

TREATMENT AND STORAGE OF LOW AND INTERMEDIATE LEVEL WASTE AT A NUCLEAR POWER PLANT

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Authorisation

By virtue of the below acts and regulations, the Radiation and Nuclear Safety Authority (STUK) issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards:

- Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987)
- Section 29 of the Government Resolution (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Government Resolution (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Government Resolution (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Government Resolution (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Government Resolution (478/1999) on the Safety of Disposal of Spent Nuclear Fuel.

Rules for application

The publication of a YVL guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear power plants, or to those under construction, and to licensees' operational activities. The guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into account section 27 of the Government Resolution (395/1991), which prescribes that *for further safety enhancement, action shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.*

If deviations are made from the requirements of the YVL guides, STUK shall be presented with some other acceptable procedure or solution by which the safety level set forth in the YVL guides is achieved.

1 General

Low and intermediate level radioactive waste from the operation of a nuclear power plant, hereafter called NPP-LILW, is generated from the treatment of radioactive liquids and gases and from repair and maintenance works in the controlled areas. NPP-LILW does not include spent nuclear fuel, waste from decommissioning of a NPP or liquid and gaseous discharges from a NPP. Most of NPP-LILW contains radioactive substances to such extent that it must be properly conditioned, stored and disposed of.

In accordance with Section 116 of the Nuclear Energy Decree, *the Radiation and Nuclear Safety Authority (STUK) controls that measures included in nuclear waste management and their preparation are carried out in accordance with the pertinent rules and regulations and the decisions issued by virtue of Section 28 of the Nuclear Energy Act. In addition, STUK must confirm how the licence-holder with a waste management obligation should keep records of the nuclear waste generated by the use of nuclear energy.*

This Guide gives the general principles that shall be followed when planning and implementing the treatment, storage, transfer, activity monitoring and record-keeping of NPP-LILW. The guide does not include any detailed design criteria for treatment and storage facilities. Clearance from regulatory control of waste originating from nuclear facilities is addressed in Guide YVL 8.2.

This Guide also addresses, where applicable, to the treatment and storage of state-owned small-user waste subject to the provisions of the Radiation Act.

2 General safety principles

The provisions given in the Government Resolution (395/1991), where applicable (Sections 3–11, 13, 19–21, 23–27), and in the Government Resolutions (396/1991) and (397/1991) address also treatment and storage of NPP-LILW.

In accordance with Guide YVL 1.0, a NPP shall have adequate facilities for treatment and storage of low and intermediate level waste. Such systems shall be designed as are needed for the

safe treatment and transfer of wastes and for the monitoring of the type and quantity of their radioactive content.

The treatment and storage facilities for NPP-LILW are generally part of the controlled area of the NPP and their radiation protection arrangements shall be carried out in accordance with Guides YVL 7.9, YVL 7.11 and YVL 7.18. If the risk of external exposure or spread of contamination arising from the waste is small, the treatment and storage facility may be exceptionally located also in the supervised area of the NPP. Guides YVL 4.3 and YVL 5.5, where applicable, shall be adopted as a design basis for structural and operational fire protection and ventilation systems of NPP-LILW treatment and storage facilities.

The licensee of a NPP shall establish a generic plan for the management of NPP-LILW, where the following safety principles are considered:

- Generation of waste shall be limited i.a. by proper planning of repair and maintenance works and by means of decontamination, clearance and volume reduction practices.
- Waste shall be appropriately segregated and categorised with regard to its further treatment, storage and disposal method.
- Waste that can be disposed of, shall be conditioned and packed in accordance with the disposal specifications.
- Waste that cannot yet be disposed of, shall be conditioned and stored in an appropriate and safe manner until disposal.
- Radiation exposure of workers due to waste treatment shall be limited, spread of radioactive substances inside the plant or into the environment shall be prevented and preparedness for transient and accident situations shall be maintained.
- Radioactive and other properties of wastes shall be characterised and recorded so that the necessary information of waste packages to be disposed of or of waste for extended storage are available.
- Waste management shall be grounded on a management or quality assurance system; important issues are e.g. clear definition of responsibilities, working up instructions for var-

ious waste management procedures and continuous improvement of waste management practices motivated by technical progress or observed faults and deficiencies.

3 Segregation, storage, treatment and packaging

3.1 Wet waste

As a rule, wastes that are markedly different by chemical composition, activity concentration or nuclide content, shall be treated separately if they arise in significant quantities in comparison with the overall waste amounts. Waste types that are generated only in small amounts, can be mixed with other waste, unless it complicates the further treatment of waste or substantially degrades the properties of the final waste product.

The storage capacity of wet wastes shall be adequate with respect to a single container damage or a failure of treatment facility. In timing the waste treatment activities, ageing of waste shall be considered in order to decrease exposures to or discharges of short-lived radioactive substances.

In storing wet waste, attention shall be paid to the prevention of phenomena adverse to safety. Such phenomena are, e.g. corrosion of containers, sedimentation or crystallisation that may complicate further treatment of the waste, and formation of combustible or volatile compounds in containers. Appropriate arrangements shall be provided for the detection and recovery of container leakages.

The choice of the treatment and conditioning methods for wet waste shall be based on the consideration of requirements imposed by operational safety and long-term safety of disposed waste. One option is to solidify wet waste, i.e. to mix it with a strong or tough binding agent to form uniform, homogenous products. Alternatively wet waste can be closed in a container as dried or with a suitable absorbing medium.

To ensure the safety of the treatment process and the quality of conditioned wastes, operating instructions and restrictions shall be specified. These may concern e.g. relevant process parameters and process control, mixing ratios

and concentrations of additives, fire protection, sampling and other process control measures and the quantities of radioactive substances in conditioned waste.

3.2 Dry waste

To limit waste quantities generated in controlled areas, unnecessary objects and materials shall not be brought there. Whenever feasible, working processes that create little or easily manageable wastes shall be utilised. Waste from repair and maintenance works shall be gathered and removed from the process rooms without delay and, whenever practicable, sorted already at the collection point in a way that facilitates the further waste treatment. During collection of waste, such items which has an exceptional nuclide content, shall be separated and marked.

Extended storage of flammable waste, e.g. waste in sacks, shall be avoided. In order to reduce radiation exposure and to limit the potential for radioactive releases in case of fire, sacks with high dose rates shall be stored separately in a room that provides radiation shielding and shall be treated further as soon as possible. In planning the storage and treatment of dry waste, the potential for self-ignition of the waste shall be considered.

For interim storage or disposal, dry waste shall be packed into containers which facilitate waste transfers, prevent the spread of radioactive contamination and diminish the fire risk of waste. In packing the waste, one shall aim at volume reduction e.g. by means of a sorting box, compressor or segmentation facility. The spread of radioactive substances shall be prevented by providing the treatment facilities with outlet air suction-filtering devices or by utilising a treatment method that does not create dust.

In the treatment rooms for dry waste, the external dose rate, the radioactive surface contamination and the airborne radioactive concentration shall, as a rule, be kept within the limits of the lowest radiation level category (YVL 7.9).

Unnecessary staying in the treatment and storage facilities for dry waste shall be prevented by keeping the rooms locked and by limiting access to them.

3.3 Other waste

Initial storage of activated metal waste in water pools or in other rooms providing sufficient radiation shielding is appropriate in order to reduce the activity level of waste. During segmentation and packaging of activated metal waste, due consideration shall be given to the prevention of spread of contamination and to ensuring the radiation protection of workers, taking account of both external and internal exposure.

Whenever decontamination does not cause significant occupational exposure, contaminated metal objects shall be cleaned of easily removable radioactive substances in order to clear them from regulatory control or to reduce the risk of spread of radioactive contamination. Volume reduction of metal scrap is often required when packaging for storage or disposal. If the immediate segmentation of the metal object is not appropriate it must be packed for interim storage by closing the ends of pipes and apertures of components that are internally contaminated. Furthermore, metal scrap must be covered with plastics as necessary.

Containers for temporary storage of contaminated oils, chemicals and other liquids shall be corrosion resistant and also otherwise fit-to-purpose. This kind of easily spreading waste shall not be stored for several years, unless the aim is to age the waste to be cleared from regulatory control. In storing flammable wastes, fire protection shall be of particular concern. Contaminated liquids that cannot be decontaminated below clearance levels shall be solidified, absorbed in a suitable medium or closed as such into a container with adequate strength and corrosion resistance.

4 Transfer and storage of waste packages

The requirements for the storage of waste are principally determined on the basis of the activity of the waste packages. If wastes of different activity levels are stored together, the requirements to be applied are those of the most active waste types.

The transfer of waste packages in a storage facility for intermediate level waste shall, as a rule, be done by remote control. In a storage for low level waste, even transfer operations close to the waste packages may be done. In that case, the radiation protection arrangements shall be designed so that exposure of workers will be small. In designing the radiation protection arrangements for the transfer of waste packages between different parts of a NPP and at the outdoor areas of the plant, the potential exposure of individuals in the proximity of the transfer route shall be considered. A preferred option is to perform transfers periodically and with several loads at a time so that centralised radiation protection arrangements can be implemented.

The radiation dose rates and concentrations of radioactive substances outside the walls of the storage building and outside the controlled area shall not exceed the values given in Guide YVL 7.9. Besides that, the limitations concerning the exposure of off-site population shall be observed (Guide YVL 7.1).

The conditions in a waste storage shall be designed so that waste packages are not substantially degraded while in the storage. For this purpose, limitations concerning air humidity and temperature variations in the storage may be needed. Follow-up of the quality of waste packages in a storage and the removal substantially degraded waste packages from the storage shall be feasible.

Appropriate fire protection arrangements (fire compartments, fire detection and extinguishing arrangements) for the transfer and storage of waste packages shall exist. A storage with large fire loads shall be equipped with a fixed fire extinguishing system. Also other arrangements for fire extinguishing shall be designed so that unnecessary exposure of the fire-fighting personnel is avoided.

For protection against sabotage, a separate interim storage shall be surrounded with a fence and provided with other guarding arrangements. The number of people who have access to the storage shall be kept low.

5 Activity monitoring and record-keeping

The information to be specified and recorded of untreated waste, to be stored for several years, shall include at least

- waste type
- amount, expressed e.g. in cubic metres, kilograms, linear metres or as number of items
- activity inventory data by using appropriate methods (waste origin data, sampling, gamma spectrometry, dose rate monitoring calculational method)
- special characteristics, such as exceptional nuclide content, flammability or classification as nuclear material
- location in a storage room.

Identification of individual waste packages shall be possible on the basis on markings. Prior to the transfer for extended storage or disposal, the content of the most important nuclides in waste packages shall be determined. This activity monitoring can be based on the following methods:

- The gamma activity of dry waste is determined by making gamma spectrometric measurements of waste packages.
- The gamma activity of wet waste is determined either by analysing samples prior to conditioning and packaging or by making gamma spectrometric measurements of conditioned waste packages.
- The activity of other waste types is determined on the basis of the origin of waste and by using the most suitable ones of the following methods: analysis of samples, gamma spectrometric measurements, dose rate monitoring, calculational methods.
- The activities of significant pure beta or alpha emitters are estimated by means of indirect methods, e.g. they can be related to the activities of suitable gamma emitters by adopting sufficient safety margins. Major fuel leakages shall be considered in the determination of the proportionality factors.

Activity monitoring need to be carried out for a statistically representative fraction of waste packages having similar origin and nuclide con-

tent. In that case, the nuclide-specific activities of other waste packages can be calculated on the basis of package-specific dose rates and the measured nuclide contents. Adequate safety margins shall be adopted in the calculations.

Waste surface contamination measurements are not generally required for solidified waste packages prior to their transfer into a storage. Contamination shall mainly be prevented by keeping the treatment and storage rooms clean. Potential surface contamination of packages containing dry waste shall be checked by measuring a statistically representative number of the packages.

The records of waste packages transferred into a storage shall include at least

- waste type and amount of waste
- treatment and packing method and year
- identification of waste package and its storage location
- activities of dominant nuclides, potential surface contamination and the date for activity determination
- classification as nuclear material or other exceptional content
- other information required for wastes to be disposed of (Guide YVL 8.1).

The information of wastes subject to interim storage shall be reported in accordance with Guide YVL 1.5.

6 Safety assessment

The safety assessments shall include analyses of potential radiation impacts from treatment and storage of NPP-LILW on the workforce and the public as a consequence of normal operation, operational transients and accident situations. The analyses included in the Preliminary Safety Analysis Report aim at demonstrating by experience, design basis considerations or by simplistic calculations that the planned waste management practices meet the safety goals. The Final Safety Analysis Report shall include a more detailed evaluation of the radioactive releases and exposures due to various waste management practices. An alternative way is to give evidence that they will remain insignificant due to the safety systems.

Analyses of the radiation impacts from the normal operation shall be based on the planned NPP-LILW management practices and the arising radiation exposure shall be included in the optimisation and dose limitation analyses for the whole NPP (Government Resolution (395/1991), Sections 7–9).

As a consequence of on-site management of NPP-LILW, the radiation exposure of individuals in the public arising from anticipated operational transients, shall remain below the constraint given in Government Resolution (395/1991), Section 10, (dose commitment of 0,1 mSv in any period of one year) and that arising from postulated accidents occurring at the NPP site shall remain below the constraint given in Government Resolution (395/1991), Section 11, (dose commitment of 5 mSv in any period of one year). The anticipated operational transients and postulated accidents to be included in the analyses shall be selected representatively, taking into account the waste management practices and the safety features of the management facilities.

Typical anticipated operational transients related to management of NPP-LILW include

- consequences of the failure of a non-redundant system (e.g. leakage of wet waste, loss of underpressure in process room, loss of power supply, drop of waste package or other transfer failure)
- fire of flammable waste (e.g. untreated dry waste).

Typical postulated accidents related to management of NPP-LILW include

- consequences of a failure of a redundant system or a common failure of two non-redundant systems
- fire of non-flammable waste (e.g. wet waste or packed waste)
- design basis earthquake (Guide YVL 2.6)
- airplane crash.

7 Regulatory control

STUK regulates the facilities, systems and components used for the treatment and storage of NPP-LILW, and the operation of such facilities, in accordance with Guide YVL 1.1, where applicable.

Waste management facilities and systems that are built as a part of a new NPP are dealt with as parts of the plant, unless a waste management facility is to be considered as a separate nuclear facility intended for extensive handling or storage of nuclear wastes, as referred to in Section 6 of the Nuclear Energy Decree. The documents that relate to waste management facilities or systems to be built in an operating NPP can be submitted as amendments of or supplements to the corresponding documents of the plant, if the construction of the facility or system can be done by virtue of the operating licence of the plant.

A construction license application for a NPP shall be appended by a description of applicant's plans and available methods for arranging nuclear waste management (Nuclear Energy Decree, Section 32). The generic waste management plan referred in Section 2 of this Guide shall be included in the Final Safety Analysis Report, appended in the operating licence application, or shall be submitted for STUK's approval in other way prior to the commissioning of the NPP. The operating instructions concerning waste treatment, storage and record-keeping shall be submitted to STUK for information.

Whenever applicable, the inspection procedures to be utilised in pre-inspections, supervision of manufacture, construction inspections and commissioning inspections, are the same as are used in the inspection of the comparable systems, structures and components of the NPP (Guide YVL 2.0). The safety classification of systems, structures and components (Guide YVL 2.1), as well as the applicable inspection procedures, are chosen on the basis of their importance to the safety of waste treatment and storage and to the long-term properties of waste packages.

Test operation shall be performed for systems that may have significant influence on radiation safety and on the long-term properties of waste packages and for equipment of which adequate operational experience is not available. The test operation programme shall be submitted to STUK for approval. The test operation shall be performed in accordance with Guide YVL 2.5, where applicable.

For facilities intended for extensive handling or storage of nuclear waste, Technical Specifications

shall be drawn up and submitted to STUK for approval. The Technical Specifications of a waste management facility or a system attached to an operating NPP shall be included in the respective document of the whole plant.

The licensee shall request STUK to inspect and give a commissioning approval (Nuclear Energy Act, Section 20) for new facilities intended for extensive handling or storage of nuclear waste. The request shall be made not later than one month before the planned commissioning date. STUK may call for a similar commissioning approval for such extensive modifications of waste treatment or storage practices, which will be made by virtue of the operating licence of the NPP.

STUK performs inspections related to operation of NPP-LILW facilities in accordance with a separate inspection programme. STUK or persons authorised by STUK make also extra inspections as required.

8 Definitions

Nuclear waste

refers, in accordance with Section 3 of the Nuclear Energy Act, to radioactive waste generated in connection with or as a result of the use of nuclear energy and to materials, objects and structures which, having become radioactive in connection with or as a result of the use of nuclear energy and having been removed from use, require special action because of the danger arising from their radioactivity.

NPP-LILW (low and intermediate level waste from the operation of nuclear power plant)

refers to low and intermediate level waste in solid or liquid form, arising from the cleanup of liquids or gases at a NPP or from repair and maintenance works at the controlled areas of a NPP.

On the basis of activity, NPP-LILW is grouped into the following activity categories:

- **Low level waste** contains so little radioactivity that it can be treated without any special radiation protection arrangements. The activity concentration in waste is then not more than 1 MBq/kg, as a rule.
- **Intermediate level waste** contains radioactivity to the extent that effective radiation protection arrangements are needed when it is treated. The activity concentration in the waste is then from 1 MBq/kg to 10 GBq/kg, as a rule.

On the basis of origin, physical form and way of treatment, the following NPP-LILW types can be identified:

- **Untreated waste** can be stored at the plant but it has not been conditioned and packed into its final form. Such waste is e.g. wet waste stored in a container, dry waste collected into sacks and unpacked scrap metal.
- **Packed waste** has been conditioned and enclosed into a container for storage or disposal. **Waste package** means the entity formed by the waste product and the surrounding container.
- **Wet waste** consists of radioactive concentrates, such as spent ion exchange resins, evaporator bottoms, corrosion sludges, charcoal sludges and decontamination slurries, arising mainly from the water purification system of a nuclear power plant. Wet waste is of intermediate or low level.
- **Dry waste** consists of trash (paper, plastics, insulation material, cloth, wood, small metal pieces and ventilation filters) arising mainly from repair and maintenance work. On the basis of its material composition, dry waste is often divided into **combustible** and **incombustible** or **compressible** and **incompressible** waste. Dry waste is mainly of low level.

- **Contaminated metal** waste consists of large worn-out equipment or machinery with radioactive contamination on surfaces. It is mainly of low level.
- **Activated metal waste** consists of components and devices that have been removed from inside the reactor vessel and which have been activated by neutron flux. It emits initially very intense radiation but when packed for interim storage or disposal, it can be classified as intermediate level waste.

Small-user waste

refers to radioactive such waste originating from medical, industrial or research facilities which is subject to radiation legislation (not to nuclear energy legislation). Most of small user waste items are spent sealed sources.

9 Bibliography

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