Archive number	2011-08-10 ID8 ID20 ID21 Radwaste v01.docx
Date	2011-03-30
Rev. Nr.	01 draft
Rev. Date	2011-08-10
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Interfaces

LINAC

ID 8, 20, 21 –

Storage and Transportation of Radioactive Materials, and Radioactive Waste Management

DRAFT

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SUMMARY

This document deals with radioactive waste management, generation, storage, and transportation from the accelerator division point of view.

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1. RADIOACTIVE WASTE MANAGEMENT

Materials removed from the accelerator area will be considered radioactive until proven otherwise. No waste shall be disposed of or recycled without proper examination. The activation levels of a piece of equipment can vary over a wide range, depending on its location in the tunnel, its constituent materials and the exposure time.

As shown in the preliminary radiation protection study [1], metal pieces (magnets, beam pipe, etc) close to the beam at the high-energy end of the accelerator could give off dose rates in excess of 10 μSv/h at one metre distance for almost six months after shutdown. Such pieces cannot be safely handled or stored without precautions, regardless if they are waste or meant for reparation. Time spent working in environments with that high dose rates should be controlled, to keep the accumulated dose below 20 mSv/year.

1.1 Radioactive waste

All solid materials or contained liquids or gases being removed from the accelerator tunnel after some time of operation are considered waste and should be disposed of unless there is a reasonable chance that they will be re-used.

Releases of radioactive liquids and gases are treated in another document (ID 24).

1.1.1 Waste materials

At SNS the largest portion of the generated waste from the accelerator are bottles of ion exchange resins that are exchanged regularly. As ESS will have a significantly lower demand on cooling water without the accumulator ring and without warm quadrupoles (no water-cooling in the accelerator prior to the HEBT), there will be less need for the ion exchange resin bottles. Additionally, one could expect some flanges, pieces of beam pipe, magnets, cavities, tools, electronics, and possibly plastic hoses (if any cooling circuits will not be pipe-based) to be replaced from time to time. Rags, wipes, and protective equipment are examples of consumables that will be wasted after one or a few uses. A rough estimate of expected wastes is given in **Table 1**.

Table 1: *Expected wastes from the accelerator*

DESCRIPTION	AMOUNT	TYPE
Ion exchange resins	<~ 10 bottles/year	LLW
PPE	~ 250 l/year	LLW
Solid debris	~ 1 m^3/year	LLW/mixed

1.1.2 Waste flow

All materials removed from the accelerator tunnel must be treated as radioactive, and should be handled with caution. Good practice would be to have a shielded waste treatment area in direct connection with the accelerator tunnel, where waste could be surveyed, sorted and treated before transportation to other storage locations. The ion source, while emitting prompt x-ray radiation, should not contribute any activated waste.

Some low level waste could possibly be deposited in communal waste processing plants, given that it can be packaged according to the rules set by the Swedish Radiation Authority (SSM) [2]. According to those rules a facility is allowed to deposit a total of 10 ALI_{min} (Annual Limit on Intake) per month, with a maximum of 1 ALI_{min} per container and less than 5 μGy/h dose from the surface. Another possibility for low-level waste is shipping to external caretakers (e.g. Studsvik Nuclear AB [3]), who are specialised in radioactive waste treatment. They can incinerate or melt waste for maximum space saving and recycling and the remains might be deposited in their repositories.

1.1.3 Treatment

In order to save space the waste can be volume decreased (cut and/or compressed) and packaged in the local treatment area prior to being put in storage or shipped offsite, as far as this can be safely done. With proper remote handling capability most waste could be taken care of. However, waste that shows too high radiation levels needs to be stored for some time so that the radiation can decay to acceptable limits even before being treated. A waste management plan for ESS will eventually be established.

1.1.4 Storage of radioactive materials

Since both accelerator and target will generate radioactive waste, there are several options as to how the waste can be stored on site.

There could be a common waste facility, accessible from both target building and accelerator tunnel in a separate building where all radioactive waste can be taken with no need for outside transport. An entrance from the outside facilitates accessibility for transportation off-site. A drawback of this solution would be that there would have to be an entrance to the high-energy part of the tunnel and that all materials would have to be taken through this part, resulting in unnecessary exposure to personnel.

Another solution could be to have separate storage areas for accelerator and target, located close to the entrance of each respective facility. The drawbacks are increased cost and use of space.

Thirdly, there could be a common storage and treatment facility not accessible from one or both of the target building and accelerator tunnel. This then requires outdoor transportation of radioactive waste which, in turn, requires special precautions. Furthermore, a small area for transport preparation is necessary close to the entrance to whichever facility is not in contact with the storage.

Duration of the storage is another variable to be considered. There are several options for the storage building concept, depending on how long the radioactive waste remains on site.

Option one: mid-term storage on site, where activated waste could be kept for several years - up to a few decades - would give time for radioactivity to decay. This will allow to use less stringent handling procedures when shipping the waste off-site. Part of the waste might even be released for unmonitored handling. This would leave less waste to be send for final long-term deposit.

Option two: getting rid of as much waste as possible as fast as possible to minimise the need of on-site storage. This would necessitate handling and shipping of waste with higher activation levels with the associated cost and risk.

In any case, waste storage buildings must be limited access areas. They must be made of concrete and should be located underground for radiation protection.

Studies need to be performed to determine the extent of shielding necessary.

Long-term storage on site is undesired. Negotiations for deposition of long-lived waste in the nuclear power industries (SKB) midrange depositories could be an option, if there's any space available in those.

1.1.5 Transportation

Any and all transportation of radioactive waste or materials must follow regulations and strict protocol to protect both personnel and the general public. Proper packaging must be used, so that the radiation from the outer surface stays below the applicable limits. This makes on-site transportation to a stand-alone building quite cumbersome, particularly if the site were open to the public and the strictest limits were to apply.

1.1.6 Expected waste generation

A rough estimate of the amount of waste generated from the facility can be done by drawing on experience at SNS. ESS should not generate significantly more waste, but will likely produce waste with higher activation. A list of all radioactive waste generated at SNS is given in Table 2.

Table 2: *List of rad waste generated as SNS. (A B-25 container is 96 ft^3 ≈ 2.72 m^3.)*

Date	Container Type	Haz, LLW or Mixed	Waste Description	Status
12/17/09	B-25 (96 CF)	Mixed	Low Mercury - Mixed waste contaminated debris (D009)	Shipped by LWS
12/18/09	B-25	LLW	Standard sized debris - Metal, plexiglass from target wastes	2109 Complete. Submitted to WA. LWS will Ship.
9/22/08	55 GALLON	LLW	View screen, wiring, and miscellaneous solid	Shipped by ES

Date	Container Type	Haz, LLW or Mixed	Waste Description	Status
	DRUM		items. Items consist of aluminum, carbon steel, plastic, and copper.	
9/22/08	30 GALLON DRUM	LLW	Cable spreader tool, made of carbon steel and plastic	Shipped by ES
9/22/08	55 GALLON DRUM	LLW	Stainless steal parts, carbon steel parts, and PPE associated with the water system.	Shipped by ES
9/22/08	55 GALLON DRUM	LLW	Stainless steal parts, carbon steel parts, and PPE associated with the water system.	Shipped by ES
9/22/08	55 GALLON DRUM	LLW	PPE associated with the water system.	2109 Complete. Isotopes Exceed Profile limit. Revised Profile needed. Trotter working w/ES on profile.
9/22/08	55 GALLON DRUM	LLW	PPE associated with the water system and mercury system (no mercury is present).	Shipped by ES
9/22/08	55 GALLON DRUM	LLW	Stainless steal parts, carbon steel parts, and PPE (>90%) associated with the water system.	Shipped by ES
9/22/08	55 GALLON DRUM	LLW	3 empty mercury catch - pots, constructed of stainless steel.Once held liquid elemental mercury. No visible mercury is present on the exterior of the pots. Meets the definition of a "RCRA Empty" container per 40 CFR 261.7 (b)(1).	Shipped by ES
9/22/08	55 GALLON DRUM	LLW	PPE and a moisture sensor associated with the water system.	Shipped by ES
7/9/09	55 GALLON DRUM	Mixed	Four plastic bags of mercury contaminated PPE from cleaning activated mercury targets from LANL.	Shipped by LWS
7/9/09	55 GALLON	Mixed	Four plastic bags of mercury contaminated PPE from	Shipped by LWS

Date	Container Type	Haz, LLW or Mixed	Waste Description	Status
	DRUM		cleaning activated mercury targets from LANL.	
4/9/09	16.5 Gallon Drum	Mixed	8 smoke detectors in a plastic bag.Each smoke detector contains a 1 uCi Am-241 source (8 uCi total). Contains solder.	Shipped by LWS
3/25/09	2.5 Gallon Bucket	Mixed	Spent acetone (~50%) and toluene (~50%) used as a solvent, 100% before use. Contains trace tritium and C14 from neutron activation.	Shipped by LWS
3/25/09	2.5 Gallon Bucket	LLW	Water (~50%) with Perflourohexane (~50%) and Purfluorethane (trace). RPK-01. Contains trace tritium and C14 from neutron activation.	Shipped by LWS
2/12/10	Target Liner in a TN-RAM Cask	LLW	1st Target Module from the SNS	Shipped by ES
4/23/10	B-25	LLW	LINAC Resin Bottles - 12 large bottles and 4 small bottles.	Shipped by ES
4/23/10	B-25	LLW	LINAC Resin Bottles - 13 large bottles.	Shipped by ES
4/23/10	B-25	LLW	LINAC Resin Bottles - 13 large bottles.	Shipped by ES
4/23/10	B-25	LLW	LINAC Resin Bottles - 7 large bottles.	Shipped by ES
4/23/10	B-25	LLW	LINAC Resin Bottles - 7 large bottles.	Shipped by ES
7/10/10	30 GALLON DRUM	LLW	Spent Molecular sieve from MOTS. TB-08	Characterization Data Complete, 2109 Incomplete.
7/7/10	B-25	Mixed	Solid debris containing RCRA metals (Lead, cadmium, Chromium, Arsenic, Barium, Selenium, and Silver). Waste in the box was characterized using 3 separate WCCs. See Attaches Spreadsheet for details on each item. MPK-03. UHCs =	2109 complete. Turned into LWS on 8/3/10. Shipped by LWS.

Date	Container Type	Haz, LLW or Mixed	Waste Description	Status
			Antimony	
7/7/10	B-25	LLW	Solid debris (Paper, Plastic Cardboard, Non- regulated (RCRA/DOT) metal alloy samples). Also contains incidental amounts of Drierite (calcium sulfate).	2109 complete. Turned into LWS on 8/4/10
7/12/10	30 GALLON DRUM	LLW	PPE, Plastic, Rubber, Gloves and Hg Analyzer (no mercury present from Cask Cart Room, Counting counting Station and TA-148 (Mercury System). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	PPE, Cloth, Massalin, Respirator filters, lock, from Transfer Bay and Manipulator gallery (Mercury System Isotopes). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	PPE, Cloth, plastic, Valve (stainless steel), etc. (Mercury System and Water System Isotopes). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	PPE, Cloth, plastic, smears, etc. (Mercury System Isotopes). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	Proton Beam Window piping and metal cover plate. (Mercury System Isotopes). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	PPE, Cloth, plastic, etc. (Mercury System and Water System Isotopes). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	PPE, Cloth, plastic, etc. (Mercury System Isotopes). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.

Date	Container Type	Haz, LLW or Mixed	Waste Description	Status
7/12/10	55 GALLON DRUM	LLW	PPE, Cloth, plastic, etc. (Mercury System Isotopes). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	PPE, Cloth, plastic, Manipulator boots, copper oxide reactor, etc. (Mercury System). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	Molecular Seive from MOTS (Mercury System). See Attached Spreadsheet for details.	Characterization Data Complete, 2109 Incomplete.
7/12/10	55 GALLON DRUM	LLW	PPE, Cloth, plastic, Manipulator boots, copper oxide reactor, etc. (Mercury System). See Attached Spreadsheet for details.	

Most of the low level waste gives off a dose rate in the range 50-100 μSv/h by contact. Something to watch out for is activated heavy metal that might have to be considered mixed waste.

1.1.7 Recycling

Lowly activated metals can be recycled in specialised plants, to be used for instance in radiation shielding. That option should be chosen for disposing of applicable materials.

2. REFERENCES

[1] Ene, *Radioprotection studies for the ESS superconducting linear accelerator Preliminary estimates,* 2010

[2] Strandman, *Strålsäkerhetsmyndighetens författningssamling 2008:50,* ISSN 2000-0987, 2009

[3] www.studsvik.se

[4] Taylor, *Private communications,* 2010