Treatment and storage of radioactive waste at a nuclear power plant

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Authorisation

By virtue of section 55, second paragraph, point 3 of the Nuclear Energy Act (990/87) and section 29 of the Council of State Decision (395/91) on General Regulations for the Safety of Nuclear Power Plants, the Finnish Centre for Radiation and Nuclear Safety (STUK) issues detailed regulations concerning the safety of nuclear power plants.

YVL Guides are rules an individual licensee or any other organisation concerned shall comply with, unless STUK has been presented with some other acceptable procedure or solution by which the safety level set forth in the YVL Guides is achieved. This Guide does not alter STUK's decisions which were made before the entry into force of this Guide, unless otherwise stated by STUK.

Translation. Original text in Finnish.

1 General

Radioactive wastes, so called reactor wastes, are generated during the treatment of radioactive liquids and gases and as a consequence of repair and maintenance work in the controlled area of a nuclear power plant. Most reactor wastes contain so much radioactivity that they cannot be cleared from regulatory control but must be properly conditioned, stored and disposed of.

In accordance with section 116 of the Nuclear Energy Decree the Finnish Centre for Radiation and Nuclear Safety 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, the Centre must confirm how the licenceholder 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, storing, transfer, activity monitoring and record keeping of reactor wastes. The guide does not include provisions for spent fuel or for treatment and discharges of liquids or gases containing radioactive substances. Neither does the guide include any detailed design criteria for treatment facilities or storages.

2 General safety principles

For treatment and storage of reactor wastes at a nuclear power plant, provisions are included in the Council of State Decision (395/91) where applicable (sections 3–11, 13, 19–21, 23–27) and in the Council of State Decisions (396/91) and (397/91).

In accordance with Guide YVL 1.0, a nuclear power plant shall have enough room for treatment and storage of low and intermediate level wastes. 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.

A fraction of reactor wastes may contain so little activity that it can be cleared from regulatory control in accordance with the principles given in Guide YVL 8.2.

The rooms for treatment and storage of radioactive wastes are part of the controlled area of a nuclear power plant and their radiation protection arrangements shall be carried out in accordance with Guides YVL 7.9, 7.11 and 7.18. These arrangements shall aim at limiting the radiation exposure of workers due to waste treatment, preventing radioactive substances from spreading inside the plant or into the environment and maintaining preparedness for accident situations.

Besides the short-term radiation safety goals, the requirements for waste packages related to their final disposal shall be considered (YVL 8.1). These requirements may concern e.g. the structure of the waste packages, their physical and chemical composition, their resistance to external and internal loads and the amount and stability of radioactive substances in the waste packages.

One objective for waste management, to be considered especially in the planning of repair and maintenance work at nuclear power plants, shall be the limitation of waste amounts. The reduction of waste volumes is appropriate unless it results in a significant increase in radiation doses or discharges or in a complication of further treatment of the waste.

Management of reactor wastes shall comply with the quality assurance practice of the nuclear power plant. This calls for careful planning of waste management activities, surveillance of their implementation and adoption of improved practices whenever needed. Systematic waste management

presupposes a good practice of recordkeeping, a clear allocation of responsibilities and explicit instructions.

3 Segregation, treatment and packaging of wastes

Wet wastes

As a rule, wastes that are markedly different by chemical composition, activity concentration or nuclide content, should 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 wastes, unless this results in complication of further treatment of wastes or in substantial degradation of the properties of final products.

The design basis for the storage capacity of wet wastes shall be such that it allows for the damage of a single container or the failure of treatment facilities. An aspect to be considered in the timing of waste treatment activities is that the ageing of waste may decrease the exposure or discharge due to short-lived volatile radioactive substances.

In storing wet waste, attention shall be paid to the detection of container leakages and to the prevention of other phenomena adverse to safety. Such phenomena are, among other things, corrosion of containers, sedimentation that may complicate further treatment of the wastes and formation of combustible or volatile compounds in the containers.

A preferred option is to solidify wet wastes, i.e. to mix them with a strong or tough binding agent to form uniform, homogenous products. Wet wastes that are difficult to solidify can also be closed in a container in some other form, e.g. as dried or with a suitable absorbing medium. In that case, the properties of the container shall be such that the waste package meets the requirements concerning further handling, interim storage and disposal.

To ensure the safety of the solidification process and the quality of solidified products, 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 contents of radioactive substances in solidified products.

Dry wastes

To limit the quantities of wastes generated in the controlled area, unnecessary objects and materials should not be brought there. Whenever feasible, working processes that create little or easily manageable wastes shall be utilized. Dry wastes shall be gathered and removed from the process rooms without delay and, if possible, sorted already at the gathering stage in a way that facilitates their further treatment. When gathering wastes, one shall separate and mark those wastes which have an exceptional nuclide content or which are particularly flammable.

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

For interim storage or disposal, dry wastes shall be packed into containers which facilitate their transfer, prevent the spread of radioactive contamination and diminish the fire risk of the wastes. In packing the waste, one shall aim at volume reduction by means of a sorting box, a compressor, a fragmentation facility or by some other methods. The spread of radioactive substances shall be prevented by providing the treatment facilities with suction-filtering devices for outlet air or by

utilizing 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 rooms for dry wastes shall be prevented by keeping the rooms locked and by limiting access to them.

Other wastes

Activated metal waste shall be stored in water pools or in some other rooms providing sufficient radiation shielding. It is recommended to store activated metal wastes for extended periods prior to packing in order to reduce their activity. During fragmentation and packaging of activated metal wastes, adequate radiation protection of workers shall be ensured, taking account of both external and internal exposure.

Contaminated metal blocks shall be cleaned of easily removable radioactive substances whenever the decontamination does not cause significant radiation exposure of workers and thereby the block can be cleared from regulatory control or the risk of spread of radioactive contamination can be substantially reduced. If the immediate fragmentation of the metal block is not appropriate it must be packed for interim storage by closing the end of pipes and apertures of components that are internally contaminated and, when necessary, by covering the blocks with plastic.

Containers for temporary storage of contaminated liquids shall be corrosion resistant. Contaminated liquids and other wastes, from which radioactive substances can easily spread, shall not be stored for extended periods in untreated form, unless the aim is to age the waste so that it can be cleared from regulatory control. In storing flammable wastes, one shall pay extra attention to fire protection.

Contaminated liquids that cannot be decontaminated below clearance levels shall be solidified, absorbed in a suitable medium or closed as such into a corrosion resistant container with adequate strength.

4 Transfer and storage of waste packages

The requirements to be set on the interim storage of reactor waste are principally determined on the basis of the activity of the waste. If wastes of different activity levels are stored together, the regulations to be applied are those of the most active wastes.

The transfer of waste packages into a storage room for intermediate level waste shall 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 the design of radiation protection arrangements for the transfer of waste packages between different parts of the plant and outside at the plant area, the number 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 centralized radiation protection arrangements can be implemented.

The radiation dose rates and concentrations of radioactive substances outside the walls of an interim storage 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).

Interim storage rooms with their loading areas are classified as controlled area and shall be provided with proper radiation protection arrangements (Guides YVL 7.9 and 7.10).

The ventilation of an interim 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.

The fire protection arrangements (fire compartments, fire detection and extinguishing arrangements) for the transfer and interim storage of waste packages shall be designed so that when all exposure pathways are taken into account a potential fire cannot cause to an individual of the public an effective dose in a year that exceeds

— 0,1 mSv, if the waste is flammable and combustible (e.g. dry waste packed in sacks); this constraint equivalent to the limit for an anticipated operational transient is included in the Council of State Decision (395/91)

— 5 mSv, if the waste is not flammable (e.g. dry waste compressed in drums, wet waste immobilized in bitumen or cement); this constraint equivalent to the limit for a postulated accident is included in the Council of State Decision (395/91).

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.

As a design basis for the ventilation and fire protection systems of an interim storage, Guides YVL 4.3 and YVL 5.6 shall be adopted where applicable.

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. The requirements concerning physical protection are given in Guide YVL 6.11.

5 Activity monitoring and recordkeeping

The information to be specified and recorded of untreated waste subject to extended storage shall include at least
— waste type
— amount, expressed e.g. in cubic metres, kilograms, linear metres or as number of items
— special characteristics, such as exceptional nuclide content, flammability or classification as nuclear material
— of wet wastes, the activities of the dominant nuclides based on sampling
— location in the storage.

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 analyzing samples prior to solidification or by making gammaspectrometric measurements of packages of solidified waste.

— The activity of other waste types is determined on the basis of the origin of waste, by analyzing samples, with gammaspectrometric measurements, with calculational methods or by combining the methods given above.

— The activities of such pure beta or alpha emitters that cannot adequately be determined directly by radiochemical

separation and measurement, are estimated by means of indirect methods, e.g. by relating them to the activities of suitable gamma emitters and with the adoption of sufficient safety margins.

Of waste packages having similar origin and nuclide content, a statistically representative fraction needs to be monitored. 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 before waste is transferred to an interim storage. Contamination shall mainly be prevented by keeping the treatment and storage rooms clean. Potential surface contamination of the waste packages shall be checked by measuring a statistically representative number of the packages.

The records of waste packages transferred into an interim storage shall include at least
— waste type
— amount of waste
— treatment and packing method
— identification of waste package
— date of packing
— location in the storage
— date of activity determination
— activities of dominant nuclides
— surface contamination, if any
— 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 Regulatory control

The Finnish Centre for Radiation and Nuclear Safety regulates the facilities, systems and components that are used for the treatment and storage of radioactive wastes from nuclear power plants, and the operation of such facilities, in accordance with Guide YVL 1.1, where applicable.

Waste management rooms and systems that are built in connection with a new nuclear power plant are dealt with as part of the plant, unless a waste management facility shall be considered 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 into an operating nuclear power plant 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.

Whenever applicable, the inspection procedures to be utilized 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 nuclear power plant. 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 products and for equipment of which adequate operational experience is not available. The test operation programme shall be submitted to the Finnish Centre for Radiation and Nuclear Safety 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 the Finnish Centre for Radiation and Nuclear Safety for approval.

The licensee shall request the Finnish Centre for Radiation and Nuclear Safety to inspect and give a commissioning approval (Nuclear Energy Act, section 20) for new rooms intended for extensive handling or storage of nuclear waste. The request shall be made not later than one month before the planned date of commissioning. The Finnish Centre for Radiation and Nuclear Safety may call for a similar commissioning approval for extensive modifications related to waste treatment of storage, to be made by virtue of the operating licence of the nuclear power plant.

The operating instructions concerning waste treatment, storage and recordkeeping shall be submitted to the Finnish Centre for Radiation and Nuclear Safety for information.

The Finnish Centre for Radiation and Nuclear Safety performs inspections related to operation of waste management facilities in accordance with a separate inspection programme. Extra inspections are carried out as required.

7 Definitions

In accordance with section three of the Nuclear Energy Act, **nuclear waste** refers 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.

Reactor wastes, that include solid and liquid waste arising from the controlled area of a nuclear power plant and that contain almost exclusively beta and gamma emitters, are grouped into the following activity categories:

— **Low level waste** contains so little radioactivity that it can be treated at the nuclear power plant 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 they are 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 waste 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 or dry waste collected into sacks.

— **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, absorbent carbon 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 low level.

— **Contaminated metal waste** consists of large discarded equipment or machinery with radioactive contamination on surfaces. It is mainly low level.

— **Activated metal waste** consists of fragments 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.

— **Contaminated liquids** consist of oil, sludges and chemicals that contain radioactive substances and that cannot be conditioned in the normal water purification systems of a nuclear power plant. Such waste is as a rule low level.

8 Bibliography

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3 IAEA Safety Series No 111-S-2, Safety Standards, Predisposal Management of Radioactive Waste, in preparation.

4 Application in the Nordic Countries of International Radioactive Waste Recommendations, the Radiation Protection Institutes in Denmark, Finland, Iceland, Norway and Sweden, Helsinki 1986.