STUK

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RADIATION PROTECTION OF WORKERS AT NUCLEAR FACILITIES

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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.

Translation. Original text in Finnish.

1 General

The use of nuclear energy is prescribed in the Nuclear Energy Act (990/1987) and in the Decree (161/1988) given by virtue of the Act. The provisions of Section 2 and Chapter 9 (radiation work) of the Radiation Act (592/1991) are also applied to the use of nuclear energy.

According to Section 2 of the Radiation Act, *to be considered acceptable, the use of radiation and practices involving exposure to radiation shall meet the following criteria:*

1. *The benefits derived from the practice shall exceed the detriment it causes (principle of justification);*
2. *The practice shall be arranged so that the resulting exposure to radiation hazardous to health is kept as low as is reasonably achievable (principle of optimisation);*
3. *No person shall be exposed to radiation exceeding the maximum values prescribed by Decree (principle of limitation).*

This Guide applies to the radiation protection of nuclear facility workers during the operation of the facility. Guide YVL 7.10 deals with the monitoring of occupational exposure at nuclear facilities, and Guide YVL 7.11 with radiation monitoring systems and equipment in nuclear facilities. Guide YVL 7.18 provides requirements for radiation safety aspects in the design of nuclear facilities. Guide ST 7.5 [6] covers medical surveillance of exposed workers. Criteria for nuclear waste removal from regulatory control are presented in Guide YVL 8.2.

2 General requirements

According to Section 7 of the Government Resolution (395/1991), *radiation exposure arising from the operation of a nuclear power plant shall be kept as low as reasonably achievable.* According to Section 8 of the Resolution, *a nuclear power plant's design and operation shall be implemented so that radiation exposure to workers can be limited as separately enacted*. In Section 3 of the Radiation Decree (1512/1991), the following is prescribed about occupational exposure:

The effective dose caused to a worker by radiation work shall not exceed an average of 20 millisieverts (mSv) per year reckoned over a period of five years, nor 50 mSv in any one year.

The annual equivalent dose in the lens of the eye shall not exceed 150 mSv, nor shall the annual equivalent dose at any point on the hands, feet or skin exceed 500 mSv.

In order to keep individual radiation exposures low, additional dose constraints lower than the above mentioned shall be used at the nuclear facility. Annual doses over 20 mSv can be accepted only in justified exceptions.

Section 4 of the Radiation Decree provides dose limits for the training of young people:

The effective dose to a young person of no less than 16 but no more than 18 years of age who is involved in the use of radiation sources in the course of vocational training shall not exceed 6 mSv per year. The annual equivalent dose in the lens of the eye shall not exceed 50 mSv, nor shall the annual equivalent dose at any point on the hands, feet or skin exceed 150 mSv.

Protection of a foetus is prescribed in Section 5 of the Radiation Decree.

Measures to restrict the radiation exposure arising in accident situations are enacted in Section 8 of the Radiation Decree as follows:

When applying the maximum values for radiation exposure, no allowance shall be made for exposure arising from immediate measures necessary to limit the radiation hazard resulting from an accident and to bring a radiation source under control. These measures shall be arranged so that the radiation exposure resulting from the situation is limited to the least possible.

If the radiation exposure resulting from measures referred to in paragraph 1 may exceed any of the dose limits prescribed in Section 3, then the measures shall be performed on a voluntary basis. The persons performing the measures shall be advised of the hazard pertaining to the said measures. The radiation exposure of persons involved in all immediate measures shall be assessed and their medical surveillance shall be arranged in a manner corresponding to the medical surveillance prescribed for radiation workers in category A.

Except where the matter concerns the saving of human lives, the effective dose of a person involved in the measures referred to in this Section shall not exceed 0.5 Sv and the equivalent dose at any point on the skin shall not exceed 5 Sv.

In addition, the following is prescribed in Section 8a of the Radiation Decree:

When the immediate measures necessary for limiting a radiation hazard and bringing a source of radiation under control have been performed, the dose limits stipulated in Section 3 shall apply to protection work and other measures seeking to ameliorate the consequences of the accident.

Regulations for emergency response arrangements are provided in the Government Resolution (397/1991). In addition, Guide YVL 7.4 deals with emergency response arrangements at nuclear power plants.

Radiation protection at nuclear facilities shall be based on good planning of activities, appropriate working methods, up-to-date radiation protection methods, instruments and protective equipment, utilisation of prior experience as well as co-operation between the different organisation units within the nuclear facility. Commitment to the implementation of radiation protection concerns the whole staff of the nuclear facility.

A systematic recording of events, arrangements, measurement results and observations significant to radiation protection shall be upheld.

In addition to individual occupational doses, collective doses shall be followed both for various tasks and worker groups.

3 Radiation protection organisation

3.1 Responsible manager

According to Section 124 of the Nuclear Energy Decree, the duty of a responsible manager is to see that the provisions of the Nuclear Energy Act on the safe use of nuclear energy, the arrangements for physical protection and emergencies, and the safeguards control referred to in Section 118, as well as the rules and regulations issued by virtue of the Act and the licence conditions are complied with.

The responsible manager shall ensure sufficient resources and authority for the personnel implementing radiation protection. The responsible manager shall especially monitor actions which aim to keep radiation doses low.

3.2 Radiation protection personnel

A unit with a responsibility for taking care of radiation protection work in practice and for co-ordinating related functions shall be established within the nuclear facility's operating organisation. The radiation protection manager of the facility shall act as this unit's head. Task and responsibility arrangements for the implementation of radiation protection shall be presented in documents concerning the operation of the facility.

The radiation protection manager has to direct the implementation of radiation protection at the facility. In addition, he/she shall organise that radiation protection is developed and international experience in the field is followed.

Radiation protection unit shall know of the structure of the facility and general technical operating principles as well as the radiation sources at the facility. The unit shall monitor by measurements the radiation situation within the facility as well as oversee work and measures carried out in the controlled area of the facility as regards radiation protection.

Radiation protection unit shall organise that an adequate amount of radiation monitoring instruments and protective equipment is available. In addition, the unit shall ensure that these instruments and equipment are operable and that they are used according to the instructions given.

Radiation protection personnel shall have adequate authority to implement measures, which aim to keep radiation doses low, and the authority to interrupt working activities on grounds of radiation protection.

4 Medical surveillance of exposed workers

4.1 Radiation work categories

Exposed workers shall be classified to radiation work categories A or B according to the Radiation Decree. Section 10 of the Radiation Decree provides the following: *Category A shall include those workers whose effective dose caused by their work exceeds, or may exceed, 6 mSv per year, allowing for the possibility of a work-related incident resul-*

ting in abnormal radiation exposure, or an equivalent dose is or may be greater than three tenths of the dose limits stipulated for the lens of the eye, the skin, hands or feet.

Category B shall include those workers who are not classified as category A workers.

Persons working in the controlled area at nuclear facilities are mainly classified as category A workers.

According to Section 37 of the Radiation Act, a person conducting radiation work shall be over 18 years of age. A person younger than this, but not less than 16 years of age, may participate in the use of radiation sources insofar as this is necessary for his/her vocational training.

4.2 Medical surveillance

The Occupational Health Care Act (743/1978) enacts the arrangement of health care for workers. The responsible party engaged in radiation practices shall arrange special medical surveillance for its exposed workers related to occupational health care. Medical surveillance is enacted in Chapter 9 of the Radiation Act and in Chapter 3 of the Radiation Decree. Also the Government Resolution (1672/1992) on health examinations in work causing special health risks concerns the medical surveillance.

The medical surveillance of exposed workers shall be organized according to Guide ST 7.5 [6].

The licensee shall give to an external worker, either directly or via his/her employer, all necessary information and explanations on working circumstances and on any changes in activity. This information shall be forwarded to the medical practitioner responsible for medical surveillance. In addition, the licensee shall obligate an external employer to forward the dose information of its workers to the medical practitioner responsible for medical surveillance.

The licensee shall ensure that also the medical surveillance of an external worker has been organised according to the Radiation Act and Decree. The licensee shall keep a record of the performed medical examinations of category A workers

5 Area and zone division based on radiation conditions at the facility

5.1 Bases for zone division

Dose rate measurements and determinations of the concentration of airborne activity and surface contamination (surface activity) shall be systematically conducted at the facility. Based on the results of measurements, the workplaces are classified into controlled and supervised areas. Area outside of the controlled and supervised areas is an uncategorised area in terms of radiation protection. Workers' exposure to radon in underground facilities and their radiation measurements are dealt with in Guide ST 12.1 [11].

5.2 Supervised area

If the effective dose may exceed 1 mSv in a certain area, the equivalent dose to an eye 15 mSv or the equivalent dose to hands, feet or skin 50 mSv per year, the area shall be defined at least as a supervised area.

Working conditions in the supervised area and, when necessary, individual exposure shall be monitored according to the nature and extent of radiation exposure. Radiation sources in the area and the associated radiological danger shall be appropriately marked. The markings shall, if necessary, indicate that the area is a supervised area.

Workers shall be provided with instructions on working in the supervised area, use of radiation sources and radiological danger associated with the sources. Radiological conditions of the supervised area, outlines of the area and adequacy of the protective measures shall be verified with regular inspections.

5.3 Controlled area

At least those premises of the facility, where the external radiation dose rate may exceed a value of 3 µSv/h or where a 40 hour weekly stay may cause an internal radiation dose exceeding 1 mSv per year, shall be defined as a controlled area. Limit values set for surface contamination in the lowest zone of the controlled area as well

Table I. Limit values for surface contamination at a nuclear facility.

Radioactive substances	Workplaces and tools	Workers	
	Lowest zone of controlled area Bq/cm²	Clothes Bq/cm²	Skin Bq/cm²
Alpha emitters (radiotoxicity class 1)	0.4	0.4	0.2
Other nuclides	4	4	2

as limits when leaving the controlled area are presented in Table I.

5.4 Zones of controlled area

The premises of the controlled area shall be divided into zones based on external dose rate, surface contamination and concentration of airborne activity. There shall be at least three zones.

The following conditions shall be fulfilled in the premises of the lowest zone:

- external dose rate ≤ 25 µSv/h
- surface contamination:
  beta emitters ≤ 4 Bq/cm²
  alpha emitters ≤ 0,4 Bq/cm²
- concentration of airborne activity ≤ 0,3 DAC (Derived Air Concentration, [7]).

The highest zone consists of premises where only short-term, beforehand carefully planned stays are allowed. At least those premises, where one of the following conditions is fulfilled, belong to this zone:

- external dose rate ≥ 1 mSv/h
- surface contamination:
  beta emitters ≥ 40 Bq/cm²
  alpha emitters ≥ 4 Bq/cm²
- concentration of airborne activity ≥ 30 DAC.

External dose rate, surface contamination or concentration of airborne activity may locally exceed the classification limit if the sub-area in question is separated by access barriers and marked with signs indicating the radiation situation, potential stay limitations and protective equipment required. Exceptional radiation sources shall be always visibly marked.

The zone classification of an area and the grounds for it shall be clearly indicated with signs at the entrance [5]. If the radiation situation of an area changes, the sign indicating the area's classification shall be changed without delay to correspond with the new conditions.

An updated record of the zone division and radiation conditions of premises shall be kept at the nuclear facility. It shall cover the situation both during the normal operation and annual maintenance outage.

5.5 Movement in controlled area

The access to the controlled area shall be monitored. Premises except those of the lowest zone shall be locked up or monitored. Persons moving in the controlled area shall have a personal badge visible for identification and access right checking. Persons working in the area shall always have a personal dose meter (dosimeter). If the individual radiation dose received in a workplace may exceed 0,5 mSv per week, a dosimeter enabling real-time dose monitoring shall be additionally used. An alarming dosimeter (preferably with a dose rate alarm) shall be used if the dose rate may exceed 1 mSv per hour.

Radiation dose of visitors in the controlled area shall be measured. Group dosimeters may be used if the radiation dose measured is representative considering all individuals in a group.

At least protective overalls and shoe covers shall be used as protective clothing, complemented by necessary additional protective gear (protective gloves and shoes, respirators) required in the task. Protective overalls may be replaced by protective coats in justified exceptions if the contamination risk of clothes is low.

Eating, drinking and smoking are prohibited in the controlled area. Exceptions to this rule may be separately allocated cafeterias and break areas. In addition, an exception may be the use of water dispensers. However, these premises and dispensers may be used only under the supervision of the radiation protection personnel if it can

be ensured by radiation measurements that their use will not cause any internal contamination to workers.

Hands and protective clothing of the personnel leaving the controlled area shall be checked with a measuring instrument for surface contamination. The area can be exited normally if the contamination limits of a worker are not exceeded (see Table I). Measurement results exceeding the surface contamination limit shall be recorded. For the cleanup of the surface contamination of workers, the nuclear facility shall have appropriately equipped premises for the decontamination of individuals.

If it can be suspected based on the surface contamination measurements that a worker has received internal contamination, an immediate on-site measurement by using an internal radiation monitoring equipment shall be conducted.

Materials to be removed from the controlled area shall be measured for surface contamination. Materials are permitted to be removed if the limits set in Table I are not exceeded.

6 Radiation work permit

A radiation work permit is needed for radiation work conducted in the controlled area. A permanent permit may be issued for routine and repetitive tasks. The methods and responsibilities for issuing of the radiation work permit shall be defined in the radiation protection procedures of the facility.

The radiation work permit or related documents shall include at least

- author and acceptor of the permit
- date of granting
- names of workers (or supervisor and headcount)
- task and radiation conditions in the workplace
- job description
- requirements concerning measurement of dose rate, surface contamination and airborne activity
- work-specific dose monitoring
- safety instructions and protective equipment.

The radiation work permit shall be visible at the workplace. The radiation protection personnel shall have the right and responsibility to inspect that the work performed in the workplace complies with the permit.

Based on the monitoring of radiation work permits and work, records shall be kept of work which has caused significant radiation doses.

7 Radiation protection training

According to the Radiation Act, workers shall be provided with training and instructions for their duties taking into account the features of work and conditions at the workplace.

Aim of radiation protection training is to provide workers with preconditions for correct working in the controlled and supervised areas, prohibit unnecessary radiation exposure and influence to the accomplishment of the radiation protection goals. In addition, training shall give preconditions to act consistently if unpredictable situations occur at the workplace. As far as possible, work phases shall also be trained before they are performed in demanding workplaces as regards radiation protection.

Training provided to personnel working in the controlled area shall at least include the applicable parts of the radiation legislation and regulations issued by virtue of it, fundamentals of radiation and radiological risks, instructions for working in the controlled area as well as information on the monitoring of radiation exposure.

Training shall be given to all permanent and temporary workers of the nuclear facility working in the controlled area. In addition, specific radiation protection training shall be given to those persons whose work (e.g. work planning) affects significantly to the results of radiation protection.

In connection with giving training and instructions the worker's responsibility for taking care of his/her own and other persons' radiation safety shall be highlighted.

Radiation protection training at nuclear facilities shall be given to both domestic and foreign workers to an adequate extent.

Workers shall demonstrate the adequacy of their radiation safety knowledge in a written exam. A record shall be prepared of the exam, indicating the name of the worker who perfor-

med the exam and the name of the employer who evaluated it.

Training requirements for the responsible manager, radiation protection manager and other radiation protection personnel are presented in Guide YVL 1.7. The radiation protection personnel shall undergo an exam in which the employees shall be able to show that they understand the radiation protection regulations and measures required in their duties and that they know how to use the instruments needed in their work.

Radiation protection training shall be given already before the commissioning of the facility. In addition to the initial training, refresher training shall be organised at regular intervals. Radiation protection training can be considered to be qualified for both Finnish nuclear power plants, if the plant specific characteristics and differences have been taken into account in connection with training. For example, it is sufficient that written material is handed out to workers. On the same basis, radiation protection training in Sweden can also be approved at Finnish nuclear power plants.

8 Radiation protection procedures

Procedures on the implementation of radiation protection shall be established at the nuclear facility. The procedures shall include at least

- principles of radiation protection and the organisation responsible for implementing them
- behaviour rules in the controlled and supervised areas
- radiation measurements in the controlled and supervised areas
- radiation work permit policy
- individual monitoring
- real-time and individual monitoring of doses
- medical surveillances and radiation work categories of radiation workers
- instructions for using of personal protective equipment
- decontamination of individuals.

Radiation protection procedures shall be kept up to date and evaluated regularly according to a way defined in the quality management system of the nuclear facility. In addition, activities defined in radiation protection procedures shall be evaluated as a part of quality control [9]. Guide YVL 1.9 deals with the quality management of the operation of nuclear power plants.

Radiation protection procedures shall be delivered to STUK for information.

9 Regulatory control

STUK regulates the operation of nuclear power plants as presented in Guide YVL 1.1. As a part of the periodic inspection programme for the operation, STUK also oversees the implementation of radiation protection on the plant site. In addition, STUK inspects items significant to radiation protection and conducts separate inspections during outages.

A written action programme for keeping the radiation doses low (ALARA action programme) shall be established at the plant. The programme shall include both short-term and long-term plans and measures of how the plant pursues to bring the doses of exposed workers low according to the ALARA principle. ALARA action programme shall be kept up to date and delivered to STUK for information.

If the collective radiation dose of personnel at one plant unit exceeds the value 2,5 manSv per one GW net electric power as an average of two consecutive years, the reasons for exceeding and the possibly needed measures aimed for improving radiation safety shall be reported for STUK.

If a worker's individual radiation dose at a nuclear facility exceeds 20 mSv during one calendar year, the reasons leading to this radiation dose shall be reported to STUK.

The documents on fuel reloading outages and planned extensive repair outages shall include e.g. the number of personnel participating in radiation protection, special arrangements during the outage concerning radiation protection and also an estimate of the collective radiation dose of workers caused by the outage work. Outage control conducted by STUK is dealt with in more detail in Guide YVL 1.13. Control of modifications, repairs and maintenance is dealt with in Guide YVL 1.8.

If it is predicted while planning the work that the dose resulted will exceed 0.05 manSv or that there is a significant risk of internal radioactive contamination, a detailed document describing work plans and radiation protection actions shall be sent to STUK for information well before the work is initiated. If there are several tasks of this type, a combined document may be sent to STUK.

Reports on the operation of nuclear power plants to be delivered to STUK are presented in Guide YVL 1.5.

STUK shall be notified about the contents and plans for radiation protection training. STUK oversees radiation protection training in connection with radiation protection inspections during outages and training inspections of the periodic inspection programme for the operation.

10 References

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