Säteilyturvakeskus
Finnish Centre for Radiation and Nuclear Safety

YVL-ohje
YVL Guide
1 July, 1985

YVL 8.3

1 (18)

Translation

TREATMENT AND STORAGE OF RADIOACTIVE WASTE AT THE POWER PLANT

CONTENTS

Helsinki 1985
Government Printing Centre

ISBN 951-46-9118-0
ISSN 0781-4321

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1 INTRODUCTION

A nuclear power plant generates radioactive waste, so called reactor waste, in the treatment of radioactive liquids and gases and in connection with repair and maintenance work performed in the controlled area. Most reactor wastes are so long-lived that they cannot be exempted from control but they must be properly treated, stored and disposed of.

The rooms and equipment that exist at the power plant for the treatment and storage of waste set forth boundary conditions on waste management activities and on the properties of the final products. However, it is possible to influence radiation safety significantly by planning the management activities with care, by supervising the implementation and by developing waste management practices in line with changing situations. Systematic waste management at a nuclear power plant presupposes a good practice of record keeping and clear-cut directives.

2 SCOPE

This guide presents the general principles that shall be followed when planning and implementing the treatment, storing, transfers, activity determination and record keeping of solid and liquid radioactive wastes at a nuclear power plant and when preparing directives for waste management activities. The guide concerns power plants, as well as waste treatment plants and interim storages in their vicinity.

This guide does not deal with the treatment and storage of spent fuel, the treatment of radioactive waters and gases at a power plant, or with radioactive effluents. Neither does the guide include detailed design criteria for treatment equipment or storages.

3 DEFINITIONS

The following definitions are not meant to be general but intended for this guide only.

The solid and liquid wastes, which originate in the controlled area of a nuclear power plant and in which the activity consists almost entirely of beta and gamma emitters, are divided into the following activity classes:

Low-level waste means waste whose activity is so small that the waste can be treated at the power plant and transported without any special radiation protection arrangements. The activity content of the waste is generally no more than 1 MBq/kg.

High-level waste means waste whose activity is so high that its transport and treatment at the plant require very effective radiation protection arrangements. The activity content of the waste is generally at least 10 GBq/kg.

Intermediate-level waste means waste that does not belong to low-level or high-level waste.

The following waste types are determined on the basis of the origin, form, and treatment method of the waste:

Untreated waste means waste that can be stored at the power plant but that has not been treated and packed to its final form, such as wet waste collected into tanks, trash waste collected into sacks and active machinery removed from service.

Packed waste means waste that has been treated and enclosed in a container for interim storage or final disposal. Waste package means the entity formed by the

waste product and the surrounding container.

Wet waste means radioactive waste that is principally generated in the water clean-up systems of the power plant, such as spent granular and powder ion exchange resins, evaporator bottoms, corrosion sludges, charcoal sludges, and decontamination slurries. These wastes are intermediate or low level wastes.

Dry waste means radioactive waste that is generated in the ventilation systems of the power plant, such as charcoal filters and particle filters, and waste that is principally generated in connection with maintenance and repair work (so-called trash waste), such as paper, plastics, insulation material, cloth, wood, small metal objects etc. On the basis of their material properties, the dry wastes are often divided into combustible and uncombustible or compressible and incompressible. Most dry waste is low-level waste, only a small portion being intermediate-level.

Contaminated metal waste means large, discarded equipment and machinery, which have radioactive contamination on the surface. Most of them are low-level waste.

Activated metal waste means parts and equipment which have mostly been removed from within the reactor vessel and which have been activated by neutron radiation. A considerable part of this waste is high-level when removed from the reactor, but when it has been packed for interim storage or final disposal, it can usually be classified as intermediate-level waste.

Contaminated liquids mean, among other things, oils and chemicals containing radioactive substances, which cannot be treated in the normal water clean-up systems of the power plant. Waste of this kind is usually low-level.

4 GENERAL OBJECTIVES OF RADIATION SAFETY

The treatment and storage rooms of radioactive waste are part of the controlled area of a nuclear power plant, and their design, health physics programmes and radiation monitoring arrangements with respect to radiation protection shall be carried out in accordance with the pertinent YVL Guides (Guides YVL 7.9, 7.11 and 7.18). One shall limit the radiation exposure caused by the management of radioactive waste by taking radiation protection measures so that the personnel is not exposed to radiation emitted by the waste, by preventing the radioactive substances from spreading inside the plant or into the environment, and by being prepared for accident conditions and for measures alleviating their effects.

Besides the short-term radiation safety objectives, one shall in the treatment and storage of the waste take into account the long-term requirements that the waste packages must meet in the final disposal. These requirements concern e.g. the physical and chemical stability of the waste packages, resistance against external and internal stresses, and the ability of the packages to keep the radioactive substances enclosed. Even when these requirements have not been specifically defined, it shall be the primary objective of waste treatment and packing to achieve good long-term properties. These properties shall be maintained during the interim storage, too.

5 SEGREGATION AND STORAGE OF UNTREATED WASTE

5.1 Wet waste

Wet wastes of different types must usually be treated separately if they exist in considerable amounts. If some type of waste is generated only in small amounts, it can be mixed with other wastes, provided that further treatment does not become essentially more difficult or

that the properties of the final product are not essentially degraded. One should avoid mixing waste batches which have an exceptionally high activity content or contain a great number of long-lived nuclides with wastes which have a considerably lower activity content but a larger volume.

The use of storage rooms and the timing of the treatment activities of wet wastes should be designed so that there will be enough storage room in the case of a single container damage or disturbances in the waste treatment equipment. If the wastes contain considerable amounts of easily vaporizable short-lived (half-life less than 10 d) nuclides, the wastes should not be treated until after a sufficiently long aging period, unless there are other reasons in favour of a sooner treatment.

In storing wet waste, one shall pay attention to the prevention of phenomena and events that jeopardize safety or impede further treatment. For this purpose, one shall, for instance, try to prevent container corrosion, waste sedimentation and the formation of vaporizable or combustible compounds and to detect and prevent leaks in waste tanks.

5.2 Dry waste

One aim in the repair and maintenance work at the power plant shall be the limitation of the amount of waste originating in the controlled area. One shall avoid bringing unnecessary objects or materials to the controlled area. If possible, one should utilize working processes that create little or easily manageable waste. Dry wastes shall be gathered and taken away from the plant rooms without delay. At the gathering stage, the wastes should be sorted into compressible and incompressible or combustible and uncombustible parts, depending on further treatment. Whenever possible at the gathering

stage, one shall separate and mark those wastes which have an exceptional nuclide content, which have a considerable use value or which ignite and burn with remarkable ease.

One shall avoid storing dry waste in an easily combustible form. To limit the activity that is released when untreated trash waste burns, sacks with a high surface dose rate, exceeding at least 100 uSv/h, shall be segregated from the rest, stored separately and, whenever possible, given further treatment during the maintenance and repair period or immediately thereafter.

Unnecessary staying in the storage rooms of dry waste shall be prevented by restricting the number of persons who have access to the storage rooms.

The storage of untreated dry waste shall be so designed that the dose rate of external radiation in the working areas of storage rooms does not regularly exceed 150 uSv/h.

5.3 Other wastes

Activated metal waste shall be stored in fuel pools, well storages or in some other rooms providing a sufficient radiation shield. It is recommended that activated metal waste be stored a long time prior to packing because activity can then be reduced considerably.

Contaminated liquids shall be stored in vessels that are resistant to corrosion. One shall avoid long-term storing of untreated contaminated liquids and other wastes which can easily spread the contamination, unless the purpose is to age these wastes so that they can be exempted from control. In storing flammable wastes, one shall pay extra attention to fire protection and safety arrangements.

The spreading of radioactive substances shall be limited by tightly packing the waste containing radioactive substances in particulate or vaporizable form and by closing the ends of contaminated pipes and the apertures of contaminated equipment.

6 TREATMENT AND PACKING OF WASTE

6.1 Wet waste

As a rule, wet waste shall be solidified, i.e. mixed with a strong or tough binding agent to form uniform, homogeneous products. Wet wastes can also be closed in a container in some other form, for instance as dried or with a suitable absorbing medium, if the activity content of the waste is low.

To ensure the safety of the solidification process and the quality of the solidified products, one shall draw up the necessary requirements and restrictions, which can concern, for instance:

- sampling of the waste to be solidified and the preliminary tests that are performed on the samples
- quality control of the solidification agent and the additives
- temperatures, pressures and other important process parameters in the solidification process
- mixing proportions and percentages of the additives
- maximum activity of the solidification products
- control of the solidification process
- quality control of the solidification products
- keeping of recrods.

Depending on the properties of the solidification product, requirements can also be set on the tightness, strength

and radiation protection of the container.

As concerns the radiation level classification, the control room of the solidification plant and the other rooms where there is personnel in regular work belong to the lowest zone (Guide YVL 7.9). Active process rooms can belong to the highest zone. However, it shall be possible to perform maintenance and repair work in the process rooms without exposing the workers unnecessarily to radiation.

6.2 Dry waste

For interim storage or final disposal, the dry waste shall be packed into containers, which make the transfer of the waste easier, prevent contamination from spreading and diminish the fire risk of the waste. In packing the waste, one must try to achieve a reduction in volume by using sorting box, compressor and fragmentation equipment.

Wastes that will be treated further, e.g. incinerated, can also be packed in sacks into large transport containers. The container must be tight enough so that the radioactive substances cannot spread outside during the transport.

In the treatment rooms of dry waste, the dose rate of external radiation, the surface contamination of radioactive materials, and the concentration in air must as a rule conform to the definitions of the lowest radiation level zone.

The spreading of radioactive substances must be prevented by providing the treatment equipment with suction and filtering devices of outlet air and by utilizing treatment methods that do not create particulate contamination.

6.3 Other wastes

When necessary, activated metal waste shall be fragmented and packed with equipment provided with an effective radiation shield. The waste container that is to be used must form a good radiation shield and it must be so strong that treatment accidents cannot break it so much that the workers might be significantly exposed to radiation.

Contaminated metal components of considerable sizes must be cleaned of easily removable contamination when this can significantly reduce the risk of spreading radioactivity and the decontamination does not cause unreasonable radiation exposure to the workers. Contaminated components of considerable sizes which cannot be fragmented must be packed tightly for interim storage.

The aim shall be to clean all contaminated liquids at the plant. If it is not possible, alternative measures can be taken, i.e. solidification, absorbtion in a suitable medium, closing the waste in liquid form into a suitable container, or transportation to another place for treatement. If the waste product that is placed in a container is not completely solid, the waste package shall be so strong and tight that its contents cannot leak out as a consequence of a treatment accident regarded as possible.

When choosing containers for different types of wastes, one shall try to find externally uniform types of packages, which will make the transfers of waste simpler. However, it shall be easy to distinguish between various types of waste, for instance, by means of different colours or marks on the packages.

7 INTERIM STORAGE

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 activities are stored together, the regulations to be applied are those of the most active wastes.

Activated metal wastes can be kept in the interim storage of intermediate-level waste, provided that they have been packed in a container strong and tight enough and that the surface dose rate of the packages does not essentially exceed the maximum surface dose rate of intermediate-level waste packages.

The dose rate outside the interim storage walls and the controlled area must not exceed 7.5 uSv/h. In addition, one shall see to it that the radiation exposure of the population outside the plant site does not exceed the set dose limits.

With the exception of interim storages where the dose rate of external radiation is very low (less than 7.5 uSv/h), the interim storages and the loading areas are included in the controlled area, which shall be provided with proper facilities (protective barrier, protective clothing, radiation monitoring equipment and washroom).

As a rule, it shall be possible to transfer waste packages into the interim storage of intermediate-level waste with the help of remote control. In the storage of low-level waste, packages can also be moved on the spot. Radiation protection arrangements shall be so planned that the dose rate of external radiation does not regularly exceed 150 uSv/h in the loading area of waste or in the sections of the storage where people must stay during the transfers of waste.

The ventilation of the interim storage shall be so designed that the condition of the waste packages cannot essentially deteriorate during the interim storage. If wastes are packed in steel drums, the humidity of air in the storage must be low enough. In the storage of waste solidified in concrete, there shall be available a warming system of air if the temperature could otherwise sink below the freezing point for several days.

The fire areas, fire alarms and extinguishing systems of the interim storage must be so designed that the activity released into the outside air from the storage during a fire does not exceed 100 GBq if the wastes are not easily inflammable (e.g. trash waste compressed in drums, wastes solidified in bitumen or concrete). However, if the wastes are easily inflammable and combustible (e.g. trash waste packed in sacks), the activity released into the outside air must not exceed 1 GBq.

It shall be possible to extinguish the fire without unnecessarily exposing the fire-fighting personnel to radiation.

To protect a separate controlled interim storage against sabotage, it shall usually be surrounded with a fence, provided with necessary contacts to the guarding centre and to the control room of the power plant, and guarded. The number of persons who have access to the storage rooms must be kept low.

8 TRANSFERS AT THE PLANT SITE

In planning transfers that take place at the plant site, outside the plant rooms, one shall as a rule apply the regulations on transports of radioactive materials issued by virtue of the Resolution (610/78) of the Ministry of Communications, although they do not directly deal with

transfers at the plant site. These regulations and recommendations concern dose rates, surface contaminations and transport containers. However, it is possible to deviate from these regulations if it is unreasonably difficult, in view of the extent of the operation, to arrange the transport in accordance with the regulations and sufficient radiation safety can be achieved by other means.

The fire protection of the radioactive waste transfers (amount of combustible wastes in the load, transfer containers, extinguishing measures) shall be so designed that the activity released into the air during a fire does not exceed 100 GBq. The aim is to perform the transfers periodically and with several loads at a time, which means that the radiation protection and safety precautions can be taken care of in a centralized manner.

9 DETERMINATION OF ACTIVITY AND KEEPING OF RECORDS

At least the following information shall be recorded concerning untreated waste to be stored a long time

- type of waste
- amount, expressed e.g. in cubic metres, kilograms, linear metres or as number of packages
- origin, if it differs from that of the other wastes of the same type
- location in various storage rooms.

Whenever possible, the activity of the most important nuclides in wet waste should be determined by sampling.

The activity of the most important nuclides in packed waste shall generally be ascertained before the waste is transferred for interim storage or for final disposal. The activity can be ascertained with the following methods:

- The gamma activity of dry waste is determined from the waste packages with gammaspectrometric measuring equipment.

- The gamma activity of wet waste to be solidified is determined either by analysing samples before the solidification or with gammaspectormetric measuring equipment from the waste packages.

- The activity of other waste types is estimated on the basis of the origin of the waste, by analysing samples, with gammaspectrometric measurement or with calculational methods, depending on the suitability of each method.

- The activity of such significant pure alpha or beta emitters that are impractical to determine with radiochemical separation and measurements, is estimated by using indirect methods, e.g. by proportioning it to the activity of a suitable gamma emitter with a sufficient safety margin.

It is not necessary to determine the activity of every waste package. When the waste packages have similar origins and nuclide contents, a statistically representative number, e.g. 1/10, is enough. The nuclide-specific activity of other waste packages can be calculated on the basis of the measured nuclide contents and the surface dose rates of the packages. Sufficient safety margins shall be used in the calculations.

It is not generally practical to measure the surface contamination of solidified wastes before they are transferred to an interim storage, but contamination shall be prevented by keeping the treatment and storage rooms clean. Trash waste packages shall be checked for surface contamination, unless it can be otherwise shown

that the amount of contamination is negligible. It is usually enough if the surface contamination is measured from some waste packages, typically 1/20...1/10 of all packages.

At least the following information shall be recorded of the waste packages transferred to an interim storage:

- type of waste
- amount of waste
- treatment and packing methods
- identification marks of the waste package
- date of packing
- place of interim storage
- date for ascertaining the activity
- nuclide-specific activity
- surface contamination, if any.

The information concerning wastes in the interim storage shall be reported as per Guide YVL 1.5.

10 SUPERVISION PERFORMED BY THE AUTHORITIES

The Finnish Centre for Radiation and Nuclear Safety supervises the facilities, systems and components that are used for the treatment and storage of radioactive wastes from nuclear power plants, in accordance with Guide YVL 1.1, whenever applicaple. Waste management rooms and systems that are built in connection with a new nuclear power plant are treated as parts of the plant. The documents that concern waste management rooms and systems to be built into an operating nuclear power plant, can be submitted as modifications or supplements to the corresponding documents of the power plant. A separate waste management plant that is located at the power plant site shall be described in a separate safety analysis report.

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 corresponding systems, structures and componets of a nuclear power plant. The safety classification of systems, structures and components, as well as the applicable inspection procedures, are chosen on the basis of their importance to the safety of the waste treatment and storage and to the properties of the waste packages.

Test operation shall be arranged for systems that have a significant effect on radiation safety and on the properties of the final products and for equipment which are not sufficently known as concerns their operation. The test operation program shall be submitted to the Finnish Centre for Radiation and Nuclear Safety for approval. Important waste treatment plants shall be provided with technical specifications, which shall be submitted to the Finnish Centre for Radiation and Nuclear Safety for approval.

Of the operating instructions concerning the treatment and storage of waste, the power company shall seek the approval of the Finnish Centre for Radiation and Nuclear Safety for the instructions that involve radiation protection and for those whose approval is required separately. The other operating instructions shall be submitted to the Centre for information.

The licensee shall request the Finnish Centre for Radiation and Nuclear Safety to inspect and to give an approval of the commissioning of new rooms intended for the treatment and storage of significant amounts of waste. The request shall be made not later than one month before the planned date of commissioning. The inspection procedure is also applied when a room previously used for other purposes is converted into a treatment and storage room of wastes by

making modifications that are important to safety.

During the operation, the Finnish Centre for Radiation and Nuclear Safety performs inspections in accordance with a separate inspection program. Extra inspections are also carried out, when necessary.

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In the event of any differences in interpretation of this guide, the Finnish version shall take precedence over this translation.