WATEC working group provides advice and recommendations on technical and technological aspects of radioactive waste management, decommissioning and environmental remediation.

Related Information

Meetings & Conferences

Publications

News & Stories

Objectives (IAEA Nuclear Energy Series NW-O)

Post Accident & Cleanup Documents

Radioactive Waste Management Information Systems

Related Resources

IAEA Scientific Forum Highlights Responsibility for Radioactive Waste

Establish Comprehensive Disposal Plans, Says Amano

By Ayhan Evrensel, IAEA Department of Nuclear Energy

24
September 2014

Showing a stainless steel capsule used for conditioning disused sealed radioactive sources, which would have been used in medical, food, construction and other industries, IAEA Director General Amano emphasizes that radioactive waste is an issue for all States. (Photo: A. Evrensel/IAEA)

A two-day *Scientific Forum* during the IAEA's annual *General Conference* emphasized the need for a comprehensive, integrated, cradle-to-grave approach for management of radioactive waste.

Related Stories

Addressing Radioactive Waste
Read →

Strengthening Cradle-to-Grave Control of Radioactive Sources
Read →

Related Resources

- Director General Statement, 23 September 2014
- Radioactive Waste - The Journey to Disposal, 23 September 2014
- Scientific Forum 2014
- Director General Statement, 23 September 2014 (Full Text)
- Radioactive Waste: Meeting the Challenge - Science and Technology for Safe and Sustainable Solutions, Scientific Forum Report, 24 September 2014
- IAEA Meeting to Highlight Technologies to Safely Manage

Safety & Security

SAFETY FUNDAMENTALS

General Safety Requirements

- Vol.1 Governmental and Regulatory Framework
- Vol.2 Leadership and Management for Safety
- Vol.3 Radiation Protection and Safety of Radiation Sources
- Vol.4 Safety Assessment
- Vol.5 Predisposal Management of Radioactive Waste
- Vol.6 Decommissioning and Termination of Activities
- Vol.7 Emergency Preparedness and Response

Specific Safety Requirements

- 1. Site Evaluation for Nuclear Installations
- 2. Safety of Nuclear Power Plants
  - 2.1 Design and Construction
  - 2.2 Commissioning and Operation
- 3. Safety of Research Reactors
- 4. Safety of Nuclear Fuel Cycle Facilities
- 5. Safety of Radioactive Waste Disposal Facilities
- 6. Safe Transport of Radioactive Material

Collection of Safety Guides

Science & Technology

IAEA International Atomic Energy Agency

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NUCLEUS provides access to over 130 IAEA scientific, technical and regulatory resources. This includes databases, websites, applications, publications, safety standards, training material and more.

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https://www.iaea.org/scientific-databases

Featured Scientific Resources

The International Nuclear Information System (INIS)

INIS offers online access to a unique collection of non-conventional literature.

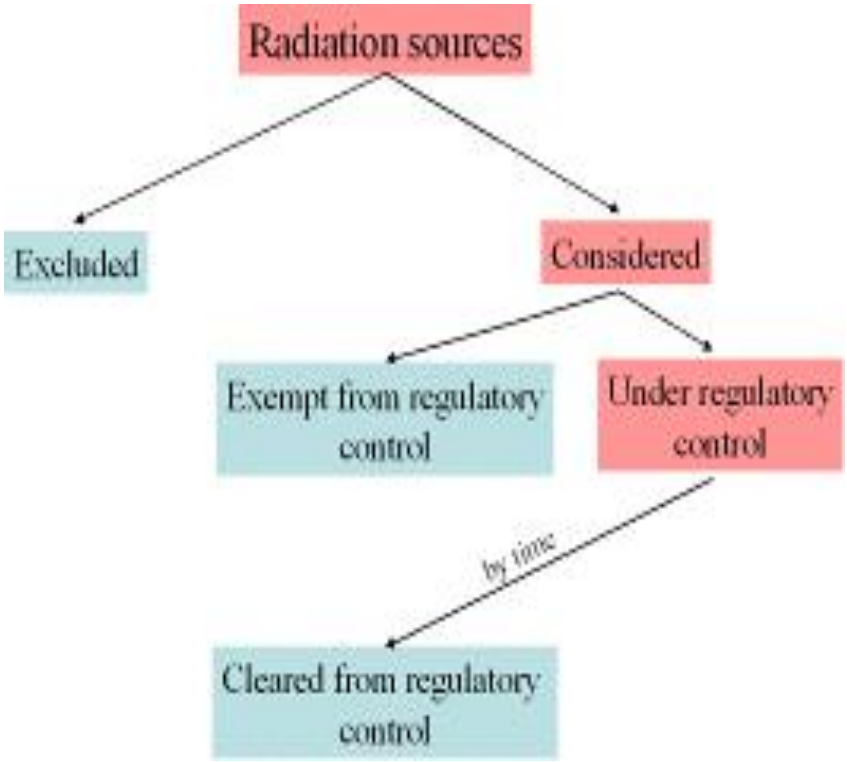
Power Reactor Information System (PRIS)

PRIS contains information on power reactors in operation, under construction or those being decommissioned.

The IAEA Library

The IAEA Library offers access to many databases, journals and other resources.

II. Radioactive Waste Management



Waste radioactive. For legal and regulatory purposes, waste that contains or is contaminated with radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body.

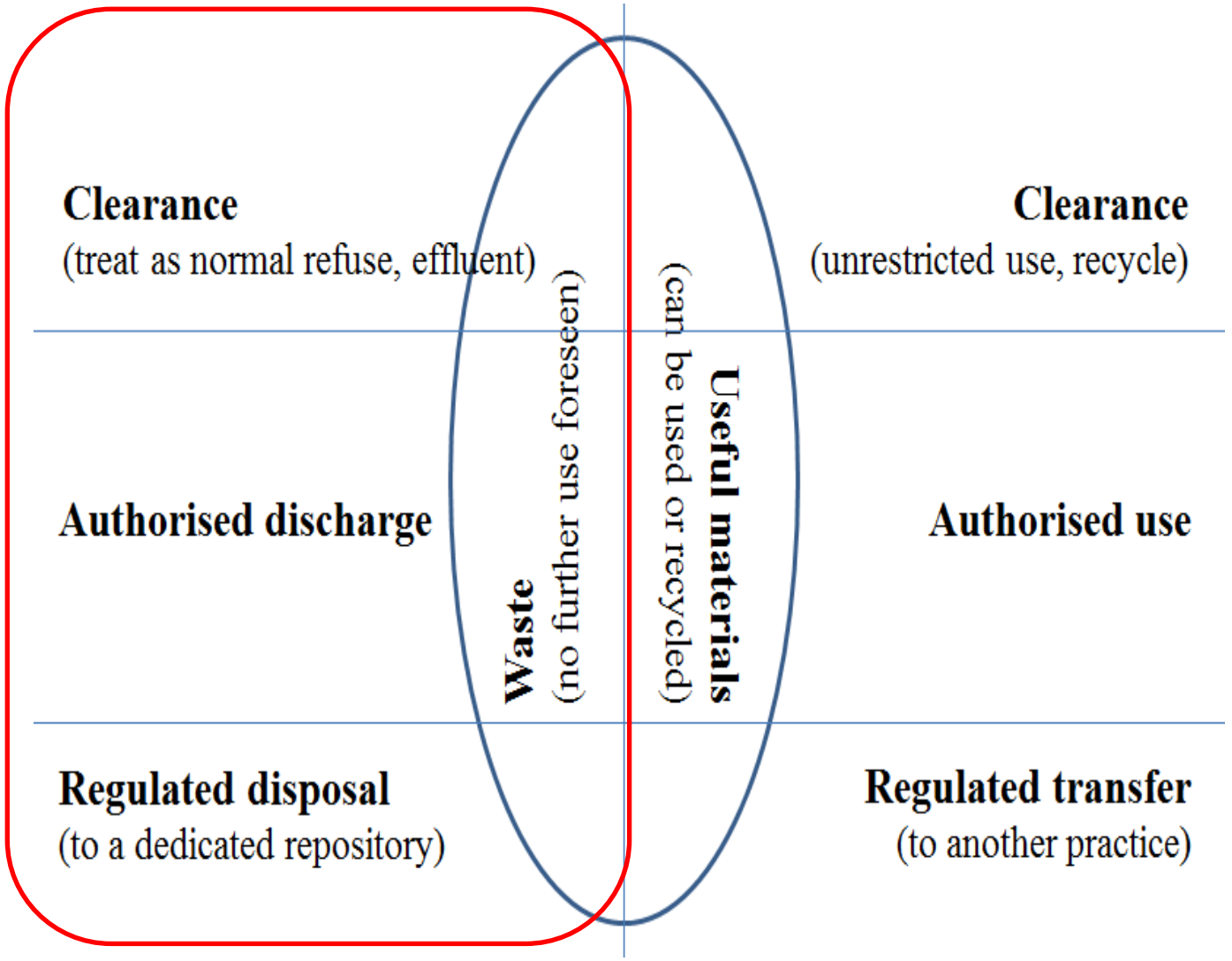
The definition is purely for regulatory purposes. Material with activity concentrations equal to or less than clearance levels is radioactive from a physical viewpoint — although the associated radiological hazards are considered negligible.

Radioactive Materials Routing

(a) **Clearance** from regulatory control (unrestricted disposal of waste, unrestricted reuse of useful materials);

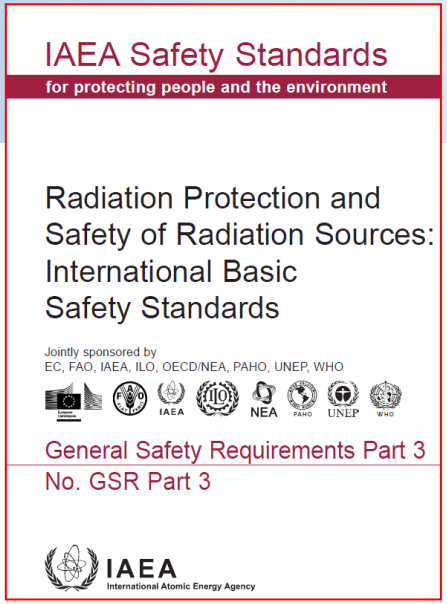
(b) **Authorized release** (discharge to the environment of waste, authorised reuse of useful materials);

(c) **Regulated disposal** of waste, regulated transfer of useful materials.



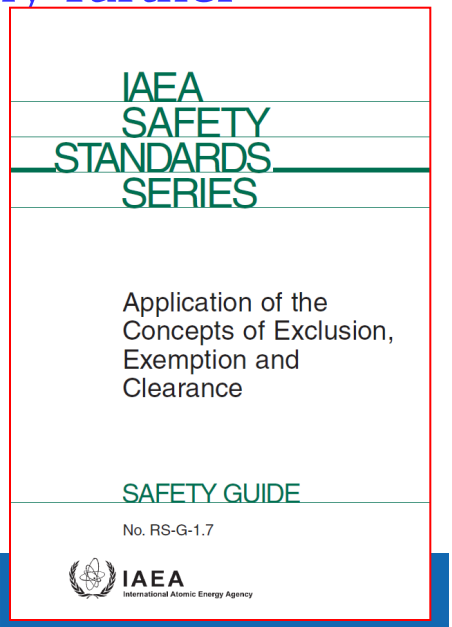
Clearance

The general principles and criteria for exclusion, exemption and clearance have been detailed in the International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources (BSS).



Clearance is defined as the removal of radioactive materials or radioactive objects within authorized practices from any further regulatory control by the regulatory body.

Specific values of activity concentration of radionuclides that may be used for bulk amounts of material for applying exclusion and exemption are given in the IAEA Safety Guide RS-G-1.7.



IAEA Safety Standards

for protecting people and the environment

Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

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General Safety Requirements Part 3

No. GSR Part 3

IAEA
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TABLE I-1: LEVELS FOR EXEMPTION OF MODERATE AMOUNTS OF MATERIAL WITHOUT FURTHER CONSIDERATION: EXEMPT ACTIVITY CONCENTRATIONS AND EXEMPT ACTIVITIES OF RADIONUCLIDES *(see footnotes 57 and 58)*

Radionuclide	Activity concentration (Bq/g)	Activity (Bq)
H-3	1×10^{6}	1×10^{9}
Be-7	1×10^{3}	1×10^{7}
Be-10	1×10^{4}	1×10^{6}
C-11	1×10^{1}	1×10^{6}
C-14	1×10^{4}	1×10^{7}
N-13	1×10^{2}	1×10^{9}
Ne-19	1×10^{2}	1×10^{9}
O-15	1×10^{2}	1×10^{9}
F-18	1×10^{1}	1×10^{6}
Na-22	1×10^{1}	1×10^{6}
Na-24	1×10^{1}	1×10^{5}
Mg-28	1×10^{1}	1×10^{5}
Al-26	1×10^{1}	1×10^{5}
Si-31	1×10^{3}	1×10^{6}
Si-32	1×10^{3}	1×10^{6}
P-32	1×10^{3}	1×10^{5}
P-33	1×10^{5}	1×10^{8}
S-35	1×10^{5}	1×10^{8}
Cl-36	1×10^{4}	1×10^{6}
Cl-38	1×10^{1}	1×10^{5}
Cl-39	1×10^{1}	1×10^{5}
Ar-37	1×10^{6}	1×10^{8}
Ar-39	1×10^{7}	1×10^{4}
Ar-41	1×10^{2}	1×10^{9}
K-40	1×10^{2}	1×10^{6}
K-42	1×10^{2}	1×10^{6}
K-43	1×10^{1}	1×10^{6}
K-44	1×10^{1}	1×10^{5}
K-45	1×10^{1}	1×10^{5}
Ca-41	1×10^{5}	1×10^{7}
Ca-45	1×10^{4}	1×10^{7}
Ca-47	1×10^{1}	1×10^{6}
Sc-43	1×10^{1}	1×10^{6}
Sc-44	1×10^{1}	1×10^{5}
Sc-45	1×10^{2}	1×10^{7}
Sc-46	1×10^{1}	1×10^{6}
Sc-47	1×10^{2}	1×10^{6}

Radionuclide	Activity concentration (Bq/g)	Activity (Bq)
Sc-48	1×10^{1}	1×10^{5}
Sc-49	1×10^{3}	1×10^{5}
Ti-44	1×10^{1}	1×10^{5}
Ti-45	1×10^{1}	1×10^{6}
V-47	1×10^{1}	1×10^{5}
V-48	1×10^{1}	1×10^{5}
V-49	1×10^{4}	1×10^{7}
Cr-48	1×10^{2}	1×10^{6}
Cr-49	1×10^{1}	1×10^{6}
Cr-51	1×10^{3}	1×10^{7}
Mn-51	1×10^{1}	1×10^{5}
Mn-52	1×10^{1}	1×10^{5}
Mn-52m	1×10^{1}	1×10^{5}
Mn-53	1×10^{4}	1×10^{9}
Mn-54	1×10^{1}	1×10^{6}
Mn-56	1×10^{1}	1×10^{5}
Fe-52	1×10^{1}	1×10^{6}
Fe-55	1×10^{4}	1×10^{6}
Fe-59	1×10^{1}	1×10^{6}
Fe-60	1×10^{2}	1×10^{5}
Co-55	1×10^{1}	1×10^{6}
Co-56	1×10^{1}	1×10^{5}
Co-57	1×10^{2}	1×10^{6}
Co-58	1×10^{1}	1×10^{6}
Co-58m	1×10^{4}	1×10^{7}
Co-60	1×10^{1}	1×10^{5}
Co-60m	1×10^{3}	1×10^{6}
Co-61	1×10^{2}	1×10^{6}
Co-62m	1×10^{1}	1×10^{5}
Ni-56	1×10^{1}	1×10^{6}
Ni-57	1×10^{1}	1×10^{6}
Ni-59	1×10^{4}	1×10^{8}
Ni-63	1×10^{5}	1×10^{8}
Ni-65	1×10^{1}	1×10^{6}
Ni-66	1×10^{4}	1×10^{7}
Cu-60	1×10^{1}	1×10^{5}
Cu-61	1×10^{1}	1×10^{6}

TABLE 2. VALUES OF ACTIVITY CONCENTRATION FOR RADIONUCLIDES OF ARTIFICIAL ORIGIN IN BULK (see para. 4.4)

Radionuclide	Activity concentration (Bq/g)	
H-3	100	
Be-7	10	
C-14	1	
F-18	10	*
Na-22	0.1	
Na-24	1	*
Si-31	1000	*
P-32	1000	
P-33	1000	
S-35	100	
Cl-36	1	
Cl-38	10	*
K-42	100	
K-43	10	*
Ca-45	100	
Ca-47	10	
Sc-46	0.1	
Sc-47	100	
Sc-48	1	
V-48	1	
Cr-51	100	
Mn-51	10	*
Mn-52	1	
Mn-52m	10	*
Mn-53	100	
Mn-54	0.1	
Mn-56	10	*
Fe-52	10	*
Fe-55	1000	
Fe-59	1	
Co-55	10	*
Co-56	0.1	
Co-57	1	
Co-58	1	
Co-58m	10000	*
Co-60	0.1	
Co-60m	1000	*
Co-61	100	*
Co-62m	10	*
Ni-59	100	
Ni-63	100	
Ni-65	10	*
Cu-64	100	*
Zn-65	0.1	
Zn-69	1000	*
Zn-69m	10	*
Ga-72	10	*
Ge-71	10000	
As-73	1000	
As-74	10	*
As-76	10	*
As-77	1000	
Se-75	1	
Br-82	1	
Rb-86	100	
Sr-85	1	
Sr-85m	100	*
Sr-87m	100	*
Sr-89	1000	
Sr-90	1	
Sr-91		
Sr-92		
Y-90		
Y-91		
Y-91m		
Y-92		
Y-93		
Zr-93		
Zr-95		
Zr-97		
Nb-93m		
Nb-94		
Nb-95		
Nb-97		
Nb-98		
Mo-90		
Mo-93		
Mo-99		

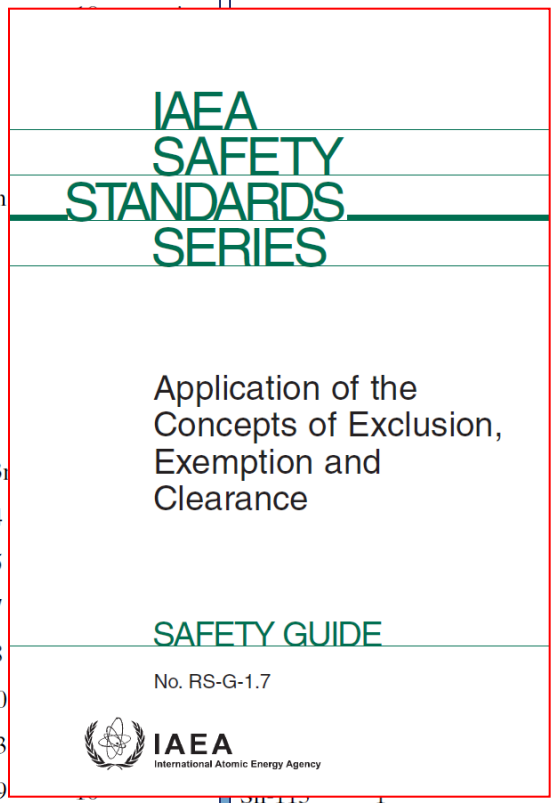


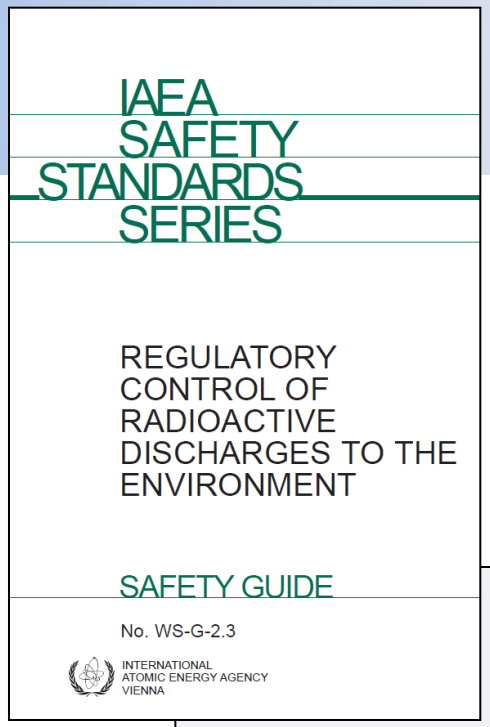
TABLE 2. VALUES OF ACTIVITY CONCENTRATION FOR RADIONUCLIDES OF ARTIFICIAL ORIGIN IN BULK (see para. 4.4) (cont.)

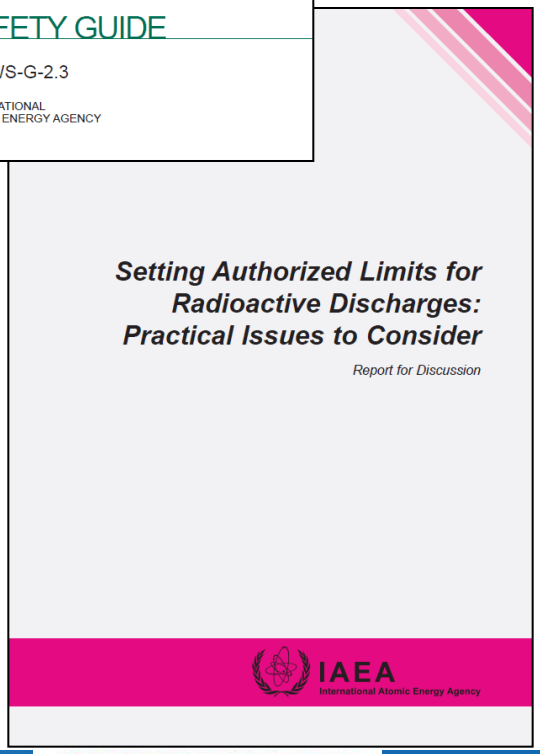
Radionuclide	Activity concentration (Bq/g)	
Mo-101	10	*
Tc-96	1	
Tc-96m	1000	*
Tc-97	10	
Tc-97m	100	
Tc-99	1	
Tc-99m	100	*
Ru-97	10	
Sn-125	10	
Sb-122	10	
Sb-124	1	
Sb-125	0.1	
Te-123m	1	
Te-125m	1000	
Te-127	1000	
Te-127m	10	
Te-129	100	*
Te-129m	10	
Te-131	100	*
Te-131m	10	
Te-132	1	
Te-133	10	*
Te-133m	10	*
Te-134	10	*
I-123	100	
I-125	100	
I-126	10	
I-129	0.01	
I-130	10	*
I-131	10	
I-132	10	*
I-133	10	*
I-134	10	*
I-135	10	*
Cs-129	10	
Cs-131	1000	
Cs-132	10	
Cs-134	0.1	
Cs-134m	1000	*
Cs-135	100	
Cs-136	1	
Cs-137	0.1	
Cs-138	10	*
Ba-131	10	
Ba-140	1	
La-140	1	
Ce-139	1	
Ce-141	100	
Ce-143	10	
Ce-144	10	
Pr-142	100	*
Pr-143	1000	
Nd-147	100	
Nd-149	100	*
Pm-147	1000	
Pm-149	1000	
Sm-151	1000	
Sm-153	100	
Eu-152	0.1	
Eu-152m	100	*

Authorized discharge

Slightly contaminated effluents could be released to the environment under the limits authorized by national regulatory authorities through *authorized discharge*.

Generic guidance on the authorization procedure is provided the IAEA Safety Guide WS-G-2.3 as well as IAEA-TECDOC-1638 which summarize international experience on the optimization of discharges and the setting by the regulatory body of authorized limits.





Discharge limits

- Set by national regulator
- Based on flowsheets for processes involved
- Assume Best Available Technology to abate discharges

- Doses to the public taken into consideration
- Reviewed on a regular basis.

TABLE 1. NORMALIZED DISCHARGES FROM NUCLEAR POWER STATIONS (AVERAGE FOR THE YEARS 1990–1994) [10]

Type of Nuclear Power Station	Normalized discharges (Bq/(GW(e)a))						
	Gaseous					Liquid	
	H-3	C-14	Noble gases	I-131	Particulates	H-3	Other
PWR	2.3×10^{12}	2.2×10^{11}	2.7×10^{13}	3.0×10^{8}	2.0×10^{8}	2.2×10^{13}	1.9×10^{10}
BWR	9.4×10^{11}	5.1×10^{11}	3.5×10^{14}	8.0×10^{8}	1.8×10^{11}	9.4×10^{11}	4.3×10^{10}
GCR[2]	4.7×10^{12}	1.4×10^{12}	1.6×10^{15}	1.4×10^{9}	3.0×10^{8}	2.2×10^{14}	5.1×10^{11}
HWR	6.5×10^{14}	1.6×10^{12}	2.1×10^{15}	4.0×10^{8}	5.0×10^{7}	4.9×10^{14}	1.3×10^{11}
RBMK	2.6×10^{13}	1.3×10^{12}	1.7×10^{15}	7.0×10^{9}	1.4×10^{10}	1.1×10^{13}	5.0×10^{9}
FBR	4.9×10^{13}	1.2×10^{11}	3.8×10^{14}	3.0×10^{8}	1.2×10^{10}	1.8×10^{12}	4.9×10^{10}

TABLE 2. NORMALIZED DISCHARGES FROM NUCLEAR REPROCESSING PLANTS (AVERAGE FOR THE YEARS 1990–1994) [10].

Discharge mode	Normalized discharges (Bq/(GW(e)a))							
	H-3	C-14	Kr-85	Sr-90	Ru-106	I-129	I-131	Cs-137
Gaseous	2.4×10^{13}	4.0×10^{11}	6.3×10^{15}	–	–	1.0×10^{9}	9.0×10^{7}	8.0×10^{7}
Liquid	2.7×10^{14}	8.0×10^{11}	–	2.0×10^{12}	2.1×10^{12}	3.0×10^{10}	–	1.0×10^{12}

Regulated disposal

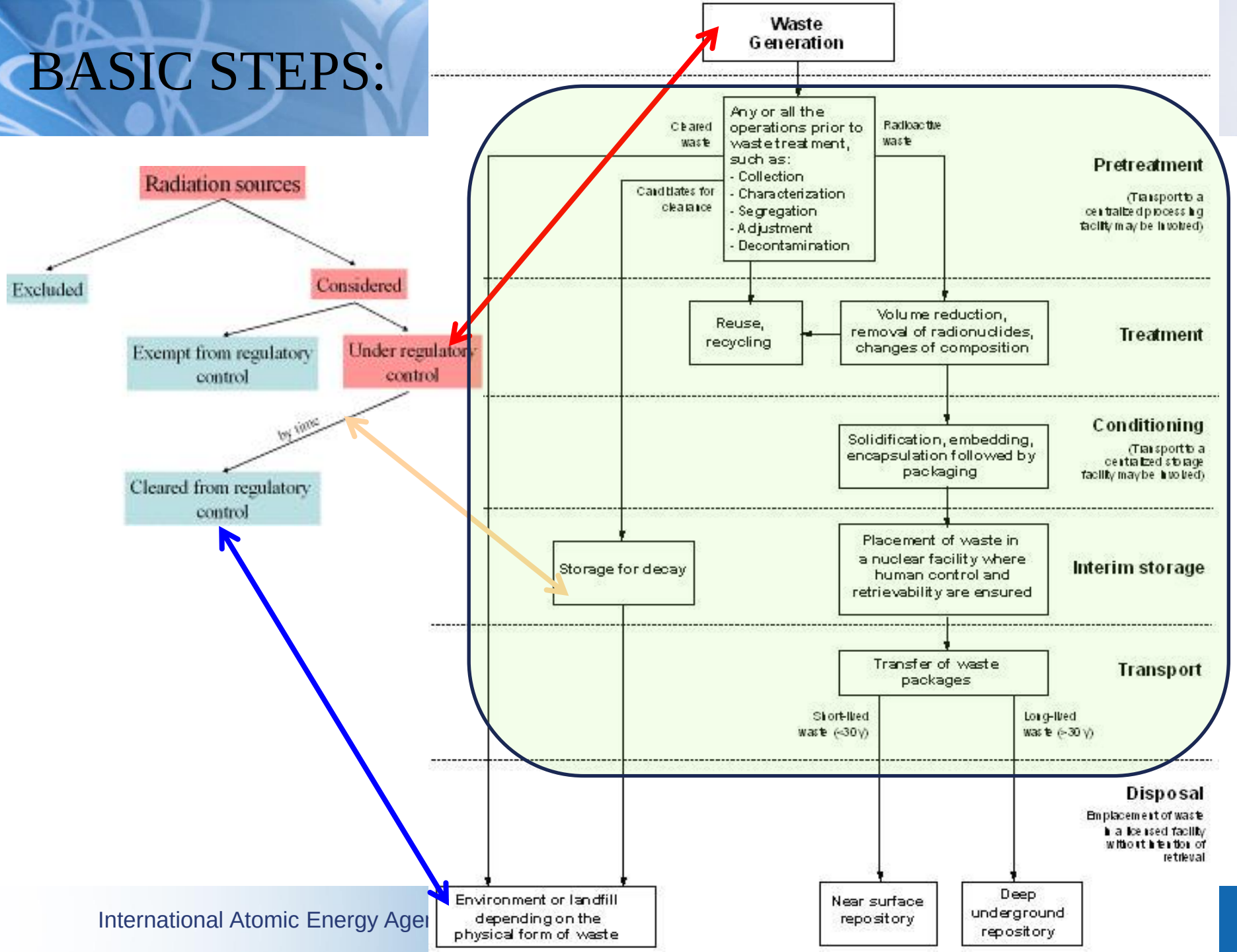
The generally preferred approach is to concentrate the waste and to contain the radionuclides in it by means of a waste form and waste container followed by disposal in an appropriate repository.

The effectiveness and safe isolation of radioactive waste depends on the performance of the overall disposal system which consists of three major components, namely:

I. The site (the host rock and surrounding geological media representing natural barriers aiding waste isolation);
II. The repository (the facility into which waste packages are emplaced for disposal, including any engineered barriers); and
III. The waste package (the waste form in any suitable container).

Only waste packages, which comply with so called “waste acceptance criteria” (WAC) are accepted for disposal.

BASIC STEPS:


Radiation sources
Excluded
Considered
Exempt from regulatory control
Under regulatory control
by time
Cleared from regulatory control
Waste Generation
Any or all the operations prior to waste treatment, such as:
- Collection
- Characterization
- Segregation
- Adjustment
- Decontamination
Cleared waste
Radioactive waste
Candidates for clearance
Pretreatment
(Transport to a centralized processing facility may be involved)
Reuse, recycling
Volume reduction, removal of radionuclides, changes of composition
Treatment
Solidification, embedding, encapsulation followed by packaging
Conditioning
(Transport to a centralized storage facility may be involved)
Storage for decay
Placement of waste in a nuclear facility where human control and retrievability are ensured
Interim storage
Transfer of waste packages
Transport
Short-lived waste (<30 y)
Long-lived waste (>30 y)
Disposal
Emplacement of waste in a licensed facility without intention of retrieval
Environment or landfill depending on the physical form of waste
Near surface repository
Deep underground repository

Generic roadmap

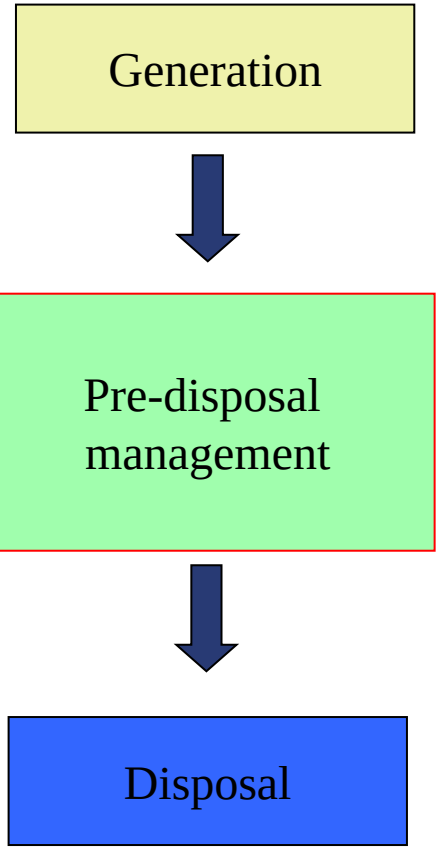
radioactive waste management

All administrative and operational activities involved in the handling, pretreatment, treatment, conditioning, transport, storage and disposal of radioactive waste.

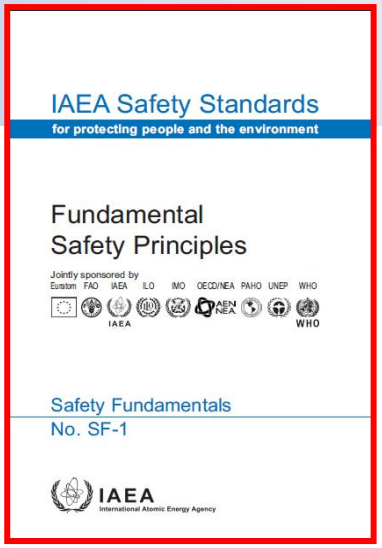
predisposal management of radioactive waste. Any waste management steps carried out prior to disposal, such as pretreatment, treatment, conditioning, storage and transport activities.

ⓘ Predisposal management is used as a contraction of 'pre-disposal management of radioactive waste'; 'predisposal' is not a form of disposal.

processing. Any operation that changes the characteristics of waste, including pretreatment, treatment and conditioning.

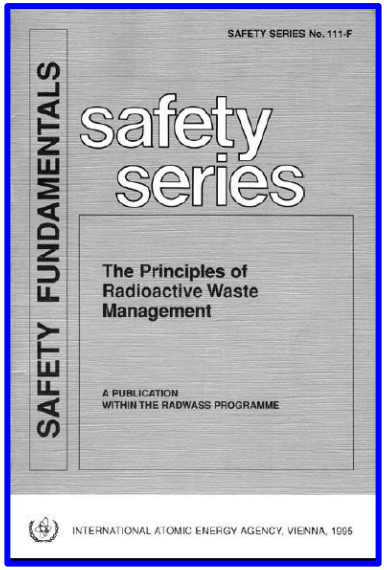


The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.



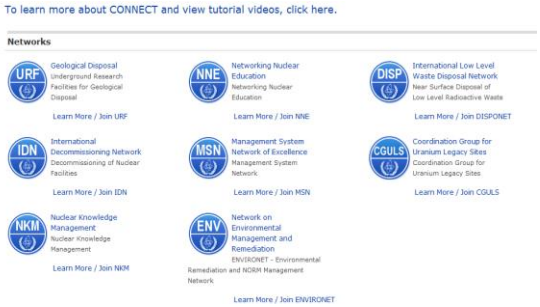
Objective of radioactive waste management

To deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations.



III. Radioactive Waste Predisposal Support

1. Technical Publications;
2. Networks:
   - International **D**ecommissioning **N**etwork (**IDN**),
   - Network for Environmental Management and Remediation (**ENVIRONET**),
   - Network for Underground Research Laboratories for Geological Disposal of HLW (**URF**),
   - Near-surface Disposal Network (**DISPONET**),
   - **Waste Characterization Network (LABONET),**
   - **CONNECT** - **Co**nnecting the **N**etwork of **N**etworks for **E**nhanced **C**ommunications and **T**raining in RWM, D&ER.
   - We are launching new network for radioactive waste predisposal management – **IMMONET**



3. Direct Assistance and Technical Cooperation Projects;
4. International Peer Review Services
5. Coordinated Research Projects;

Navigation
- Home
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    - Overview
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    - Radioactive Waste Disposal
    - Decommissioning of Facilities
    - Environmental Remediation
    - Disused Sealed Source Management
    - Contact Expert Group
  - Research Reactors
- ARTEMIS Reviews
- Assurance of Supply for Nuclear Fuel
- Publications
- Meetings
- Information Systems
- Waste Management Networks

Waste Technology Section

Predisposal Management of Radioactive Waste

Photo courtesy: COVRA

Depending on the origin, radioactive waste can occur in different physical state (solid, liquid, gas) and can have a variety of characteristics such as activity levels and half-lives of the radionuclides present in the waste. In the life cycle of radioactive waste, disposal is the final step. Before final disposal, the waste usually goes through a number of steps such as pretreatment, treatment, conditioning, storage and transport. Predisposal management encompasses all of these steps that collectively cover the activities from waste generation up to final disposal. Characterization of waste is also an essential predisposal activity that is common to all of the steps above.

IAEA's Assistance to Member States

The Waste Technology Section's assistance covers a wide range of predisposal management topics such as policy and strategy, inventory assessment, analysis of costing and waste management economics, waste minimization, selection of technical options for waste processing and storage, improvement in operating practices at nuclear facilities, optimization of waste management infrastructure, development of technologies etc. Besides the LABONET network, the assistance is delivered through:

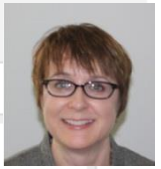
Related Information

Predisposal publications

LABONET

Contact Point

Ms. Rebecca ROBBINS



Predisposal steps Photo essay

http://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/WTS/predisposal.html

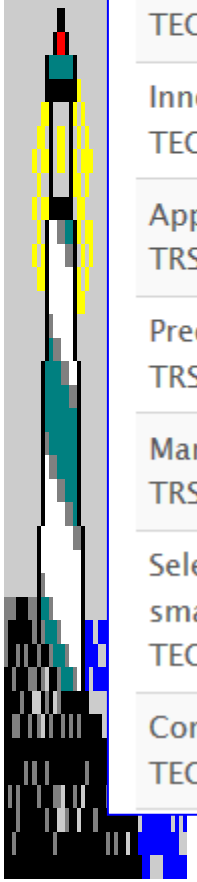
III.1. Technical Publications

Publications

Predisposal publications are organised below according to eight thematic subject categories (note some reports appear under more than one category):

1. Pre-treatment of low and intermediate level waste
2. Treatment of low and intermediate level liquid waste
3. Treatment of low and intermediate level solid waste
4. Treatment of gaseous waste
5. Conditioning of low and intermediate level liquid, solidified and solid waste
6. Processing of high level waste and spent nuclear fuel declared as waste
7. Characterization and monitoring of radioactive waste, waste forms and waste packages, and
8. Storage of radioactive waste and conditioned waste packages.

http://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/WTS/predisposal-publications.html



Treatment of Low and Intermediate Level Liquid Waste

Treatment of low and intermediate level solid waste

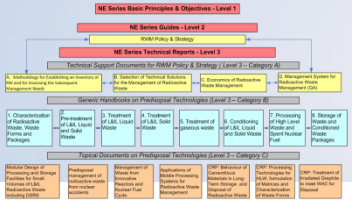
Treatment of gaseous waste

Conditioning of low and intermediate level liquid, solidified and solid waste

Characterization and monitoring of radioactive waste, waste forms and waste packages

Storage of radioactive waste and conditioned waste packages

Document Title	Link
Retrieval of fluidizable radioactive wastes from storage facilities TECDOC–1518 (2006)	
Selection of efficient options for processing and storage of radioactive waste in countries with small amounts of waste generation TECDOC–1371 (2003)	
Handling, conditioning and storage of spent sealed radioactive sources TECDOC–1145 (2000)	
Interim storage of radioactive waste packages TRS–390 (1998)	
Reference design for a centralized spent sealed sources facility TECDOC–806 (1995)	
Reference design for a centralized waste processing and storage facility TECDOC–776 (1994)	
Storage of radioactive wastes TECDOC–653 (1992)	Print Only



The Waste Technology Section is preparing a series of comprehensive state of the art technical **handbooks** on:

"**Characterization, categorization and monitoring of radioactive waste, waste forms and waste packages**",

"**Conditioning of low and intermediate level liquid, solidified and solid waste**",

"**Processing of high level waste and spent nuclear fuel declared as waste**",

"**Storage of radioactive waste and conditioned waste packages**",

"**Pre-treatment of low and intermediate level waste**",

"**Treatment of low and intermediate level liquid waste**",

"**Treatment of low and intermediate level solid waste**" and

"**Treatment of radioactive gaseous waste**" **– IAEA TECDOC-1744 (2014)**.

These are intended to assist professionals in Member States involved in field implementation of predisposal facilities by providing information on selection of technical options, design and operation in a structured way with recommendations on using cementitious materials where relevant.

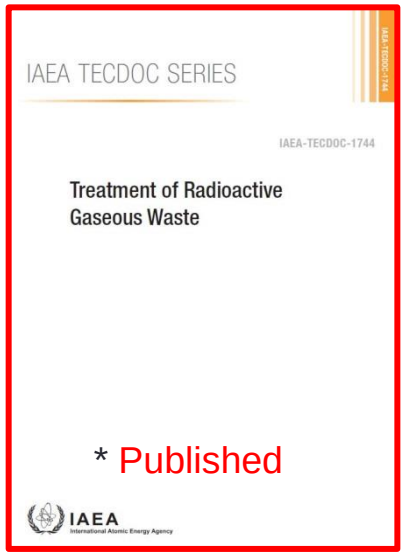
Eight New Predisposal Handbooks

1. Characterization of Radioactive Waste, Waste Forms and Packages

2. Pre-treatment of Low & Intermediate Level Solid and Liquid Waste

3. Treatment of Low & Intermediate Level Liquid Waste

4. Treatment of Low & Intermediate Level Solid Waste



* Published

6. Conditioning of Low & Intermediate Level Liquid and Solid Waste

7. Processing of High level & Spent Nuclear Fuel Declared as Waste

8. Storage of Radioactive Waste and Conditioned Waste Packages

Predisposal Document Hierarchy

NE Series Basic Principles & Objectives - Level 1

NE Series Guides - Level 2

RWM Policy & Strategy

NE Series Technical Reports - Level 3

Technical Support Documents for RWM Policy & Strategy (Level 3 – Category A)

- A. Methodology for Establishing an Inventory of RW and for Assessing the Subsequent Management Needs
- B. Selection of Technical Solutions for the Management of Radioactive Waste
- C. Economics of Radioactive Waste Management
- D. Management System for Radioactive Waste Management (QA)

Generic Handbooks on Predisopsal Technologies (Level 3 – Category B)

1. Characterization of Radioactive Waste, Waste Forms and Packages
2. Pre-treatment of L&IL Liquid and Solid Waste
3. Treatment of L&IL Liquid Waste
4. Treatment of L&IL Solid Waste
5. Treatment of gaseous waste
6. Conditioning of L&IL Liquid and Solid Waste
7. Processing of High Level Waste and Spent Nuclear Fuel
8. Storage of Waste and Conditioned Waste Packages

Topical Documents on Predisposal Technologies (Level 3 – Category C)

- Modular Design of Processing and Storage Facilities for Small Volumes of L&IL Radioactive Waste including DSRS
- Predisposal management of radioactive waste from nuclear accidents
- Management of Waste from Innovative Reactors and Nuclear Fuel Cycle
- Applications of Mobile Processing Systems for Radioactive Waste Management
- CRP: Behaviour of Cementitious Materials in Long-Term Storage and Disposal of Radioactive Waste
- CRP: Processing Technologies for HLW, formulation of Matrices and Characterization of Waste Forms
- CRP: Treatment of Irradiated Graphite to meet WAC for Disposal

III.2. Networks

bDN –beta-Delayed Neutron Emission

CGULS – Coordination Group for Uranium Legacy Sites

DISPONET – International Low Level Waste Disposal Network

ENVIRONET – Network of Environmental Management and Remediation

ICT – Instrumentation and Control Technologies

IDN – International Decommissioning Network

LABONET – International Network of Laboratories for Nuclear Waste Characterization

MSN – Management System Network of Excellence

NKM – Nuclear Knowledge Management Network

SFM – International Network on Spent Fuel Management

URF – Underground research facilities Network

International Predisposal Network. To be launched in 2016

http://nucleus.iaea.org/sites/nefw-projects/IMMONET/SitePages/Home.aspx

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Tags & Not

NEFW Projects

IMMONET ▸ Home

Sites

- Graphite CRP
- HLW-SFW Handbook
- Conditioning Handbook
- Reactor Core Waste
- Graphite Processing Approaches (GRAPA)

Discussions

- Team Discussion

WS on Technology Selection

Training on Large Size Radwaste

WS on Storage and Repository Safety

Training on PDM RER9107

TM on BMS WWER

TM on Institutional RW

WS on HLW and SFW RER9107

WS on Modular Design

WS on NPP RW Treatment

WS on Solid RW Processing

WS RWM Financing

IMM

Welcome to the IMMONET SharePoint Site!

The dedicated (registered users only) Share Point Site IMMONET is the Waste Technology Section's Predisposal Unit Site focused on nuclear waste processing technologies, immobilisation and storage of disposal ready forms. It consists of sub-sites to promote share of work results and discussions among participants of particular on-going Coordinated Research Projects. The IMMONET is also used as share point by IAEA staff and external participants developing various technical publications. In the nearest future this site will be used in development and evaluation of e-learning material devoted to training of waste specialists in different predisposal activities.

The site could be accessible to any waste management professional willing to cooperate with IAEA staff in dedicated activities. The access to the site could be obtained by first registering to IAEA NUCLEUS and then contacting Michael Ojovan (M.Ojovan@iaea.org) for user registration of IMMONET.

http://nucleus.iaea.org/sites/nefw-projects/IMMONET/SitePages/Home.aspx

Welcome to Institutional Radioactive Waste site!

Radioactive waste is generated in a broad range of activities involving the **use of radioactive material in medicine, industry, agriculture, research and education** which is often termed institutional radioactive waste aiming to emphasise that this radioactive waste arises **not from power generation**.
The Technical Meeting was intended to collect and share the operating practice and lessons learned on **institutional radioactive waste** processing and storage technologies and facilities. It should identify most important aspects and current trends as well as those areas which need special consideration and further development.

Shared Documents

Type	Name	Modified	Modified By
	Agency	8/29/2014 7:38 PM	OJOVAN, Michael
	National	12/11/2014 8:34 AM	OJOVAN, Michael
	TM Photos	8/29/2014 7:39 PM	OJOVAN, Michael
	Argentina	8/29/2014 7:46 PM	OJOVAN, Michael
	Australia	9/2/2014 8:08 AM	OJOVAN, Michael
	Azerbaijan	8/29/2014 7:46 PM	OJOVAN, Michael
	BELGIUM	8/29/2014 7:47 PM	OJOVAN, Michael
	Brazil	8/29/2014 7:47 PM	OJOVAN, Michael
	CHINA	8/29/2014 7:47 PM	OJOVAN, Michael
	Finnland	8/29/2014 7:47 PM	OJOVAN, Michael
	France	8/29/2014 7:47 PM	OJOVAN, Michael
	Hungary	9/10/2014 8:40 AM	OJOVAN, Michael
	ISRAEL	8/29/2014 7:48 PM	OJOVAN, Michael
	JAPAN add	8/29/2014 7:48 PM	OJOVAN, Michael
	Japan	8/29/2014 7:48 PM	OJOVAN, Michael
	Romania	8/29/2014 7:48 PM	OJOVAN, Michael
	Russia	8/29/2014 7:48 PM	OJOVAN, Michael
	Slovakia	10/3/2014 5:14 PM	Alena Zavazanova
	Switzerland	8/29/2014 7:49 PM	OJOVAN, Michael
	TURKEY	8/29/2014 7:49 PM	OJOVAN, Michael

III.3. Direct Assistance and TC Projects

Members States being supported through national projects in the 2012-2013 and 2014-2015 TC cycles include Argentina, Brazil, Georgia, Iraq, Jordan, Latvia, Mexico, Moldova, Serbia, Slovakia and Ukraine.

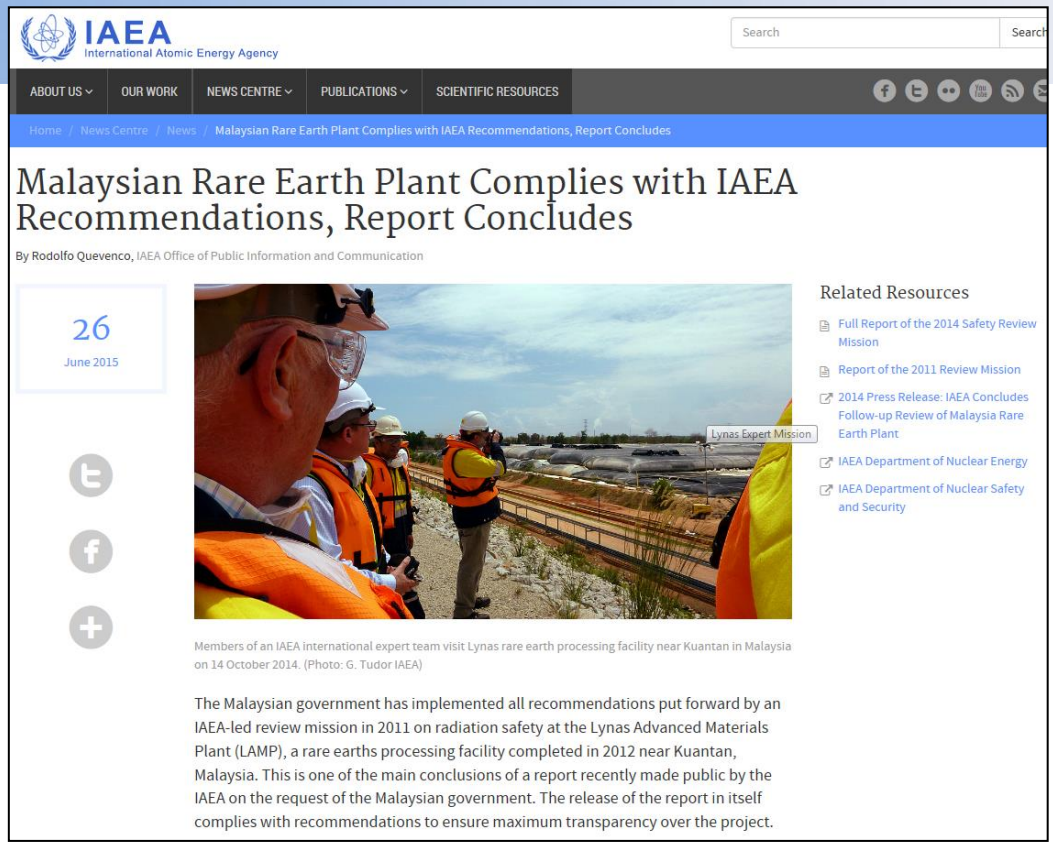
- **24 regional workshops** have been held since 2012 and one is planned for the end of October 2015.
- **3 national workshops** have been held in Argentina covering radioactive waste characterization, thermal treatment methods and off gas purification systems on plasma treatment of radioactive waste.

III.4. Peer Reviews

- International Peer Review of UK Magnox Decommissioning Programme (2008-2011) – final report handed over to Magnox representatives at the IAEA in February 2012.
- Korea: Geological disposal programme with emphasis on suitability for pyro- processed waste (2012);
- UK, NDA: Peer Review of Interim Storage of Higher Activity Waste Packages-Industry Guidance (2012);
- Russia: International Peer Review on the application of international safety standards to the liquid RWM practices in the Russian Federation (2013);
- The Follow-up International Mission on remediation of large contaminated areas off-site the Fukushima Daiichi NPP (2 EM's 2013).
- Review of Hungarian waste management framework.

Review Missions in 2014/15

- **October 2014**, IAEA Experts to Visit Japan to Present Results of Fukushima Seawater Analysis Comparison, take new samples;
- **February 2015**, IAEA Experts to Review Japan's Decommissioning Work at Fukushima Daiichi Site;
- **April 2015**, IAEA Experts to Visit Fukushima for Additional Information on Contaminated Water Management;
- **May 2015**, Third IAEA-led Expert Visit to Collect Marine Samples Offshore Fukushima.



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Malaysian Rare Earth Plant Complies with IAEA Recommendations, Report Concludes

By Rodolfo Quevenco, IAEA Office of Public Information and Communication

26 June 2015

Lynas Expert Mission

Members of an IAEA international expert team visit Lynas rare earth processing facility near Kuantan in Malaysia on 14 October 2014. (Photo: G. Tudor IAEA)

The Malaysian government has implemented all recommendations put forward by an IAEA-led review mission in 2011 on radiation safety at the Lynas Advanced Materials Plant (LAMP), a rare earths processing facility completed in 2012 near Kuantan, Malaysia. This is one of the main conclusions of a report recently made public by the IAEA on the request of the Malaysian government. The release of the report in itself complies with recommendations to ensure maximum transparency over the project.

Related Resources

- Full Report of the 2014 Safety Review Mission
- Report of the 2011 Review Mission
- 2014 Press Release: IAEA Concludes Follow-up Review of Malaysia Rare Earth Plant
- IAEA Department of Nuclear Energy
- IAEA Department of Nuclear Safety and Security

The Third Decommissioning Mission to Japan

9-17 February 2015;

- ✓ Follow-up mission and review of current on-site status & strategic plans for D&D and review progress in specific areas:
  - ✓ Management of contaminated water,
  - ✓ Countermeasures against groundwater ingress,
  - ✓ Removal of spent fuel and damaged fuel debris from Units 1-4,
  - ✓ Management of waste: storage, features of waste, identifying waste streams,
  - ✓ Institutional and organisational issues: responsibilities, staffing and training, safety culture, communication with public …
- ✓ Team : 11 IAEA staff (NE, NS, NA, OPIC), 4 external experts (Philippines, RF, USA, OECD/NEA);
- ✓ Team leader : Juan Carlos Lentijo, DIR-NEFW.

III.5. Coordinated Research Projects

- ✓ CRP on Planning, Management and Organizational Aspects in Decommissioning of Nuclear Facilities (2009-2011), IAEA-TECDOC-1712 published in 2013;
- ✓ CRP on Innovative and Adaptive Technologies in Decommissioning of Nuclear Facilities (2004-2008), IAEA-TECDOC-1602 published in 2008;
- ✓ **Performance and Behaviour of Cementitious Materials in Long Term Storage and Disposal of Radioactive Waste (2007-2010), IAEA-TECDOC-1701 published in 2013;**
- ✓ **Treatment of Irradiated Graphite to Meet Waste Acceptance Criteria for Disposal (2011-2013) – TBP2015;**
- ✓ Processing Technologies for **High Level Waste**, Formulation of Matrices and Characterization of Waste Forms (2013-2015).

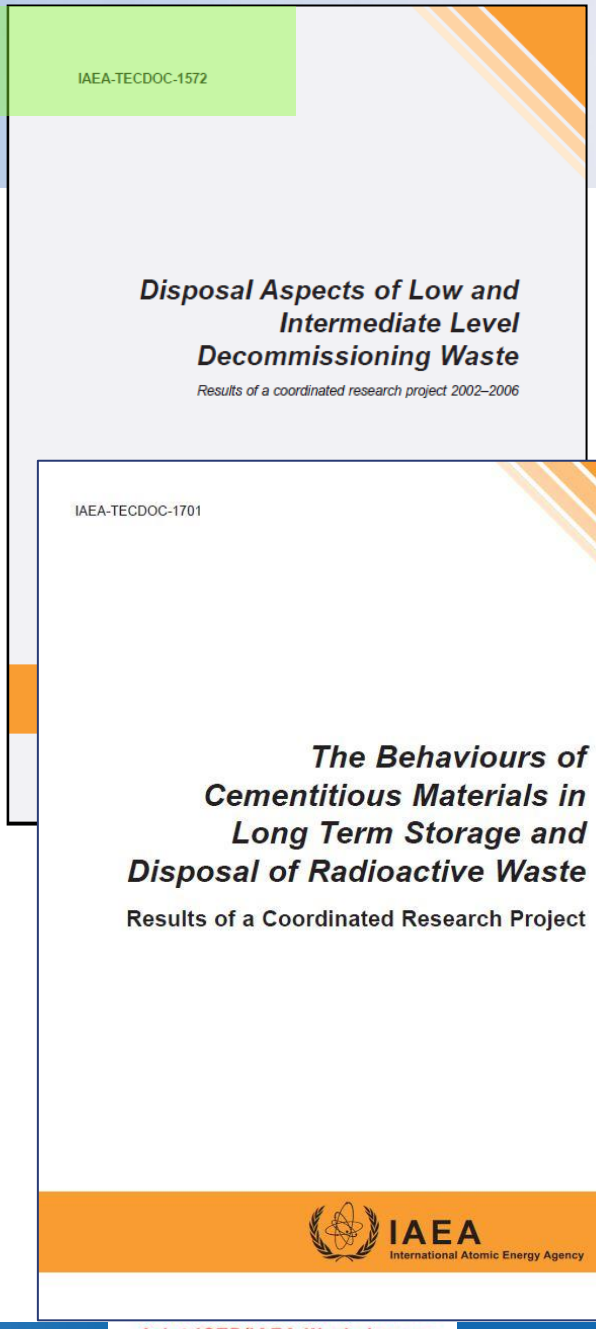
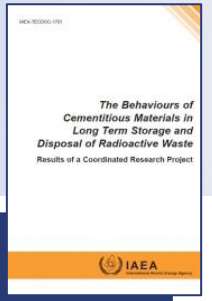


Photo CRP Cement

CRP on **Performance and Behaviour of Cementitious Materials in Long Term Storage and Disposal of Radioactive Waste (2007-2010)**



Designation	Formation conditions	Comments
Calcium sulphoaluminate cement (CSAC)	Available commercially or made by mixing commercial calcium aluminate cement (CAC) with calcium sulphate	Has a history of use (~40 years) as a construction cement. Developed in China but now widely available.
Calcium aluminate cement (CAC)	Based on clinkers or fused products with dicalcium silicate and $CaAl_2O_4$	Calcium aluminate cements are widely available as commercial products with a long history of use in construction.
Geopolymer SIAL	Mixture of sodium silicate (hydrate) with metakaolin	Geopolymer-type matrix which is characteristically X ray amorphous
Magnesium phosphate cement	Mixture of fine grained MgO (periclase) and a phosphate source, e.g, phosphoric acid or monopotassium phosphate	Many variants are known, differing in pH and solubility. Not fully commercial except for small scale applications, e.g., as refractory or dental cements

Photo CRP HLW

Joint ICTP/IAEA Workshop on Radioactive waste management – solutions for countries without nuclear power programme

Consultants Meeting on "Treatment of Irradiated Graphite to meet Acceptance Criteria for Waste Disposal", 22 – 24 July 2014, IAEA, Vienna, Austria

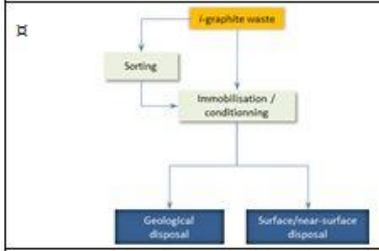
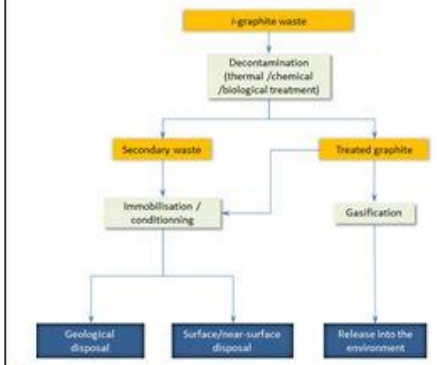
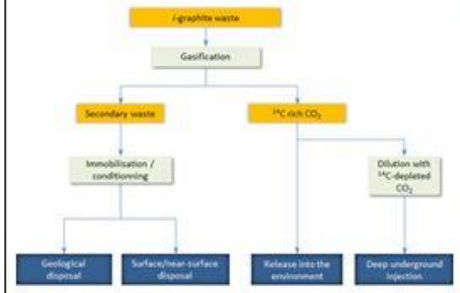
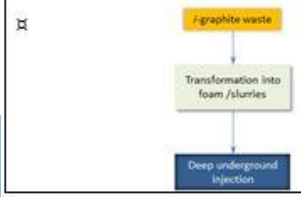
Processing of Irradiated Graphite to meet Acceptance Criteria for Waste Disposal

Results of a coordinated research project

Jose-Luis Leganes, Mary Lou Dunzik-Gougar, Anthony J. Wickham
Martin Metcalfe, Laurence Petit, Werner von Lensa

CRP on **Treatment of Irradiated Graphite to Meet Waste Acceptance Criteria for Disposal (2011-2013)**

GRAPA

Management options	Investigated by (within the CRP)
	• PSI (Switzerland*)
	• Enresa (Spain*) • PSI (Switzerland*) • FZJ (Germany*) • FNAG (Germany) • EDF/CEA/Andra (France*) • NDA (UK*) • University of Sheffield (UK) • INPP & LEI (Lithuania*)
	• EDF/CEA/Andra (France*) • UoM (UK) • Idaho State University (USA) • Radon (Russia) • Tsinghua University (China) • INPP & LEI (Lithuania*)
	• VNIINM (Russia) • Bradtec/Hyder/Studsvik UK/Costain (UK)
	• L'arbresle Ingéniérie (France)

*National official policy

Consultancy Meeting on Proposed International Project on Management of Spent Irradiated Graphite from Decommissioning (GRA-PA), IAEA HQ, Vienna, 5 – 8 May 2015

IV. On-going Support Activities

- Technical Meeting on International Project on Irradiated Graphite Processing Approaches (**GRAPA**) (9-12.02.2016).
- Technical Meeting to Launch the International Predisposal Network **IMMONET** (28.06-1.07.2016).
- Technical Meeting on the Processing & Storage of Activated Material from Reactor **Cores** and Structures (29.11 2.12.2016).

On-going Projects

- **CIDER** - Constraints in the Implementation of Decommissioning and ER project;
- **DACCORD** - Data Analysis and Collection for Costing of Research Reactor Decommissioning project;
- **DRIMA** International Project on Decommissioning Risk Management (DRiMa);

Management of Disused Sealed Sources

- Development of publications and technologies
- Support of field activities – conditioning and removal of higher-activity sources and aggregations:
  - currently underway in more than 20 countries (Europe, Middle East, Africa, Central and South America),
  - in some cases Mobile Hot Cell is used.

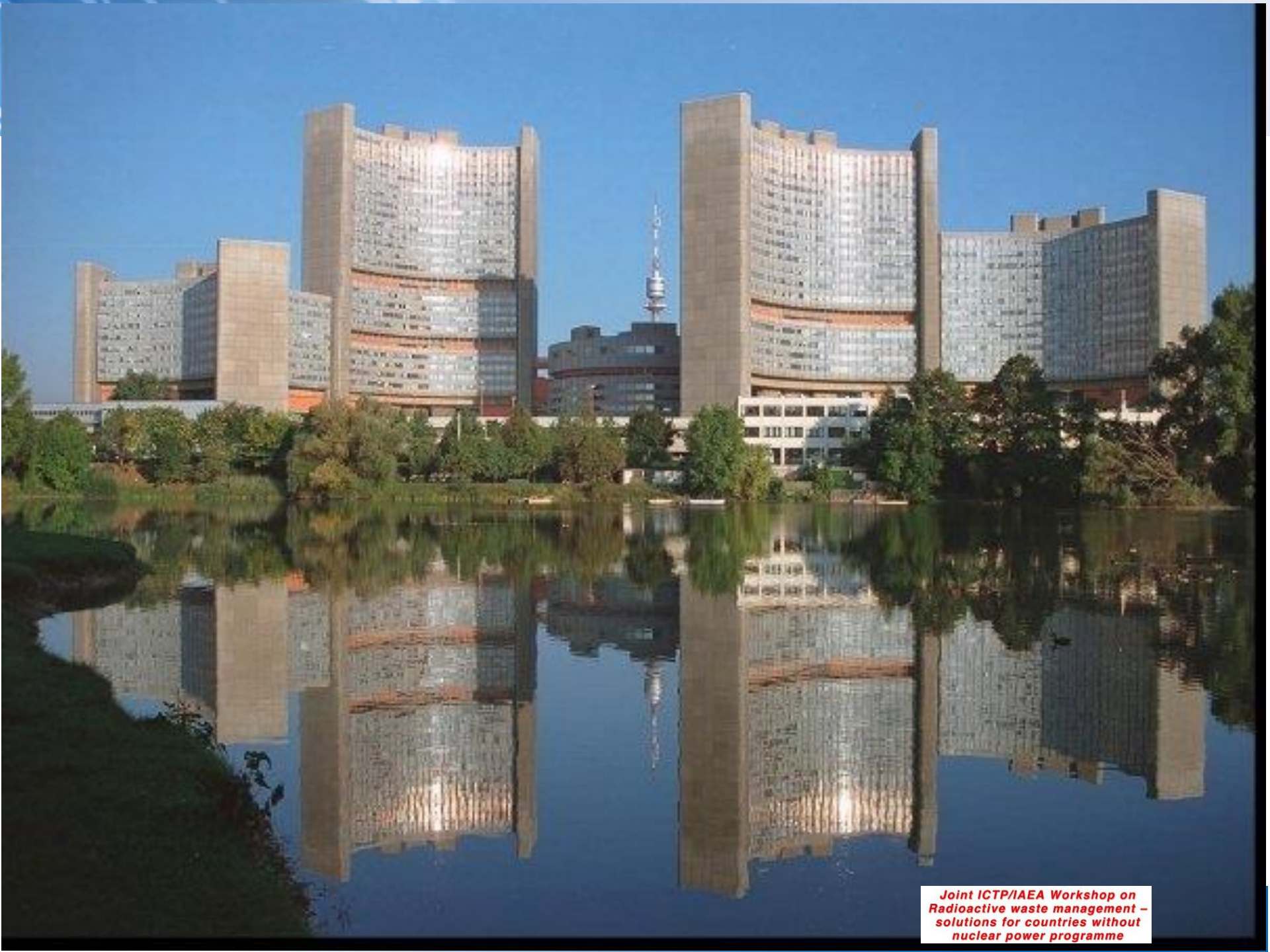
WES International Projects & Working Groups

- Integrated Safety Case for Dual Purpose Casks for SNF;
- **HIDRA Project: Human Intrusion in the context of Disposal of RW;**
- **Follow up project on Demonstration of Safety of Geological Disposal (GEOSAF);**
- **Prisma: Follow up of Prism on demonstration of safety of near surface disposal (SC and SA);**
- **International WG on Disposal of ILW;**
- **CRAFT Project : Demonstration of Safety for predisposal management;**
- **MODARIA: Modelling and Data for Radiological Impact Assessment**;
- RSLS: Regulatory supervision of Legacy Sites;
- CGULS: Coordination Group for Uranium Legacy Sites;
- R2D2: International Research Reactor Decommissioning Demonstration Project.

Support to Newcomer Countries

- INIR (Integrated Nuclear Infrastructure Review) Missions (Jordan, Nigeria + planned to Kenya, Morocco, Bangladesh);
- WTS organized Workshop/Training Meeting on Radioactive Waste dedicated for newcomers countries in Vienna. Similar regional events were organized through TC.

- Peer reviews for MSs (ARTEMIS);
- Development of costing methods and financing schemes for waste disposal;
- IAEA, OECD-NEA and EC Joint Working Group on Status and Trends in Radioactive Waste Management and Spent Fuel Management;
- IAEA International conference on the safety of radioactive waste management (November 2016, VIC).



Joint ICTP/IAEA Workshop on Radioactive waste management – solutions for countries without nuclear power programme