FNCA Newsletter No.7

Radiation Safety & Radioactive Waste Management

Mar. 2013

Issued by
Nuclear Safety
Research Association
(FNCA Secretariat,
JAPAN)

Contents

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Australia

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Intermediate Level Waste Return Project

The Australian Reactor

The now retired High Flux Australian Reactor (HIFAR) at Lucas Heights first went critical on the 26 January 1958. HIFAR was the first nuclear reactor in the southern hemisphere and it was used for producing neutrons for scientific research and the production of radioisotopes for medicine and industry. After close to 50 years of reliable operation, it was retired in January 2007 with the commissioning of the new, state-of-the-art OPAL reactor.

HIFAR's reactor core consisted of 25 fuel elements and has a nominal maximum thermal power output of 10 megawatts. The original uranium enrichment of the fuel used in HIFAR was 93% U235. In 1983, 60% enriched HEU fuel was introduced and a stepwise reduction towards LEU was actioned in 2004. The conversion to LEU was completed in 2006.

Fig1. The retired HIFAR

Approximately 37 spent fuel elements were generated by HIFAR each year. Once discharged from the reactor, the spent fuel elements were stored underwater for several years to allow much of the short-lived activity to decay.

The fuel elements were then transferred to an engineered dry storage facility, consisting of holes drilled into the bedrock and lined with stainless steel welded tubing.

The National Radioactive Waste Management Act 2012 defines “high level radioactive material”, as “material which has a thermal energy output of at least 2 kilowatts per cubic metre. Unlike power reactors, Australia’s research reactors do not generate any used fuel that would be classified as HLW.

Spent Fuel Shipment for Reprocessing

As Australia does not have a nuclear spent fuel reprocessing facility, the used HIFAR fuel elements were sent overseas for reprocessing. Reprocessing is the chemical process whereby fissile and fertile materials in the spent fuel are recovered in order to provide fresh fuel for existing and future nuclear power plants. It offers benefits in increased uranium and plutonium utilisation, and a reduction in the volume of high level waste. The resulting liquid waste from the reprocessing process is then solidified for long-term storage.

Between 1996 and 2009 there were eight overseas shipments of used ANSTO’s nuclear fuel - four shipments to France (for reprocessing), three shipments to the United States (US) as part of the US DOE spent fuel take back program and one shipment to the United Kingdom (UK) for reprocessing. Each shipment was carried out safely using approved and licensed transport packages on dedicated INF-2 classification ships.

The waste arising from reprocessing of spent fuel elements shipped to the US under the US Department of Energy (DOE) Foreign Research Reactor Spent Nuclear Fuel Acceptance Program (FRR-SNF) will not be returned to Australia. However the inter-governmental agreements made with France and UK specifies that the wastes arising from the reprocessing of the ANSTO’s spent fuel in these countries will be returned to Australia. It is internationally accepted that countries are responsible for the management of the radioactive waste they produce.

Intermediate Level Waste Return from France

Vitrified Waste Residues

A total of 1288 spent fuel elements were sent to France. The waste residues arising from the reprocessing of these elements were melted together with glass material at high temperatures for incorporation into the glass matrix. The melted mixture is poured into stainless steel canisters, and after controlled cooling, the canisters are sealed by welding and then decontaminated to remove possible surface contamination. A maximum of 28 vitrified waste canisters will be loaded into a French-designed and developed transport and storage package (TN 81 cask), and shipped back to Australia in the second half of 2015.

Fig2. The TN-81 Cask

The TN-81 cask measures around 7.2m in length and 2.7m in diameter, when fully loaded weighs close to 120 tonnes. Containment and shielding is be provided by the thick forged steel cylindrical vessel with the welded bottom, the external lead-filled aluminium profiles and the primary/secondary lids with the associated seals. The TN-81 cask is designed to withstand a drop of 9 metres, temperatures above 800 degrees Celsius, earthquakes and jet plane crashes.

Technological Wastes

The technological wastes produced during the operation and maintenance of the reprocessing facility such as contaminated gloves and tools will also be returned at this time.

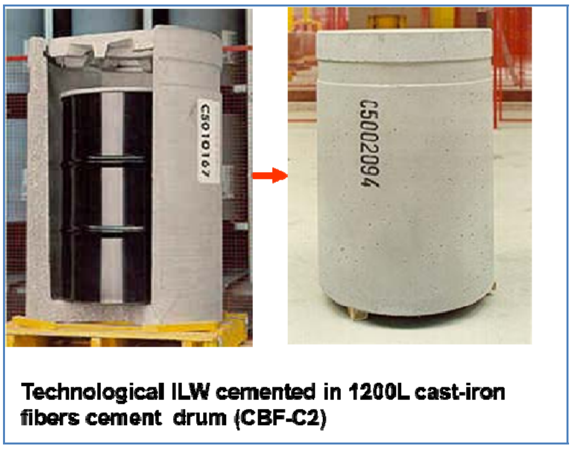

Fig3. The cemented technological wastes

The technological waste will be cemented within cast-iron fibre cement over pack containers (CBFC Type 2) and the six CBF-C2 containers will be placed in a rack which will be securely fastened inside a 20 foot ISO IP2 container for shipment.

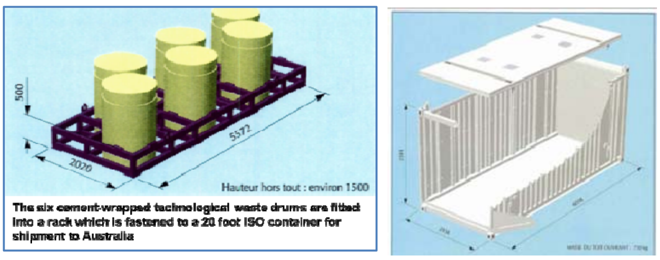

Fig4. Cemented technological wastes secured in rack *within the ISO IP2 transport container*

Intermediate Level Waste Return from UK

A total of 114 spent fuel elements were sent to United Kingdom. The reprocessing and waste immobilisation process at Dounreay, Scotland is outlined in the flowchart below.

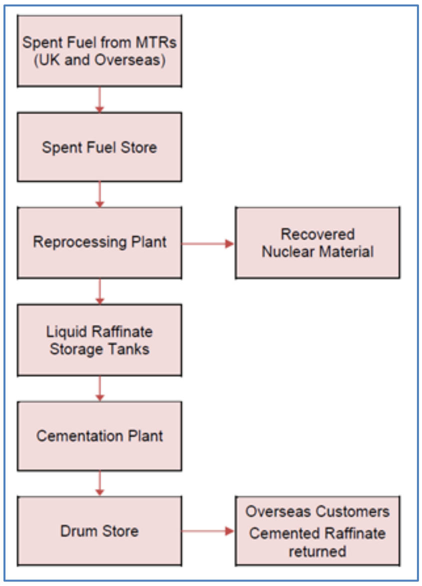

Fig5. Process flowchart for spent fuel processing and waste cementation in Dounreav. Scotland

Fifty-one 500L cemented drums have been designated for return from Dounreay to ANSTO. However negotiation is currently underway on the inter-governmental level for a policy option to permit the substitution of the radioactive waste at Dounreay for an alternate radiologically equivalent amount of vitrified ILW at Sellafield, England. A feasibility study into the return of the reprocessed wastes from the UK to Australia found in favour of the vitrified waste form. Some of the benefits for vitrified residue option are given below:

- A new transport and storage package will need to be sourced for the 51 x 500L cemented drums.
- A single TN-81 transport and storage cask can be used for the 2-6 x vitrified containers. The same package handling equipment/tooling acquired for the French return waste can be used.
- Reduction in waste and primary containment volume of the returned waste from 25m^3 to less than 1m^3.

- A smaller footprint required for storage.
- Reduced number of required shipments.

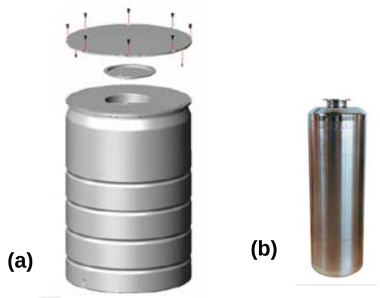

Fig6. Option to substitute the (a) 51 x 500L cemented ILW from Dounreay, Scotland with (b) 2-6 x 150L vitrified residue canisters from Sellafield, England.

Interim Storage in ANSTO

An interim storage facility will be located at the Lucas Heights Science and Technology Centre (LHSTC) site for the storage of the French return waste. License applications will be submitted to the regulator, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) shortly for the siting and construction of the Interim Waste Store (IWS). The IWS will be operational by 2015 to receive and temporarily store the returned waste from France. The Australian National Radioactive Waste Management Facility (NRWMF) is anticipated to be operational by the end of the decade, at which time the French returned waste will be transported for long-term storage in the NRWMF.

The UK returned waste will be transported directly from port to the NRWMF. However in the unlikely event that the NRWMF is not operational at the time of the UK waste return, the IWS at the LHSTC has been designed to accommodate the UK returned wastes.

Bangladesh

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Precipitation Characteristics around the Country in Bangladesh

For establishment of a nuclear facility, it is a primary criterion for selecting a suitable site, so as to provide reasonable assurance that the facility can be operated at the site without undue risk on the health and safety of the occupational workers, the general public and the related environment. It is based on the evaluation of detailed information and data about geography, geology, hydrology, meteorology, seismology, transportation and communication, demography, industrial installations, facilities in the vicinity, and the region surrounding the site.

The evaluation of extreme values of meteorological phenomena e.g., the value of precipitation must be documented for an appropriate period of time. Since the type and amount of precipitation may influence the amount of surface erosion, the occurrence and depth of groundwater, leaching and transport of nuclear materials, and the rate of evaporation in the area. Thus precipitation and water level are important factors in the consideration or selection process of a site. This report based on the available information concerning long-term annual and monthly variations in precipitation in different districts of Bangladesh. All the precipitation data have been collected from the 34 stations throughout the country with the courtesy of Bangladesh Meteorological Department (BMD).

Table 1: The Average annual precipitation (mm) during the period (2001- 2011)

Divisions	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Dhaka	1842	2118	1662	2213	2176	1711	2405	1920	1630	1621	1776	1915
Sylhet	3193	3448	2925	3660	3269	2746	3427	2613	2869	3614	2575	3121
Rajshahi	1420	1649	1402	1911	1772	1179	1717	1470	1248	985	1644	1490
Rangpur	2315	2850	2350	2587	2826	1673	1835	1873	2132	1898	1822	2196
Khulna	1619	2238	1691	2062	1906	1805	1977	1713	1575	1311	1860	1796
Barisal	2787	2597	2226	2682	2590	2280	2686	2353	2084	2042	2357	2425
Chittagong	3202	2983	2910	3214	3842	2709	3600	3159	2915	2822	3400	3159

Fig 1: Average rainfall distribution different districts around the country

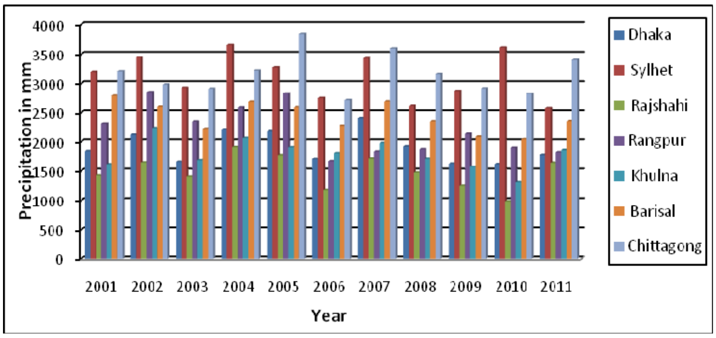

Fig 2: Variation of annual precipitation in different divisions Bangladesh

Table 2: Monthly average precipitation (in mm) around the country (2001- 2011)

Divisions	January	February	March	April	May	June	July	August	September	October	November	December
Dhaka	5	15	42	91	217	371	386	299	276	179	21	7
Sylhet	3	30	90	304	516	611	546	467	340	171	31	8
Rajshahi	6	6	28	62	138	286	287	266	245	148	5	4
Rangpur	6	9	30	106	246	486	447	315	293	228	7	4
Khulna	9	14	37	51	169	322	375	282	337	173	24	5
Barisal	8	13	30	60	212	473	558	372	384	280	31	4
Chittagong	5	11	32	79	340	633	711	522	380	240	36	8

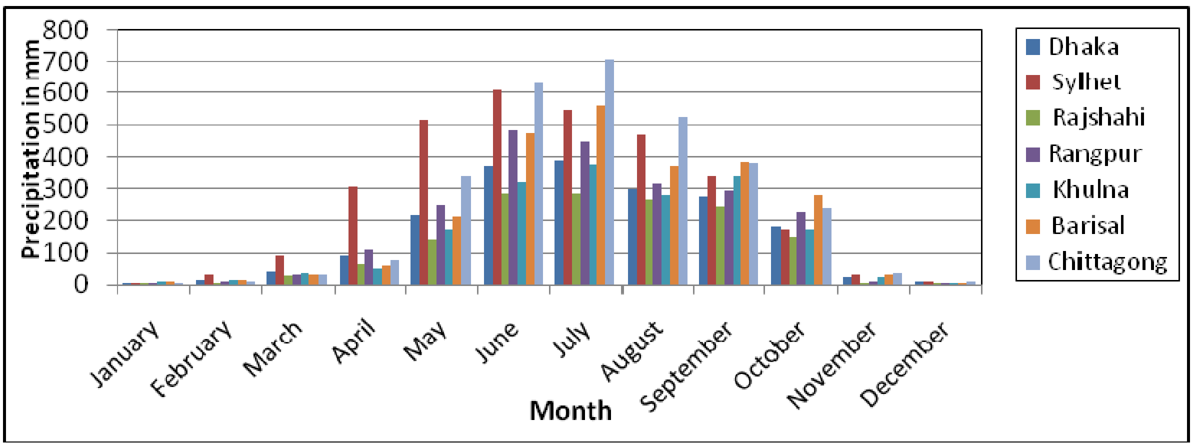

Figure3: Monthly rainfall distribution in different divisions around the country

The average annual precipitation in seven divisions of Bangladesh form 2001 to 2011, ranging from a minimum of 1490 mm to a maximum of 3159 mm. The variation of total annual precipitation is shown in Figure 2. From this figure it has been observed that the total amount of annual precipitation is higher in Chittagong and Sylhet region whilst the lower precipitation record observed in the Rajshahi region. The monthly precipitation distribution is shown in Figure 3, from the analysis of data it is seen that rainy season with heavy rain occurs in June, July month, while the dry season with least rain were recorded in December. The maximum rainfall occurs from May until October.

During the site selection procedure the region must be assessed to determine the potential for flooding due to natural causes such as runoff resulting from precipitation that may affect the safety of the nuclear installation. The collected rainfall data analysis will be useful for site selection process for the establishment of a nuclear facility in the country.

Indonesia

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Radioactive Waste Management in Indonesia

Introduction

Nowadays, the use of nuclear energy in various fields, such as in research, agriculture, medicine, industries, and energy, has progressed rapidly. Radioactive Sources such as Co-60, Cs-137, Ir-192 are used for sterilization, level gauge, thickness gauge, non destructive testing etc.

However, besides its large benefit, radioactive application also has radiation hazard to the workers, the public, and the environment. Radioactive waste is defined as any radioactive material and any material as well as equipment that has been contaminated by radioactive material or becomes radioactive due to the operation of a nuclear installation and cannot further be used. Based on the potential dangers that can be caused, the radioactive waste need to get a proper management for to endanger people and the environment.

At the present time, the main legal framework of radioactive waste management in Indonesia is the Act no. 10 Year 1997 on Nuclear Energy, the Government Regulation No.. 27 Year 2002 on Radioactive Waste Management, the Government Regulation No. 26 Year 2002 on Safety of Transport of Radioactive Materials, and the others.

Regarding to the regulation the Radioactive Waste Technology Center (RWTC - NNEA) is the centralized for management radioactive generating for all Indonesian areas.

Transportation of Radioactive Waste Into RWTC

There are two regulations on transportation of radioactive waste. The Government Regulation No. 26 Year 2002 on Safety of Transport of Radioactive Materials and the Decree of the Head of Nuclear Energy Regulatory Agency (BAPETEN) No. 04/Ka-BAPETEN/V-99 on Safety Conditions for Transportation of Radioactive Substances. Transportation of radioactive materials is defined as the movement of radioactive materials from one place to another through a public transportation line using vehicle/transporter by land, water or air. There are four parties involved on radioactive waste transportation, every party has an obligation and responsibility for the implementation of radioactive materials transportation safely and secure. They are consignor (waste producer), Carrier, Consignee (RWTC), and Regulator (BAPETEN).

Some important things related to the transport of radioactive waste shall be considered :

1. The transportation of radioactive waste only be done if the both consignor and consignee has the license of utilization on nuclear energy from BAPETEN.
2. Before transporting has done, the consignor must get an approval letter of radioactive materials transportation from BAPETEN
3. The consignor shall perform in packaging of waste accordance with the type and category packaging..
4. Carrier shall provide signs, labels, and or plaques on the packaging and transport vehicles.

Here is a flow diagram of radioactive waste tansportation procedures from waste producer (WP) to RWTC :

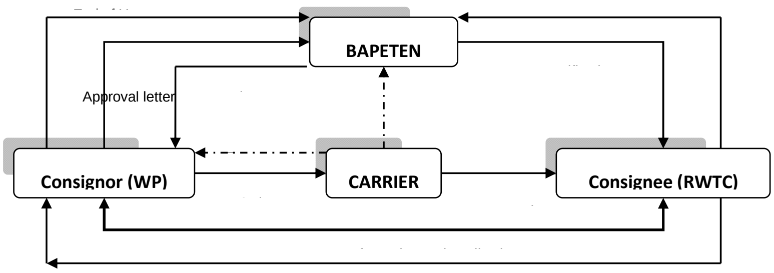


Figure 1. Flow diagram of waste transportation

From the diagram above, the general procedure for radioactive waste transportation to PTLR - BATAN can be explained as follows:

1. Consignor (WP) apply for an transportation approval letter to BAPETEN.
2. After obtaining approval from BAPETEN, radioactive WP requests to RWTC for the management of radioactive waste. RWTC will response associated with radioactive waste management cost. WP then find carrier to transport the radioactive waste to RWTC.
3. RWTC reported periodically to the BAPETEN about waste management activities (especially inventory).

Transportation of radioactive materials is done by high safety standards due to ensure the safety, security, tranquility, and health workers, the public and the environment during activity. In order to achieve safety objective, the consignor and consignee must apply safety principles i.e.:

1. During transportation, the radioactive substances do not leave from container in both normal and accident conditions.
2. Radiation exposure at packaging surface was not upper than safe limits
3. In the case of the transport of nuclear material, it must be in subcritical condition.
4. The heat generated by radioactive substances should be removed completely.

Radioactive Waste Management at RWTC

Based on its form, radioactive waste is managed by RWTC can be classified into liquid, semi-liquid, solid, and spent nuclear fuel. RWTC - NNEA as the executing agency for radioactive waste management in Indonesia is responsible for the management of radioactive waste involved to be processed, stored. RWTC has a vision to become a national center for radioactive waste management services and development of technology on environmental safety and marine radioecology. To realize the vision and mission, RWTC is equipped with equipment and supporting facilities.

The management of radioactive waste in RWTC can be summarized in the Figure 2.

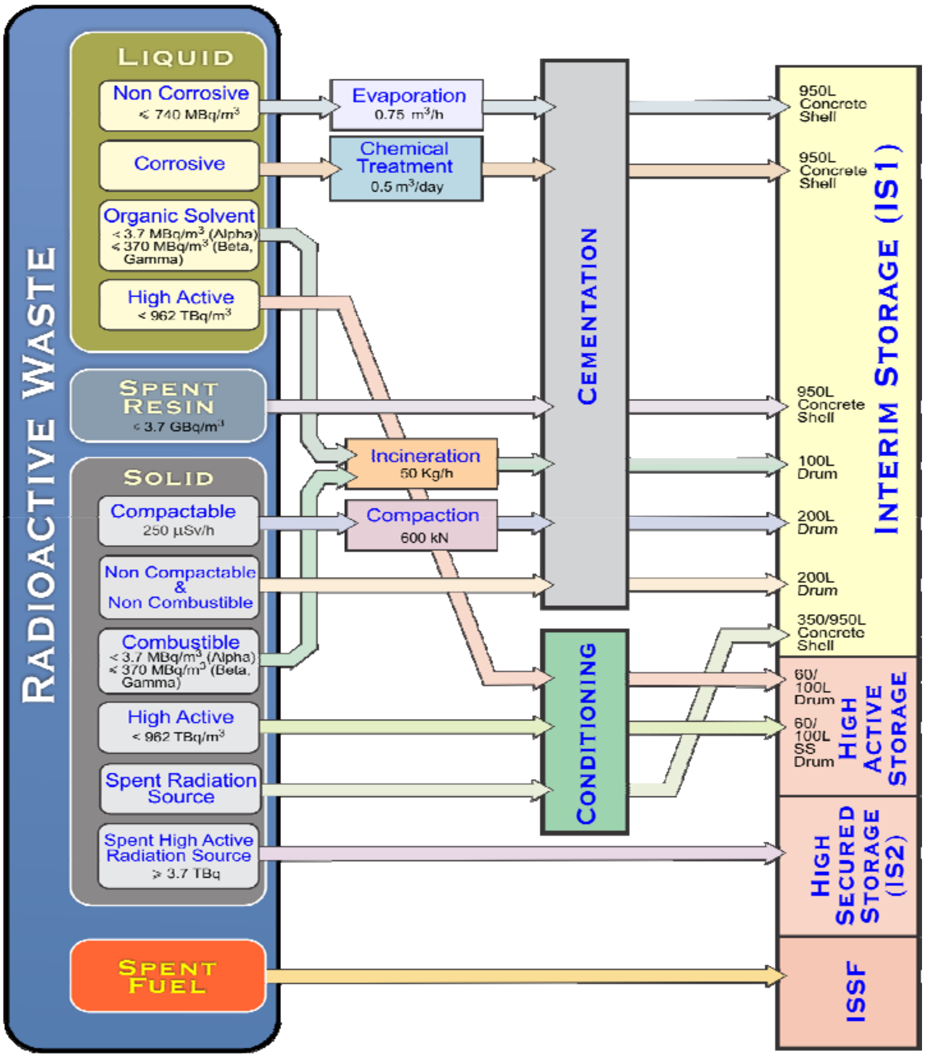


Figure 2. Flow diagram of radioactive waste processing

Liquid radioactive waste management

Liquid radioactive waste is classified into organic and inorganic. For example Organic liquid radioactive waste are Tributhyl Phosphate (TBP), kerosene, and other mixed organic solvents. Organic liquid is treated using incinerator. Flue gas from incineration process is filtered through HEPA filter and then scrubbed using NaOH for neutralization. While the radio nuclides concentrated in the ash, and then further immobilized in a steel drum volume of 100 liter using cement matrix.

Non corrosive inorganic liquid radioactive waste is processed by evaporator to produce distillate and concentrate. The concentrate is then immobilized in a 950 liter concrete shell using cement matrix. Capacity of evaporator unit is 0.75 m^3/hr. While corrosive liquid radioactive waste is treated by coagulation-flocculation technique. Sludge treatment outcomes of chemical Treatment unit is immobilized in 950 liter concrete shell size using cement matrix.

Semi-liquid radioactive waste management

A semi-liquid radioactive waste is mainly spent resin from 30 MW Multi Purpose Reactor. The spent resin is immobilized in a 950 liter concrete shell using cement matrix. Further concrete shells are stored in Interim Storage.

Solid and contaminated material radioactive waste

In general, solid radioactive wastes are classified into burnable (combustible), compactible and uncombustible uncompactible. Combustible solid radioactive waste such as paper, wood, contaminated clothing was processed using incinerator. The capacity incinerator unit is 50 kg / hr. Effluent of incinerator is processed by filtering using HEPA filter and then scrubbing for neutralization in washing coloumn. While the remaining radionuclides is concentrated in ash, further the ash is immobilized in a 100 liter mild steel drum using cement matrix.

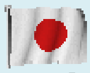
The compactible solid radioactive waste such as cans, glass, soft metal, and plastic, was packed in a 100 liter shell drum. A several the packed waste is compressed into a 200 liter using compactor with hydraulic force 600 kN. And then immobilized by cement matrix. An uncombustible uncompactible solid radioactive waste such as soil, sludge, iron and other hard metals was packed in q 100 liter drum. Furthermore, a 100 liter shell drum is inserted into the a 200 liter shell drum and immobilized using cement matrix. Finally, treated waste is store at interim storage building.

Disused Sealed Radioactive Sources (DSRS) management

Spent sealed radioactive sources shall be managed as radioactive waste. There are two options for the management of DSRS, which are returned to the country of origin (re-export), or are transfered to RWTC. At RWTC, DSRS is grouped by similarity of radio nuclides type, then was conditioned on a 200 liter shell drum, 350 liter concrete shell, or 950 liter concrete shell depend on the dimensions of each DSRS. The conditioned DSRS is stored in Interim Storage Building.

Management of spent fuel

Presently, RWTC manages spent nuclear fuel from GA Siwabessy Multipurpose Reactor. Spent nuclear fuel after taken from the reactor is stored at the reactor storage pool for initial cooling as long as 100 days to reduce decay heat and activity, then transferred to Interim Storage for Spent Fuel (ISSF).



Japan

Dr. Shoji Futasukawa
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The influence on radiation handling establishments of the Great East Japan Earthquake

1. Introduction

An observation earthquake biggest (Mw.9.0) in history around Japan which assumed the bottom of the sea of 130km from the coast was generated on March 11, 2011. The maximum seismic intensity was 7 and the influence of the earthquake extend to the whole East Japan (the focal region of north-south 500km, East-West 200km). By the earthquake, a huge tsunami more than 20m in height was generated, and crushing damage occurred in the coast of Pacific of the Tohoku district and the Kanto district. The dead person and the missing person caused by the earthquake and tsunami disaster were equal to approximately 20,000 people. In addition, the Tokyo Electric Fukushima First Nuclear Power Plant accident was caused by the huge tsunami. Radioactive materials from the plant were released by environment and extensive areas of the East Japan have been contaminated by radioactive materials. Therefore many beginners measure a radiation using radiation detectors.

Also much radiation handling establishments (institutes and facilities) which have been permitted by MEXT existed in the crushing damage area (about 480). The MEXT investigated with hearing the damage situation of them promptly, but security was confirmed in all institutions and facilities except one facility.

2. Confirmation result of a radiation sources affected by the Great East Japan Earthquake

As for the confirmation contents and the result of the situation of the radioisotope sources which were used in the radioisotope handling establishments of Pacific coastal areas damaged by the Great East Japan Earthquake, following.

(1) About 230 institutes and facilities were located in the area limits more than seismic intensity of 4 and used the radioisotope sources having a big quantity of radioactivity. The security was kept in all institutes and facilities.

(2) About 250 institutes and facilities were located in the area facing the Pacific damaged by the tsunami and used the radioisotope sources having a little quantity of radioactivity. Only one radiation source (Co-60 (2.59MBq) +Cf-252 (1.11MBq), for Moisture-Gauge) in one facility was lost, but the security was kept in other institutes and facilities.

3. Radiation measurement since the Nuclear Power Plant Accident

Many beginners measure radiation using various radiation detectors since the Nuclear Power Plant Accident. Various kinds of domestic and import radiation detectors are supplied. Not domestic radiation detector makers but also domestic other various goods makers make new radiation detectors (survey meter). Also the radiation survey meters which the certifications are not attached of inferior quality are imported.

Because many people performed radiation measurement of the private or public place where nobody had measure so for, some radiation sources under no control were discovered. The radiation sources most were Ra-226 which they were used as luminous paints before laws are established (Table1).

Many NaI(Tl) scintillation detectors and Ge semiconductor detectors are supplied for measurement of radiation materials in soil, food and so on. Consumer Affairs Agency has set 394 NaI(Tl) scintillation detectors in 279-related local government for screening investigation of food contamination. About 400 conventional double Ge semiconductor detectors have been installed (not official data). A lot of standard sources are necessary for the proofreading of these radiation detectors. Table2 shows the numbers of standard sources supplied by JRIA before and after the accident. The number of standard sources after the accident is increased rapidly than one of before the accident. The data also indicate the increase of the number of the radiation detectors.

4. Conclusion

The Great East Japan Earthquake has many influences in various fields. Though it was a great earthquake disaster, the safety of the radiation handling establishments located in the area almost was secured.

Table1. Radiation sources under no control discovered in private or public place since the accident

Date	Place	Nuclide	Form	Handling
2011.10.14.	Private house where a person das not live in.	Ra-226	Dozens of bottles which radiation powder was in, under a floor.	Put it in a lead container and enclose it in a metal can.
2011.11.10.	Private house.	Ra-226 (370Mbq)	Radiation source (3mmφ×20mmL) in a metal can.	No contamination.
2011.11.16.	Private house.	Ra-226 (16kBq)	Radiation materials in a glass tube (5mmφ×50mmL), in a paper box (200mm×20mm×50mm) which was written as luminous paint.	Enclose it in a metal can.
2011.11.24.	The city land.	Ra-226 (370MBq) (555MBq) (1,100MBq)	A radiation source in a lead container (45mmφ×80mmL) and other radiation sources in a metal container (15mmφ×65mmL)	Decontaminated.
2011.12.15.	Private house.	Ra-266 (160kBq)	Radiation powder in a glass tube (10mmφ×50mmL), in a metal can which was written as radium paint.	No contamination.
2011.12.21.	Secondary school.	Ra-226 (100kBq)	Radiation source (5mmφ×250mmL) in a tube (10mmφ×50mmL), in a glass container (30mmφ×70mmL)	No contamination.
2012.01.13.	Public park.	Ra-226 (11,900Bq/kg)	Contaminated soil.	Cover the surface with a plastic sheet, and closed to the public takes a step with a protective fence.
2012.03.09.	Private house.	Ra-226 (90MBq)	Contaminated soil.	Put it in a metal cans.
2012.04.18.	Bicycle maker.	Co-60 (131.4kBq/ basket)	The bicycle with contaminated basket imported. (See Fig.1)	Collection of the sold bicycles (3,200)
2012.11.22.	Super market.	Ra-226 (2GBq)	Contaminated soil. (See Fig.2)	Put it in a metal cans.

Figure1. Same type basket of the contaminated basket

Figure2. A lump of the contaminated soil

Table2. The numbers of standard sources supplied by JRIA

Fiscal year	2010	2011	2012 (till February)
Volume source (9 nuclides)	128	663	294
Aspect source (9 nuclides)	49	35	26
Cs-137 point source	138	834	703
Cs-137 volume source	1	121	203
total	316	1,653	1,226

Thailand

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Experience on the Inter-Regional Workshop on Capture of High Quality

Figure1. Participants of the Workshop at the KIT, Karlsruhe, Germany

The Inter-Regional Workshop on Capture of High Quality Video Materials with Core Users - Part B: Field Video Production was held in Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, during the week of 18-22 March 2013. The participants were nuclear specialists, coming from Algeria, China, Egypt, Indonesia, Kazakhstan, Sri Lanka, Sudan, Tajikistan, Thailand, Ukraine, and Yemen.

The purpose of the workshop was to provide an opportunity for individual organizations that are actively engaged in CONNECT, or in a related IAEA Network, to obtain professional instruction and hands-on training in the art of making short technical videos.

The classroom training in video production technique was centred around an imaginary scenario to dismantle a radioactive component in a decommissioning nuclear Power-plant. The KIT provided a highly realistic (though not genuinely radioactive) environment for practical filming exercises.

By the end of the week, each of the participants had written a script from which they had then shot and edited their own video. So now these nuclear specialists are able to post short technical videos on a shared global educational resource available to anyone involved in decommissioning nuclear power-plants. The next Workshop on Capture of High Quality Video Materials with Core Users will – provisionally - be held in Thailand around November 2013.

What is CONNECT?

CONNECT is a web-based collaboration platform hosted by the IAEA on behalf of its Member States. It provides a gateway for interconnecting existing and planned IAEA networks, increasing the participation of individuals and organizations involved in them, and making available additional sources of information that complement existing training workshops and meetings. CONNECT also provides an e-library of audio-visual material and a data-base of concise, structured summaries of the "lessons learned" from successful and unsuccessful projects.

CONNECT can be accessed on http://nucleus.iaea.org/sites/CONNECT

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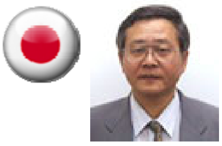

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The FNCA Framework