Disposal of large volume of radioactive waste

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Waste Technology Section
Setting the scene
„very large” volume:
in the context of the country’s existing capabilities for managing waste or radioactively contaminated residues
Reasons of generating large volume of waste

Waste generated during planned, „normal” operation

- large nuclear programmes
  - operation
  - decommissioning of nuclear facilities
- mineral processing
- long-term legacy cleanup

Waste generated as a consequence of emergency

- severe nuclear / radiological accident
- military activities (legacy sites)
- military accident
- malicious acts (terrorist acts, Radiological Dispersal Devices)
- natural disasters
- animal disease outbreaks
Very large volumes generated during emergency make an exception to the usual rules

How is it different?

- the **sudden nature** of the emergency
- its **effects on populations and territory** outside the boundaries of the nuclear facility
- **pressing need for action**

Distinguish this situation from a **long-term legacy cleanup** that may ultimately generate similar volumes of waste
Waste generated as a consequence of a severe accident

- **Complicated mixture** of waste with **varying characteristics**

- The quantity of contaminated material depends on the characteristics of the **affected environment** (urban, forest, agriculture, etc.)

- contains radioactive substances may be generated in **decontamination** or from **discarded products**

- waste arisings from accidents may also contain **non-radiological contaminants** (e.g. heavy metals, toxic organics) in greater amounts than under normal situations
• Severe accident wastes cannot necessarily be processed via the normal waste management because:
  
  • the amount of wastes may be very big
  • the waste may be unsuitable for the normal waste management
  • they contain so much radioactive substances that their disposal via normal WM wouldn’t be the optimum solution from the radiation protection point of view

• The current regulatory standards for waste may prove inappropriate
Motivation to convene this TM
Recent accident at Fukushima Daiichi points to the need of nuclear community to be **better prepared** to meet challenges of an accident related to **DD/ER/RWM on site and off site**.

In September 2011: **Action Plan on Nuclear Safety** was adopted by the IAEA's Board of Governors and subsequently endorsed by the IAEA General Conference.
Action Plan 10. PROTECTION FROM IONIZING RADIATION

Ensure the on-going protection of people and the environment from ionizing radiation following a nuclear emergency.

10.2 MSs, IAEA and stakeholders to facilitate the use of available information, expertise and techniques regarding the removal of damaged nuclear fuel and the management and disposal of radioactive waste resulting from a nuclear emergency.

10.2.3 “To collect experience and lessons learned on management of accidental waste with focus on characterization, management of large volumes of liquid and solid waste in accident conditions, storage and disposal of large volumes of waste including high level waste from defueling and make available to MSs”.

IAEA
International Experts' Meeting (IEM) on Decommissioning and Remediation After a Nuclear Accident from 28 January to 1 February 2013.

- part of the Agency's implementation of the IAEA Action Plan on Nuclear Safety

Yumiko gives more details
IEM4 Chairperson`` summary on management of damaged fuel and radioactive waste

- Problems are encountered in both the high-activity and low-activity end of the spectrum:
  - *Damaged fuel* poses particular problems as it retains its basic radiological hazard whereas the matrix has been damaged to an extent that makes it unsuitable for conventional management.
  - *Large volumes of very low level waste* may be generated during remediation, where the volume of the waste *presents a challenge* for its management.
Recommendation:

**Large volumes of radioactive waste** and materials with residual amounts of radionuclides are present in many countries.

The Agency should **review its guidance** on the management of these wastes and materials with the view of ensuring their **practical application** after a nuclear accident.
IAEA’ response
IAEA is committed to take actions to provide assistance for the MSs on SNF/RW management, environmental remediation (ER) and decontamination, decommissioning (DD) on short-term and longer-term basis to address on site and off site needs.

• help in **advance planning**
• **collect and disseminate lessons learned** and guidance
New direction: need to be better prepared

• Recognized: limited attention given to long-term cleanup and waste management in emergency response planning

• Being prepared, especially for the early post-accident phase, may significantly contribute to a sound management of post-accident conditions, including those implemented later on.

• Decisions made in the early period can significantly influence the waste management activities for the long-term period.
A nuclear accident can affect many if not all, aspects of the RWM strategy that was established prior to an accident.

- The volume of lower activity waste may increase by several order of magnitudes
- Higher activity waste may be generated (fuel debris, liquid)
Advance planning

It would seem prudent that **some preliminary planning** be done for the cleanup of large areas and the related **RWM** in the event of an accident holding the potential to release unacceptable amounts of radioactive material in countries having nuclear facilities.

**New nuclear countries** should take these issues into account as they develop their programs for managing waste.

Lessons learnt in the cases of the TMI, Chernobyl and Fukushima accident: ’**beginning with the end in mind**’

(In terms of immediate treatment of waste, it is important of having final **disposal in mind** when choosing among waste form)
BEFORE ACCIDENT MAY HAPPEN

National Policy and Strategy

National Post-accident Management and Recovery Plan

need to be prepared

what should be done

what should not be done

Such plan would not necessarily fit an actual post-accident situation, but would be a useful starting point
Collect and disseminate lessons learned

- In the past a number of large areas in the world have been affected by radioactive contamination caused by a variety of incidents, accidents and past activities in nuclear facilities.

- Based on related experience in the area of RWM it is worth considering how the lessons learnt can be utilized when implementing future remediation programs.
Source of information (1): accident-related

- Worldwide information on accident related RWM considerations
  - *Nuclear accidents* (TMI, Chernobyl, Fukushima, Kyshtym, Palomares, … )
  - *Radiological source accidents* (Goiânia)
  - *Military accidents* (Palomares)

- Worldwide experience in RWM from remediation activities for legacy sites (Maralinga-Australia, USA cleanup activities)
Legacy waste management: from technical point of view, there are **appreciable parallels** with post-accident situations.

Experience with regulation of legacy sites that have radiological contamination, such as **complex R&D sites** and **legacy uranium production sites**, offers knowledge that is transferrable to post-accident situations.

In the long term, accident sites become managed and regulated much as a legacy site would.
A very large amount of LLW will arise from decommissioning of nuclear facilities (rubble, metal, soil).

Diverse waste streams, in terms of materials and radioactivity content.

Because of cost-effectiveness, more and more countries considering VLLW disposal.
Source of information (4): NORM residues and wastes

- characteristics: huge volumes, mixed contamination, long-lived radionuclides, very low activity,…..

- Often the impacts of non-radiological contaminants is as important or even more important than radiological impacts

- NORM waste management objective:
  - to minimise the material sent for disposal as waste by using of improved process technologies and waste minimisation techniques such as reuse and recycling of residue

- A great deal of experience: remediation of NORM legacy sites
  - Significant legacy of uranium mining (Contaminated buildings, including homes, contaminated sources of drinking water)
Decommissioning

Mineral processing

Legacy site clean up

Nuclear/ radiological accident

LARGE VOLUME OF WASTE

VLLW

DD/ER waste

NORM residue

Legacy waste

$10^4$ - $10^5$ m$^3$

$10^4$ - $10^6$ m$^3$

$10^6$ - $10^7$ m$^3$
Considerable worldwide expertise and experience

**Accident-related experience**

**Other transferrable knowledge to post-accident situations**

**GOOD PRACTICE**

**INSUFFICIENT / CONTROVERSIAL PRACTICE**

**PRACTICE SUBJECT TO CHANGE**

**KEEP**

**CHANGE**

**NEW**

Considerable worldwide expertise and experience.
IAEA publications
<table>
<thead>
<tr>
<th>IAEA Publications</th>
<th>PREDISPOSAL</th>
<th>DISPOSAL</th>
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<tbody>
<tr>
<td><strong>TRS 300</strong>: Cleanup of Large Areas Contaminated as a Result of a Nuclear Accident (1989)</td>
<td>NO</td>
<td>YES</td>
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<tr>
<td><strong>TRS 327</strong>: Planning for cleanup of large areas contaminated as a result of a nuclear accident (1991)</td>
<td>NO</td>
<td>NO</td>
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<tr>
<td><strong>TRS 330</strong>: Disposal of waste from the clean-up of large areas contaminated as a result of a nuclear accident (1992)</td>
<td>very limited on treatment</td>
<td>YES</td>
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<tr>
<td><strong>TECDOC-935</strong>: Issues and decisions for nuclear power plant management after fuel damage events (1997)</td>
<td>• conditioning of abnormal waste • on site storage</td>
<td>NO</td>
</tr>
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On-going IAEA publications on accident-related RWM

The WTS made a motion to address the complex issue in different documents covering the **on-site and off-site RWM aspects** separately.

- Experience and lessons learned worldwide in **clean-up and decommissioning** of nuclear facilities after an accident (initial draft prepared in 2012).
- Experience on approaches, techniques, tools and equipment to deal with **clean-up, decontamination** and **decommissioning** (initiated in October 2013).
- Predisposal Management of Radioactive Waste in the Aftermath of Severe Nuclear Accident: Challenges, Issues and Lessons Learned (initiated last week).
- **Disposal of radioactive waste from clean-up of contaminated areas in the aftermath of a nuclear or radiological accident**
WTS Predisposal Team: Experience and lessons learned in predisposal management of RW in the aftermath of nuclear accidents

- Legal and regulatory framework
- Political decisions
- Stakeholder inputs

Post-accident strategy

Plan for RWM

ON-SITE
OFF-SITE

PREDISPOSAL treatment conditioning storage

DISPOSAL

Waste streams
Waste volumes
Waste characteristics
end state clearance recycle, etc.
WTS Disposal Team:
Disposal of radioactive waste resulting from a nuclear or radiological accident

- Legal and regulatory framework
- Political decisions
- Stakeholder inputs

NATIONAL STRATEGY

Post-accident strategy

- Waste streams
- Waste volumes
- Waste characteristics

Plan for RWM

ON-SITE

OFF-SITE

PREDISPOSAL
- treatment
- conditioning
- storage

DISPOSAL

end state clearance
recycle, etc.

Technical / scientific
Economic, socio-political
WES Disposal Team

- Legal and regulatory framework
- Political decisions
- Stakeholder inputs

NATIONAL STRATEGY

Post-accident strategy

Plan for RWM

Plan for RWM

ON-SITE

Waste streams
Waste volumes
Waste characteristics

OFF-SITE

end state clearance recycle, etc.

PREDISPOSAL

- treatment conditioning storage

DISPOSAL

Regulatory/statutory Safety demonstration
Questions worth addressing at the current TM
• Which actions may **increase preparedness** for effective waste management (disposal)?

• What are the **main aspects / factors** to be considered when planning for disposal activities for accident related waste?

• Do we have (do we need) tools for **estimate waste** generated by a nuclear or radiological accident?

• What are the advantages and disadvantages of the **long term storage / deferred disposal**?

• What factors may have influence on **selection of a disposal option / facility design**?
• Do we need new technologies and creative solutions to dispose large volume of waste safely?

• Would any research be required to dispose accident related waste more effectively?

• May the siting requirements differ for the accident related waste disposal (such as proximity to the accident, etc.)?

• Which elements have the most determining influence on the disposal cost?
  • Characterization of contamination in waste and access to reliable information on treatment and disposal can reduce cleanup costs and shorten remediation timelines.
• Are there social-scientific studies needed to be performed to address the social concerns?

• What experience / approach / technical solutions can be used from legacy waste, NORM residue or decommissioning-related disposal practice?

• What can be learned from non-radiological events?
  • World Trade Center (2001), Hurricane Katrina (2005)

• Any other related issue
Meeting objectives and scope will be further highlighted by the chairman.
Speakers:
- Australia
- China
- Egypt
- France (3)
- Germany
- Japan

Other participants:
Bulgaria, Italy, Kenya, Lithuania, Pakistan
Wish you a fruitful discussion!

IAEA