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Assessment on Future Challenges of Radiation Protection for Nuclear sector in Estonia

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Contents

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1 Executive Summary

Radiation protection competence is an essential part of the national capacity that is a prerequisite for the safe use of nuclear power. This report describes the required radiation protection capacities and related national infrastructure required by the nuclear energy programme. It should be noted that in Estonia there are already existing capacities in the field of radiation protection, and the new capacities should be developed taking them into account.

STUK has made 80 comments on the possible needs of new elements in radiation protection that need to be addressed in case Estonia makes a decision to initiate a nuclear energy programme. The comments are organized according to thematic topics. They are general and many of them may already have been taken in consideration in Estonia.

Assuming that Estonia makes a decision to initiate a nuclear energy programme, as a summary conclusion it can be stated that Estonia needs to:

- Develop legislation and regulations for the safe use of nuclear energy including binding requirements on radiation protection.

- Develop additional capacities on radiation protection to meet the needs of the nuclear energy programme. This report comprises the specific additional expertise and capabilities on radiation protection. It should be noted that these will partly depend on the NPP type and the related technologies to be selected by the licensee.

- Develop additional expert resources to support the national nuclear energy programme. Cooperation with the states that have an existing nuclear programme is highly recommended, and STUK recommends Estonia to establish national training programmes at its universities to support the nuclear energy programme. Training experts takes time and should therefore start as soon as the decision to launch a nuclear energy programme has been taken.

Considering radiation protection, Estonia has the necessary basic conditions to succesfully develop the necessary expertise and capabilities for the nuclear energy programme.

2 Introduction

STUK made an assessment on the additional responsibilities for radiation protection that will come with a nuclear power programme and means to address them. Radiation protection is one of the most important sectors in the use of nuclear power. It has to be considered already in the planning phase and consideration will last until the disposal of nuclear facility at the end of use in the nuclear power cycle. The extent of the need of radiation protection requirements would depend e.g. on plant type, site characteristics and on the number of units and total power on site. However, many requirements needed in radiation protection are the same no matter what technology is selected.

The starting point for the assessment was the guidance of the International Atomic Energy Agency (IAEA) guidance publication NG-G-3.1 (Rev.1) “Milestones in the Development of a National Infrastructure for Nuclear Power” and the following specific requirements with regard to radiation protection:

3.8.1. Radiation protection: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO (the nuclear energy programme implementing organization) should develop an understanding of the additional hazards presented by nuclear power plant operation over and above those posed by medical, industrial and research applications of ionizing radiation. In its report at the end of Phase 1, the NEPIO should identify how existing programmes will need to be enhanced to address nuclear power plant operation, transport, storage and radioactive waste management.

3.8.2. Radiation protection: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Although the radiation risk associated with nuclear power plant operation will not be present for some time, plans need to be prepared in Phase 2 and preliminary actions taken, to develop programmes to control and monitor the exposure of individuals on-site before any radioactive material arrives on-site. This includes:

- Developing specific regulations by the regulatory body;
- Planning by the owner/operator for monitoring and protecting workers and the public;
- Establishing mechanisms to involve and communicate transparently with all stakeholders;
- Reflecting radiation protection plans in the plant’s design requirements;
- Planning for associated staff recruitment and training and the procurement of equipment and services.

The task was also to provide general recommendations for further actions in the development of the national radiation protection policy for nuclear power programme.

The Estonian party wanted to focus on the additional challenges and responsibilities for radiation protection that will come with a nuclear power programme. The following aspects should be taken in account:

- Existing capabilities, regulatory framework and experience with radiation protection in Estonia
- Additional hazards presented by nuclear power plant operation over and above those posed by medical, industrial and research applications of ionizing radiation
- Needs to enhance existing radiation protection programmes to address nuclear power plant operation, transport, storage and radioactive waste management
- Needs to develop specific regulations by the regulatory body.
- Planning for associated staff recruitment and training and the procurement of equipment and services
- Provide recommendations for further action in the development of the national radiation protection policy for nuclear power programme.

Even though the assessment mainly focused on chapters 3.8.1 and 3.8.2, it was clear for all parts that, as stated in NG-G-3.1, timescales for starting to use nuclear power are long. Each nuclear power facility involves a commitment in the order of 100 years, through construction, operation, decommissioning and waste disposal. Experience suggests that the time from the initial consideration of the nuclear power option by a country to the operation of its first nuclear power plant is about 10–15 years. This may vary depending on the resources devoted to the programme.

STUK made an assessment on the existing regulatory framework and radiation protection capacities in Estonia. Additional information was exchanged in videoconferences, which gave a good starting point for the assessment. The existing capacities of Estonia give solid basis for further extension of the regulatory framework and radiation protection with regard to the use of nuclear energy.

Nuclear energy progamme brings new challenges that are additional to those posed by medical, industrial and research applications of ionizing radiation. New capacities are needed by all the stakeholder organizations that are involved in the nuclear energy programme. The licensee/operator organization of a nuclear facility needs to have profound understanding of the radiation protection principles and measures at its facility in order to run it safely and prevent excessive doses and radioactive releases in Estonia. Similar capacities are needed by the regulatory body and other national organizations in order to develop legislation and regulations, and to carry out licensing and oversight of the use of nuclear energy in Estonia. Both the licensee organization and the regulatory body can be supported by various technical support and inspection organizations, and service providers. However, expertise is needed also when procuring service and responsibility for safety cannot be delegated. The analysis was carried out assuming that the supplier of the nuclear facility has all the needed capacities with regard to radiation protection, and if needed, it can acquire additional capacities during the detailed design of the nuclear facility.

The objective of the analysis was to develop a structured list of the required additional national capacities considering typical needs of a nuclear energy programme and taking into account the existing national capacities of Estonia. The list can be used for development of job descriptions for employees in different organisations and to some extent also to assess the number of employees needed for the nuclear energy programme. Naturally the extent of the national nuclear energy programme will affect the amount of required human resources. The information can in turn be used to develop training programmes to meet the future staffing needs of the nuclear energy programme. Many of the tasks in the field of radiation protection in the use of nuclear energy are demanding and require at least a master's level basic education. It should also be noted that at advanced level the best way to learn is on-the-job training and employees also need to update their skills on a regular basis.

The implementation of the training programmes depends on the existing education system in Estonia and among others the currently available degree programmes of the Estonian universities. Establishing specific degree programs related to the nuclear energy programme takes some time and before that the first employees have the opportunity to study at international universities with relevant degrees. There are also possibilities for cooperation between the Estonian and international universities.

In this assessment some comments are presented over the possible need to enhance radiation protection programmes.

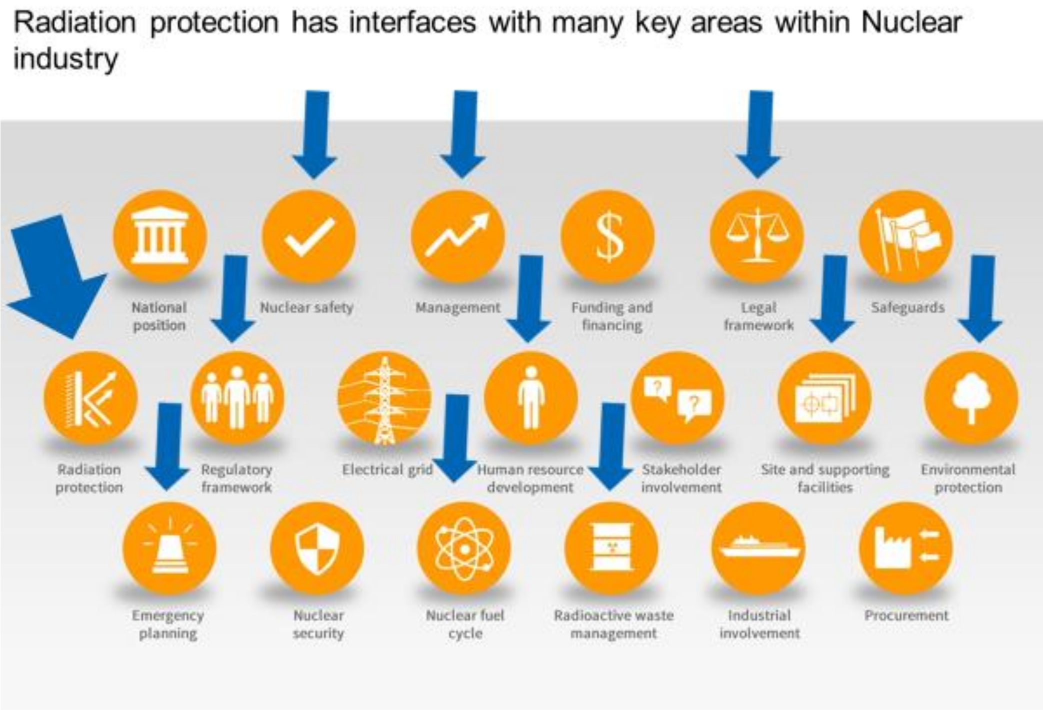

Fig 1. The interfaces of radiation protection with other key areas within the nuclear sector. Arrows added to the 19 infrastructure issues of the IAEA Milestones Approach (source: the IAEA).

The skills needs outlined in the report are based on the experience of the Finnish nuclear energy programme in the construction and operation of conventional, large nuclear power plants. Although the nuclear industry is conservative and often relies on proven technologies, there are developments in the industry that may change established practices and bring new and better technologies to the industry. The

SMR plants currently under development include many solutions that will also have an impact on radiation protection. At the same time, however, new technologies can also bring new challenges and skills requirements. International experience shows that radiation protection experts need to keep abreast of developments and update their skills. The licensee's decision on the type of nuclear installation will also affect the need for expertise in radiation protection.

3 Existing Capabilities, Regulatory Framework and Experience with Radiation Protection in Estonia

3.1 Existing Capabilities and Experience

Estonia has a national infrastructure for radiation safety related to the use of radiation for medical, industrial and research purposes. That gives good basis for expanding the existing infrastructure to the use of nuclear power. However, the use of nuclear power brings new aspects.

Considering the existing infrastructure and capabilities of Estonia there are certain areas that can be recognized as strengths. Estonia is aware of the international agreements related to the peaceful use of nuclear energy and has already joined and ratified many of them. Estonia has also developed national capabilities to deal with the legacy radioactive waste. Also essential factors such as stable economy, digital society, sound legal and educational systems of Estonia form a good basis for the further development of the national infrastructure.

In this assessment there are comments which are seen important when preparing the licensing and operation of a new nuclear facility. The comments do not mean that there are lacks in the Estonian existing capacities or future plans. The comments are not classified and some may even be of minor gravity. A lot depends on the nuclear facility selected and how much experience there already is of the use of the selected type of the nuclear facility.

3.2 Regulatory Framework in the Future

3.2.1 General Requirements for Organisation

Estonia’s Working Party on Nuclear Energy (WPONE) has emphasized the importance of establishing an independent nuclear safety regulatory body well before the decision on starting a national nuclear energy program is made. This is a good starting point for the development.

The mandate of the regulatory body in different sectors of use of the nuclear power including radiation protection should be clearly written in the legislation. Regulatory body could for example on the basis of legislation have mandate to issue regulatory guidance in the NPP sector and have possibilities to oversee the safe use of NP and supervise the practices.

The different steps of the approval process of nuclear power shall be established in the legislation. The positions of different governmental bodies in different decision making need to be clearly stated.

In legislation or in binding regulations there could be clearly stated what documentation licence applicant and later licence holder shall submit to different governmental bodies or regulatory body in different phases of the use of nuclear power.

Many important decision may be necessary to make already in the early stages of the licensing process. Because of that enough resources are needed even in RP before licensing commences.

The EU directive COUNCIL DIRECTIVE 2013/59/EURATOM has been implemented in Estonia. However, radiation safety experts used on the nuclear sector could have a separate training and their qualification could be stated. That is currently practice in Finland. In ANNEX 1 the Finnish qualification requirements including nuclear sector are presented.

Specially in radiation protection there are interfaces with several technical areas. This should be taken into account when training personnel in the special features of radiation protection in the nuclear power sector.

Use of technical support organization (TSO) may be important already at the beginning of the construction licensing phase. Building national TSO capacities for nuclear industry may be essential. TSO’s shall be independent and have suitable competence, experience and resources. The regulatory body should ensure its ability to assess TSO’s competence.

The capacity to review accident analysis is important. There is possibility that the reviewing of documentation is extremely time-consuming at some phases of licensing a nuclear facility. The use of TSO may at that time be essential.

N1. The mandate of the regulatory body concerning the use of nuclear power should be clearly written in legislation. Regulatory body could for example on the basis of legislation have mandate to issue regulatory guidance in the nuclear power sector and have possibilities to supervise the practices as well as oversee the safe use of NPP. In this consideration radiation protection plays a central role in protection of workers, public and environment.

N2. The licensing process of a nuclear facility is a large project. In order to have a full picture of all necessary details concerning licensing a separate project organization with clear responsibilities could be formed within the regulatory body. Within this project organization a detailed plan for RP responsibilities and resources could be formulated.

N3. Sufficient expertise in radiation physics, radiation protection and radiation measurements shall be available in all phases of the nuclear facility design. This concerns both the regulatory body and the licence applicant. Expertise is needed already in the preparatory work.

N4. There should be a plan of the involvement of radiation safety experts in reviews and assessments made during the various phases of design and in the decision-making affecting the implementation of radiation protection.

N5. The project organization in the regulatory body should have procedures for maintaining all the necessary documentation, meeting protocols etc. For all this material there could be clear rules for publicity and availability. Already in the feasibility studies a lot of essential material could be created.

N6. Radiation protection have many interfaces with other sub-areas within the construction of a nuclear facility. Those interfaces should be acknowledged in order to reach good results in the design and radiological planning. Interfaces with several technical areas should be taken in account when training personnel in radiation protection.

N7. On the basis of Finnish experience even project management competences are needed in order to assess the licence applicants and vendors project management systems. Training for that could be planned if necessary.

3.2.2 Requirements in Radiation Protection

In legislation or in binding regulations there could be clearly stated what documentation licence applicant and later licence holder shall submit to different governmental bodies or regulatory body in different phases of the use of nuclear power.

All necessary information concerning design should be available. It’s important that the information which has been used can be stored and the knowledge can be transported to experts even when organisational changes occur.

Knowledge is important for maintenance and if some changes are made during the operation of the nuclear facility. The information is also important for the decommissioning of nuclear facility.

The legal database compiled from the essential regulation applied in Finland in the Radiation and Nuclear Safety Authority’s field of operation is available in the address: https://www.stuklex.fi/en

In the following there are some aspects which are important for Radiation Protection in nuclear design and operation. These aspects are such that should be taken into account right from the start.

N8. Even though a nuclear facility is not yet selected, detailed technology neutral regulations concerning radiation protection in nuclear facilities could be written.

N9. Many of the IAEA recommendations are not binding. The use of nuclear power needs regulations which should state clearly what kind of requirements have to be met.

N10. The assessment of compliance with all the relevant European regulatory requirements (directives etc.) should be planned at least in general level. This comment concerns all sectors in the use of nuclear power.

N11. The special features within Radiation Protection in a nuclear facility could require specific regulations concerning:

- design features in a nuclear facility,
- environmental measurements,
- dosimetry,
- effluent control,

- nuclear waste management,
- radiation measurements within the facility,
- operational radiation protection,
- emergency preparedness,
- accident analysis and their radiological consequences etc.

3.3 Description of Arrangements in a Nuclear Facility

According to the IAEA Safety Guide, Format and Content of the Safety Analysis Report for Nuclear Power Plants Specific Safety Guide No. SSG-61, 2021 the safety analysis report should be structured as follows:

Chapter 1: Introduction and general considerations;
Chapter 2: Site characteristics;
Chapter 3: Safety objectives and design rules for structures, systems and components;
Chapter 4: Reactor;
Chapter 5: Reactor coolant system and associated systems;
Chapter 6: Engineered safety features;
Chapter 7: Instrumentation and control;
Chapter 8: Electrical power;
Chapter 9: Auxiliary systems and civil structures;
Chapter 10: Steam and power conversion systems;
Chapter 11: Management of radioactive waste;
Chapter 12: Radiation protection;
Chapter 13: Conduct of operations;
Chapter 14: Plant construction and commissioning;
Chapter 15: Safety analysis;
Chapter 16: Operational limits and conditions for safe operation;
Chapter 17: Management for safety;
Chapter 18: Human factors engineering;
Chapter 19: Emergency preparedness and response;
Chapter 20: Environmental aspects;
Chapter 21: Decommissioning and end of life aspects

The use of nuclear facility expands the consideration of radiation protection to different sectors, not only to the normal operative work at the facility. It is essential to cover environmental surveillance, emergency planning, radiation measurements, dose control etc. to make sure that the overall safety and public acceptance are met.

In order to have doses as low as possible concrete methods by which ALARA-principle would be met should be described in Chapter 12. The description should be nuclear facility specific.

Radiation protection must be taken in account in some detail at least in Chapters 1, 2, 3, 4, 6, 7, 11, 15, 16, 17, 19, 20 and 21.

Operating experience feedback from similar types of nuclear facilities shall be utilized when considering radiation safety aspects in the design of a nuclear facility. More requitements and analysis are required if the nuclear facility is FOAK.

The information provided in the safety analysis report should demonstrate compliance with IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards; with paras 2.6 and 2.7 and with Requirement 81 of SSR-2/1 and with Requirement 20 of SSR-2/2. Further recommendations and guidance are provided in IAEA Safety Standards Series No. GSG-7, Occupational Radiation Protection.

N12. In construction licence application documentation the radiation protection aspect should be well described. The information described in IAEA publication Format and Content of the Safety Analysis Report for Nuclear Power Plants Specific Safety Guide No. SSG-61, 2021, is useful.

N13. In the IAEA safety standard Radiation Protection Aspects of Design for Nuclear Power Plants the most important aspects for radiation protection in the design phase. This guide is up-dated and it is under approval phase.

3.4 Environmental Surveillance

By means of a radiological environment baseline study the licensee shall determine the radiation conditions and concentrations of radioactive substances in the environment of the nuclear facility before the construction or operation of a new nuclear facility has an impact on the concentrations of radioactive substances in the environment.

Today the Environmental Board of Estonia has the responsibility to carry out the environmental radiation monitoring programme in Estonia.

The Environmental Board composes, maintains and implements the radiation monitoring programme. The requirements for conducting radiation monitoring are described in the Radiation Act, the Environmental Monitoring Act and their regulations.

In the framework of radiation monitoring, air samples, surface water, drinking water, milk, food and soil are collected and analyzed on an annual basis. The dose rate of gamma radiation in the air is monitored continuously.

As Estonia has acceded to the Helsinki Convention for the Protection of the Marine Environment of the Baltic Sea, samples of the marine environment (seawater, biota and sediments) are also collected and analyzed. The monitoring results are made publicly available on the website of the Environmental Board.

There are 15 automated air radiation monitoring stations, 3 air filter facilities, the Environmental Board's laboratory for sample analysis, a mobile metering laboratory and cooperation between authorities for sample collection. Environmental Board participates in international cooperation and exchanges the data on radiation monitoring. The measurement system is modern. In 2014 Estonia updated the radiation monitoring network. The modern system has capability to measure both dose rates and spectrum. Information from the measurement network is automatically collected and there is a 24/7 warning system. In Estonia there are three high-volume air samplers with aerosol filters continuously operating. The weekly filters with deposited radioactivity from these stations are analyzed by the laboratory of the Environmental Board to determine the radionuclide content in the out-door air.

All environmental monitoring samples related to the national program are analyzed in this laboratory. Laboratory is equipped with modern applications and accredited to standard ISO 17025:2017.

Even though the current capability covers well the existing needs in Estonia the Environmental Board has assessed that in case that Estonian Government decides to adopt nuclear energy, arrangements for monitoring must be improved. There is a need to develop radiation monitoring plan and strategy to respond to various radiation and nuclear emergency scenarios.

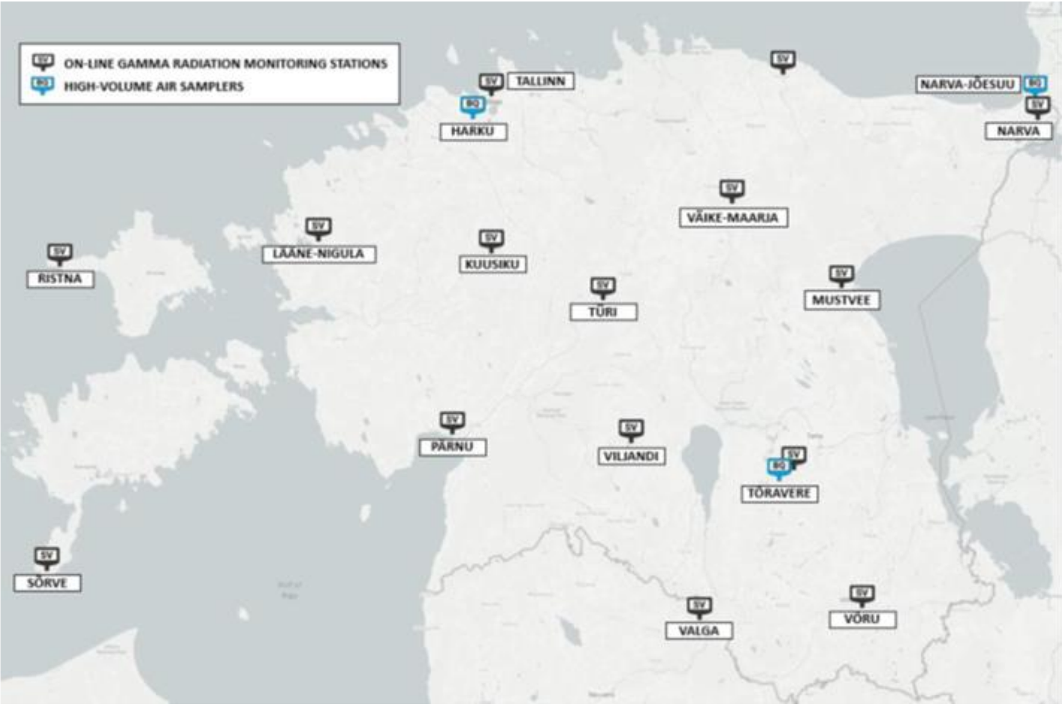

Fig 2. The radiological surveillance in Estonia covers the whole country. Source: The Estonian National Report on Compliance with the Obligations of the Convention on Nuclear Safety as referred to in Article 5 of the Convention 8th Review Meeting.

Extent of the environmental monitoring programs for SMRs would depend e.g. on plant type, site characteristics and on the number of units and total power on site.

In Finland licence holders conduct environmental monitoring. Requirements are set in regulation. STUK approves the programs and inspects the results. The monitoring program for NPPs includes external dose rate, airborne radioactivity, fallout, terrestrial indicator organisms, garden products, water intended for human consumption, seawater and site-specific compartments.

STUK also conducts independent environmental monitoring in the vicinity of NPPs. By this way STUK verifies licensee's own results, both effluents and environmental monitoring.

Even though Estonia already has excellent base for environmental surveillance here are some common recommendations which could give support to establish sufficient resources to environmental surveillance:

N14. According to the Environmental Impact Assessment Directive, an Environmental Impact Assessment (EIA) is required for a NPP project before the project can be started. This requirement needs to be considered in development of the regulatory framework for licensing of NPPs.

N15. Construction and use of a NPP has various environmental impacts and hazards similar to those of other major industrial facilities. In general the significance of the environmental impacts must be analyzed. The major impact from nuclear technology considers radioactive effluents into the atmosphere and the water bodies. It may also affect the thermal loads of waters (rivers or sea).

N16. The Regulatory body should have a clear independent role in the environmental survey. The regulatory body should have possibility to conduct independent environmental monitoring.

N17. Requirements for licensing of a new nuclear facility should also describe in certain detail the scope of environmental surveillance. The licence applicant and later the licence holder should clearly have clear responsibility for carrying out the environmental surveillance in the vicinity of a nuclear facility.

N18. Before the use of a nuclear facility a selection of representative samples from the vicinity of the nuclear facility must be taken with good understanding of the specific circumstances of the selected area.

N19. The radiation monitoring of environment is well established in Estonia and covers the existing needs for monitoring. However, when a nuclear facility is built, there may be extra needs for monitoring specially in the vicinity of the facility. For example in Finland there are continuous dose-rate measurements at the nuclear site at the distance of 2 kilometers and at the distance of 5 kilometers. By those measurement stations spreading of radioactivity can be measured in different directions and particularly in case of accidents.

N20. The responsibilities in baseline programme should be stated clearly. The licence applicant shall draw up a programme for determining the baseline for environmental conditions. In the baseline study programme, the licence applicant shall describe the sampling and measurements that are included in the baseline study as well as their timing and frequency. The planned locations for sampling and measurement shall be presented and the choices shall be justified. The programme shall also describe the methods of measurement, sampling and analysis.

N21. When defining the scope of the radiological environmental baseline study and the sampling and measurements required, account shall be taken of the nuclear facility's location and its environment, the plant type and the anticipated impacts of the activity, such as release routes, release volumes and dispersion into the environment.

N22. The surveillance programme with good consideration must be established well prior the start of the operation of a nuclear facility. Monitoring of water, air, food chains and flora and fauna etc. should be well performed to have later possibilities to assess what changes there may occur in the environment after the start of operation of a new nuclear facility.

N23. There is possibility that after analysis there is a need for alfa-analysis in the environment due to the operation of a new nuclear facility. The existing environmental surveillance in Estonia may need some improvement in the capacity to measure alfa-activity before a nuclear facility starts it's operation.

N24. The radiological environmental monitoring programme should be planned with the intent to verify that solid, liquid and gaseous radioactive releases from the operation of the nuclear power plant are kept as low as reasonably achievable and are satisfactorily controlled and monitored so that authorized limits on discharges are complied with.

N25. The principles with the environmental surveillance programme in the vicinity of a nuclear facility have to be clear: What must be recorded and what information must be regularly submitted to regulatory body and to other parties. That requires suitable equipment and analysis methods, good quality system, instructions and trained personnel.

N26. The emergency preparedness is one of the essential functions using the data of environmental measurement. It's recommended that continuous dose rate as well as continuous nuclide specific data is available from the vicinity of a nuclear facility in order to be able to establish countermeasures in case of an accident.

3.5 Monitoring of Releases

The operation of a nuclear facility may expose the surrounding population to radiation as a result of radioactive releases and direct radiation emitted from the plant. In order to minimise the radiation exposure of the surrounding population, the radiation exposure caused by the normal operation of and potential operational occurrences and accidents in a nuclear facility has to be restricted.

The radiological releases and effluents to the environment from the nuclear facility has to be known. The limitation of radioactive releases to and radiation levels in the environment in a nuclear facility shall be implemented by employing the best available techniques.

Fig 3. In a nuclear facility there is normally a stack with no visible releases.

Exhaust air from the nuclear facility ventilation and gaseous substances diverted from processes, cleaned where necessary, are released to the atmosphere in normal operation. Cleaned effluent waters from plant processes are discharged into the aquatic environment. In terms of normal releases, the significant release pathways are for example the vent stack and the outlet water channel.

In transients and accidents, radioactive substances may also find their way into the environment via exceptional pathways, and the composition of the releases may be different from normal. The releases are monitored by means of process and release measurements carried out inside the facility on the one hand, and by observing the radiation and radioactive substances present in the environment on the other.

Monitoring of radioactive releases and effluents from a nuclear facility gives the direct radiological information of the radiological impact to the environment.

Detailed requirements should be established in order to meet the targets for the reduction of radioactive releases from a nuclear power facility as well as the radiation measurements, sampling systems and laboratory determinations used for monitoring the radioactive releases from the plant.

The effect to environment depends on the meteorological conditions. Some preparation to collecting meteorological data from the site has to be done before a nuclear facility is built. By this meteorological data the analysis of radiological effects to the environment can be calculated.

According to the Commission Recommendation on the application of Article 37 of the Euratom Treaty (2010/635/Euratom), the Member States shall provide the Commission with information about the estimated environmental impacts of the use of nuclear energy. For example, the data pertaining to a nuclear power plant shall be submitted whenever possible one year, but no later than six months, prior to the issuance of an operating licence.

The sensitivity of the release measurements performed are also stated. The expose the representative person in the most highly exposed population group to radiation had to be calculated.

N27. Meteorological information gives essential data for the analysis of spreading of radioactivity. Hence, the preliminary safety analysis report for a nuclear power facility should include a plan for the meteorological measurements to be conducted at the plant site and in its vicinity.

N28. The preliminary safety analysis report for a nuclear power facility shall present a description of the area’s meteorological conditions, the mesoclimate and water areas. The description shall present the statistical distributions of wind direction and speed, atmospheric stability, the occurrence of precipitation and mixing height values during different seasons.

N29. Measurements for effluents and releases at a nuclear facility require measuring equipment which differ from equipment in other industry. There may be need for example for C-14 and tritium measurements.

N30. There are in nuclear industry typically real-time measurements and also samplers which collect sample from a longer time period. Laboratory analysis play a central role in assessment.

N31. For exceptional effluents special arrangements, equipment and measuring methods are probably needed. Those arrangements may be separate from normal effluent and release measurements.

N32. For some effluent and release measurements redundant measuring systems may be needed. That could be stated in regulations if find necessary.

N33. Discharge reporting: The data from the discharge reports received from the licensees needs to be reviewed and assessed by the regulator and then reported further. Decisions on what is needed to report (how are nuclides grouped), how they are presented (what SI unit) and how is the source defined (unit or site specific data) has to be clarified.

N34. Resources have to be submitted to reporting. Most probable there will be needs to report releases and effluents in national level: The data needs to be reported by the regulatory body in e.g. 1) Annual regulatory reports 2) Any other survey or database that is kept nationally (e.g. statistics of energy production discharges).

N35. As concerns the public's radiation doses, the radiation dose for an individual representing the most exposed group shall be defined. In the definition of radiation exposure, the significant migration routes of radioactive substances shall be taken into account.

N36. The calculation method to assess the annual dose to the average individual member of the critical group arising from all relevant practices, estimated on the basis of environmental monitoring should be available both to the licence applicant (later licence holder) and to the regulatory body.

N37. There will be requirements to report releases and effluents to different organizations. For example regulatory body in Finland have to report to EU, UNSCEAR. For example in Finland in International level:

EU-countries: RADD database (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32004H0002, https://webgate.ec.europa.eu/radddataprov/index.dox)
World wide: DIRATA database (https://dirata.iaea.org/)
Baltic Sea countries: HELCOM database (https://helcom.fi/)
Any other survey or questionnaire (e.g. UNSCEAR)

3.6 Dosimetry

Dosimetry is one sector which should be descripted in the PSAR. The need of different types of dosimetry depends on the nuclear facility. There is high possibility that the need for dosimetry must be different from that used in Estonia today.

Fig 4. A TL-dosimeter and an electronic dosimeter (real-time dosimeter).

The Environmental Board in Estonia is responsible for maintaining the register related to the doses of exposed workers. The Environmental Board also approves dose services and issues dose passports. In 2021 The Environmental Board made some improvements to the Dose Registry.

N38. An operation of a new nuclear facility may cause some extra requirements for dose service. That should be taken in account when approving the dose service used by a nuclear facility.

N39. The follow-up of doses may need both real-time and passive dosimeters in a nuclear facility. Using two dosimeters makes the dose measurement more reliable specially in unexpected situations. Also the possibility for assessment of dose can be arranged if needed.

N40. The need to measure neutron doses in nuclear facility should be estimated. Also in the transport of spent nuclear fuel there may be a need to use neutron dosimeters.

N41. Scanning of workers in a nuclear facility may be necessary not only for surface contamination but also for internal radioactivity.

N42. The possibility to calculate the internal dose of a worker may be one new aspect following the operation of a nuclear facility.

N43. The most effective way to analyze internal dose is based on nuclear specific measurements. The methods, calculation codes and equipment to realize assessment of internal dose should be established.

N44. The need for assessment of internal dose is not only necessary for the normal operation or the maintenance outages. The need should be enhanced also for incidents or accidents.

N45. Surface contamination in a nuclear facility may cause a skin dose. The methods to analyze and calculate the surface dose should be established.

N46. The possibility to send and register individual doses into the National Dose Register for internal doses, skin doses, neutron doses even for assessed doses should be established, if not yet already existing.

N47. The operation of a new nuclear facility causes some new requirement for the use of dose passports. The increasing number of transient workers may cause extra needs for using, filling, and issuing dose passports.

3.7 Radiation Measurements

The radiation levels of nuclear facility rooms and the activity concentrations of indoor air and the gases and liquids in the systems shall be measured. Stationary measurements can give constant up-to-date information from the facility. Radiation or activity measurements of different systems or processes are important.

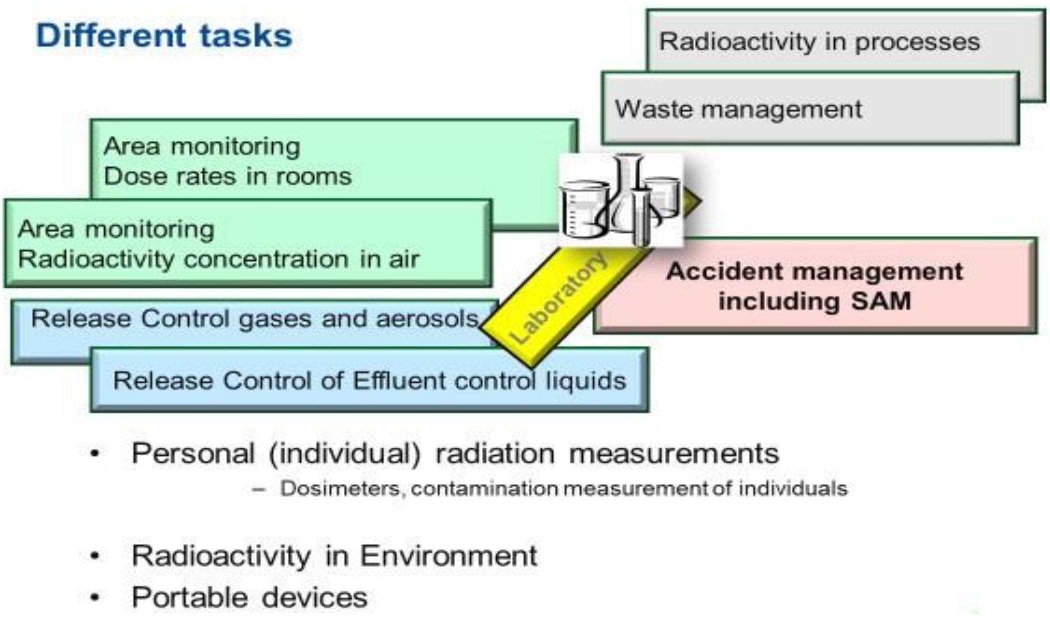

Fig 5. In a nuclear facility there are normally different types of radiation measurements giving overview of the radiological status of the different areas and systems.

The releases of radioactive substances from the nuclear facility shall be monitored and their concentrations in the environment shall be measured.

By regular measurements of dose-rates the conditions at the facility can be followed. They can give essential information how the radiological conditions are developing. Dose-rates can be measured by portable devices.

In order to have detailed information of the radiation circumstances at a nuclear facility also in PSAR a description of necessary portable measurement devices or laboratory equipment should be described.

In a nuclear facility there may be a need to measure alfa-, beta- and neutron radiation. Also special equipment used only in laboratories may be necessary at a nuclear facility.

N48. A description how radiological conditions will be measured at a nuclear facility should be written to demonstrate that the ALARA-principle can be met. The measurement capacity should be such that all necessary radiological information from the nuclear facility can be achieved.

N49. In addition to dose-rate measurements, devices measuring alfa-, beta- and neutron-activity may be needed in a nuclear facility. Devices can be stationary or portable.

N50. There should be suitable radiological measurement devices. It is important that suitability assessments will be carried out to the devises selected for the radiological measurements in a nuclear facility.

N51. On the borders of controlled areas there should be clear limits for radioactivity and devices which have capability to measure low contamination activities. Table 1 presents the limits for radioactivity in Finland for work tools, clothes and skin.

N52. Knowledge of different types of radiation measurement devices used in nuclear facilities is good to have in order to understand their suitability.

Radioactive substance	**Work sites and tools and materials used in work**	**Workers**	
	Lowest zone in the controlled area Bq/cm^2	**Clothes Bq/cm^2**	**Skin Bq/cm^2**
Alpha emitters (radiotoxity class 1)	0.4	0.4	0.2
Other nuclides	4	4	2

Table 1. Limit values for surface contamination at a nuclear facility in Finland.

3.8 Dose Assessments

Calculations had to be performed to ensure that individual doses and the collective annual dose during planned and anticipated regular work tasks are kept low. The measures taken to avoid and restrict exposures, should also be described. Normally during outages occupational exposure is at highest. During outages the maintenance work, tests, fuel exchange take place. Accessibility on system level design should be described, also for up-normal situations.

On system level and even on component level estimated dose rates during operation should be available to show that calculations are performed already in design phase. Based on those calculations it is important to show that measures are taken to improve future working conditions.

N53. Dose-assessment and dose targets for collective dose as well as individual doses should be presented by the licensee to the normal operational works at a nuclear facility. That shows that the ALARA-principle is met even in the design phase.

N54. Dose-rates is the typical working areas should be presented in design documentation. Even the dose-rates in exceptional situations and accident situations in a nuclear facility should be known.

N55. All necessary preparation for operational phase of nuclear power are made during the design phase. By good design, possibility to use robotics and remote control a lot of dose can be saved.

3.9 Lay-out, Shielding and Zoning

By well-designed lay-out radiation protection can be optimized. Zoning of rooms according to the different radiological conditions should be available already during design phase.

In PSAR or in other relevant descriptions there should be radiological consideration not only to the facility itself. The routes of transport to all necessary facilities especially to possible separate waste storages, laboratories, decontamination facilities etc. should be considered.

Hence, PSAR should demonstrate how the basic radiation protection measures of time, distance and shielding have been considered. PSAR should also demonstrate that appropriate design and operational arrangements have been made to reduce the amount of unnecessary radiation sources. Calculations for shielding are important.

Design, lay-out in particular, shall take into account the operation of a nuclear facility including commissioning, normal operation, anticipated operational occurrences, potential accidents and plant decommissioning.

The potential exposure of workers in the nuclear power facility under accident conditions, including design extension conditions with core melting, should be addressed, and the means and other measures taken to minimize such exposures should be described.

The information provided in PSAR should either describe the ways in which adequate provisions for radiation protection have been incorporated into the design, or refer to other sections of the safety analysis report where this information can be obtained.

	External dose rate	**Surface contamination (surface activity)**	**Derived Air Concentration (DAC)**
Zone 1	≤ 25 µSv/h	Beta emitters ≤ 4 Bq/cm^2 Alpha emitters ≤ 0.4 Bq/cm^2	≤ 0.3 DAC
Zone 2	25 µSv/h...1 mSv/h	Beta emitters 4 Bq/cm^2...40 Bq/cm^2 Alpha emitters 0.4 Bq/cm^2...4 Bq/cm^2	0.3 DAC...30 DAC
Zone 3	≥ 1 mSv/h	Beta emitters ≥ 40 Bq/cm^2 Alpha emitters ≥ 4 Bq/cm^2	≥ 30 DAC

Table 2. In this table there is an example what dose-rates, contamination levels and DAC-values are used for zoning of rooms in the Finnish nuclear facilities.

Arrangements to measure radiation at the nuclear facility are important. They can give information if radiation levels are changing prior any worker access to certain rooms or corridors.

N56. Preparation for shielding calculations and scattering calculation have to be made. In order to have enough information of dose rates in complex structural design alternatives or assessment of scattering Monte Carlo-calculation methods may be needed.

N57. Capacity to review shielding calculations for the special circumstances in NPP has to be established. That may require use of TSOs.

N58. The lay-out of a facility including zone classification should be available for reviewing already in an early stage of design.

3.10 Radiochemistry and Chemistry

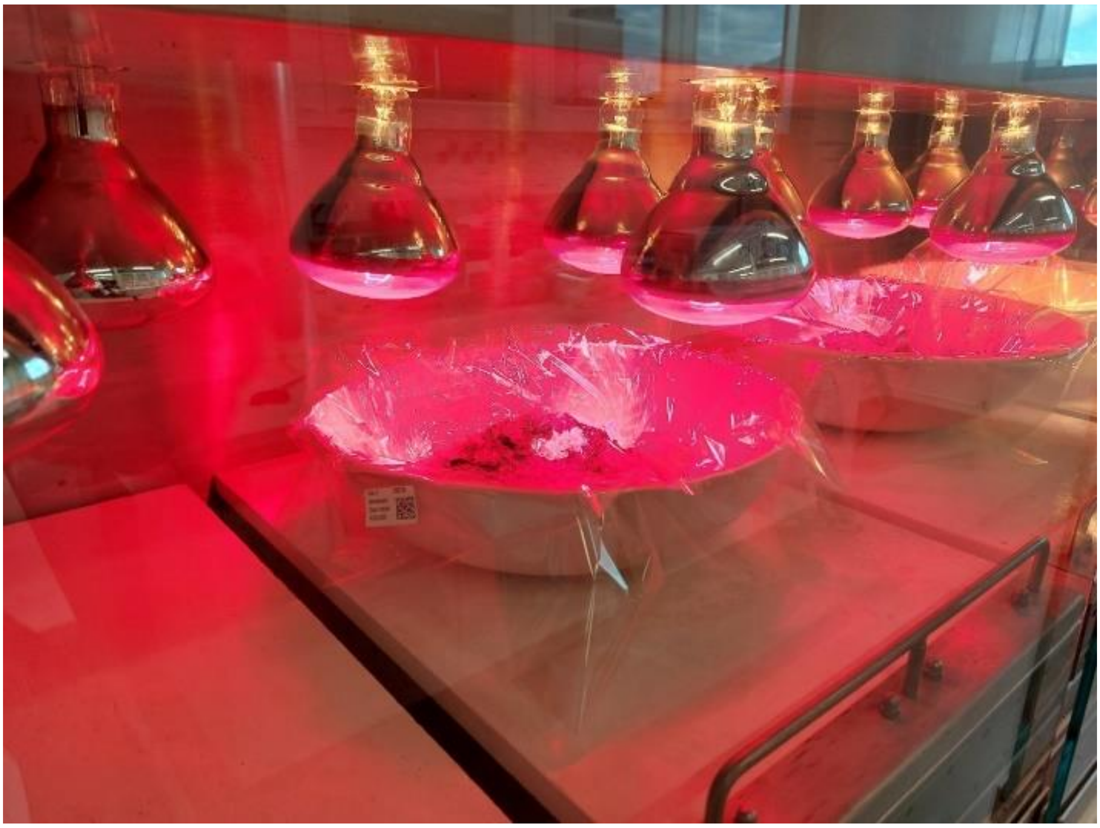

Fig 6. A photo from the laboratory of STUK.

The main contributors to the radiation field generation (and then to the collective dose during outage) are activated corrosion products. The most important radionuclides from a radiation perspective are ^{58}Co, ^{60}Co, ^{110m}Ag, ^{124}Sb, ^{59}Fe, ^{54}Mn, ^{51}Cr, ^{95}Zr and ^{95}Nb.

In Table 3 main activation products from coolant of a NPP are presented. In Table 4 the activation process of some activation products are shown. If there is a fuel damage the composition radionuclides differs once again from those presented in Tables 3 and 4. For example ^{131}I is then one of the most followed radionuclide.

Two main sources are usually defined for these radionuclides: out-of-core corrosion products (steam generator corrosion products, etc.) and fuel assembly and/or materials corrosion products (reactor internals, etc.). The first possibility to limit radiation field generation is to limit corrosion of materials and the second is to limit concentration of elements such as Ni and Co in these materials (e.g. playing on plant design, flow and chemistry of the primary coolant). From a radiation protection perspective, “the most important material issue is the corrosion resistance of the material”.

Decontamination is one essential part in the control of radioactivity. The decontamination systems and their location in nuclear facility should be described in documentation. By decontamination radioactivity can be removed from components, systems, tools and even from whole circuits if necessary. For workers special rooms for decontamination should be planned. The information where stationary radiation measurements devices and sampling points are located should be described in PSAR.

The follow-up of the effectiveness purification systems is one important function which the experts of chemistry and radiochemistry participate.

Activation Product	Reaction	Half-life	Source/Notes
^{16}N	$^{16}O(n,p)\ ^{16}N$	7.13 seconds	Activation of ^{16}O in the coolant
^{13}N	$^{16}O(p,\alpha)\ ^{13}N$	9.96 minutes	Activation of ^{16}O in the coolant and the prompt interaction of the proton recoil from the reaction above
^{18}F	$^{18}O(p,n)\ ^{18}F$	109.7 minutes	Activation of ^{18}O by proton recoil in the coolant
^{3}H	$^{10}B(n,\alpha)\ ^{7}Li(n,n\alpha)\ ^{3}H$ $^{10}B(n,2\alpha)\ ^{3}H$ $^{6}Li(n,\alpha)\ ^{3}H$ $^{6}Li(n,n\alpha)\ ^{3}H$	12.3 years	Activation of ^{10}B and ^{6}Li injected in reactor coolant to control respectively reactivity and pH Activation and release from secondary start-up sources (antimony – beryllium)
^{42}K		12.36 hours	Activation of K injected in reactor coolant to control pH at VVER reactors
^{14}C	$^{17}O(n,\alpha)\ ^{14}C$ $^{14}N(n,p)\ ^{14}C$ $^{13}C(n,\gamma)\ ^{14}C$	5730 years	Activation of ^{17}O contained in reactor coolant and into uranium oxide
^{41}Ar	$^{40}Ar(n,\gamma)\ ^{41}Ar$	1.83 hours	Activation of ^{40}Ar contained in the reactor pit ventilation air (BWR) or the reactor coolant
^{38}Cl	$^{37}Cl(n,\gamma)\ ^{38}Cl$	37 minutes	Activation of ^{37}Cl contained in coolant as impurity
^{24}Na	$^{23}Na(n,\gamma)^{24}Na$	23 hours	Activation of ^{23}Na contained in coolant as impurity
^{65}Zn	$^{64}Zn(n,\gamma)^{65}Zn$	244 days	Activation of ^{64}Zn contained in coolant as impurity or from natural zinc injection. This may be a significant contributor to shut-down dose rates

Table 3. In the following there are listed some of the most common coolant activation products in nuclear power facilities. The reaction, half-life and source with notes are presented. Source: Radiological Protection NEA/CRPPH/R(2014)2 July 2014 www.oecd-nea.org Radiation Protection Aspects of Primary Water Chemistry and Source-term Management Report.

Radionuclide	Half Life	Activation Reaction	Major Source
^{51}Cr	27.702 days	^{50}Cr (n,) ^{51}Cr	Stainless steel and nickel based alloy
^{54}Mn	312.1 days	^{54}Fe (n,p) ^{54}Mn	Stainless steel and nickel based alloy
^{55}Fe	2.73 years	^{54}Fe (n,) ^{55}Fe	Stainless steel and nickel based alloy
^{56}Mn	2.578 hours	^{55}Mn (n,) ^{56}Mn	Stainless steel and nickel based alloy
^{58}Co	70.88 days	^{58}Ni (n,p) ^{58}Co	Nickel alloys
^{59}Fe	44.51 days	^{58}Fe (n,) ^{59}Fe	Stainless steel and nickel based alloy
^{59}Ni	7.46E4 years	^{58}Ni (n,) ^{59}Ni	Stainless steel and nickel based alloy
^{60}Co	5.271 years	^{59}Co (n,) ^{60}Co	Stellite™ and cobalt bearing components
^{64}Cu	12.701 hours	^{63}Cu (n,) ^{64}Cu	17-4 PH Steel
^{65}Zn	243.8 days	^{64}Zn (n,) ^{65}Zn	Natural zinc injection
^{95}Nb	34.97 days	^{95}Zr decay	Fuel cladding (Zircaloy, Zirlo™, etc.)
^{95}Zr	64.02 days	^{94}Zr (n,) ^{95}Zr	Fuel cladding (Zircaloy, Zirlo™, etc.)
^{99}Tc	2.13E5 years	^{98}Mo (n,) ^{99}Mo ^{99}Tc	Stainless steel, tramp impurities, and fission
^{110m}Ag	249.8 days	^{109}Ag (n,) ^{110m}Ag	Silver-Indium-Cadium Control rod wear, Helicoflex™ seals
^{122}Sb	2.72 days	^{121}Sb (n,) ^{122}Sb	Secondary start-up source
^{124}Sb	60.20 days	^{123}Sb (n,) ^{124}Sb	Secondary start-up source, RCP bearings, impurities
^{125}Sb	2.75 years	^{125}Sn decay ^{124}Sb (n,) ^{125}Sb	Fuel cladding impurities and neutron capture by ^{124}Sb
^{181}Hf	42.4 days	^{180}Hf (n,) ^{181}Hf	Fuel cladding impurities
^{187}W	23.9 hours	^{186}W (n,) ^{187}W	Stainless steel, carbides, and welding artefacts

Table 4. Origin of the main activation products present in the primary cooling system of NPPs from structures or corrosion mechanism. Source: Radiological Protection NEA/CRPPH/R(2014)2 July 2014 www.oecd-nea.org Radiation Protection Aspects of Primary Water Chemistry and Source-term Management Report.

N59. Knowledge of the chemical and radiochemical processes in the nuclear facilities is recommended to have in order to understand their effect to radiation protection.

N60. In a nuclear facility material selection, decontamination and radiochemistry are key attributes in minimizing the accumulation of radioactive material to systems and components.

N61. Radiochemistry is essential in identifying different types of fuel damages.

N62. Analysis in laboratory contributes to the information which can be collected by devises and samplers from the facility. Most detailed information for example from the effluent control can be obtained by laboratory analysis. Hence, the laboratory used by a nuclear facility should be equipped with modern applications and meet the high qualification criteria (standard ISO 17025:2017).

N63. Normally laboratories measuring samples are using geometries which are adjusted to normal conditions. Also the back-ground radiation conditions of laboratories are in normal circumstances stable. In emergency situations the need for special arrangements for laboratories at a nuclear facility may arise.

3.11 Emergency Arrangements

Estonia has an Emergency Act and subsidiary legislation on radiological emergency plans. In case Estonia makes a decision to initiate a nuclear power programme, there could be some new elements to the legislation. An emergency planning zone should for example be assessed.

The licensee shall be prepared to carry out analysis and consider necessary measures required for possible emergency situations already in the design phase.

According to the Nuclear Energy Decree in Finland, the licensee shall submit to STUK, when applying for a construction licence, a preliminary plan for emergency which describes the fundamental principles of emergency arrangements. This document shall be sent for approval.

The construction licence application shall include a description of the rooms vital for emergency response. These include the emergency response centre, other facilities intended for the emergency response organisations use, the premises for repair operations, dose monitoring, radiation protection equipment, laboratory facilities and also premises possibly shared by the plant units if there are plant units already in operation at the site area.

Security aspects form a separate topic, which has close connections to emergency arrangements. This issue is not discussed in this context.

N64. The most important decisions as regards equipment and rooms to be used in emergency situations should be included in the construction licence application.

N65. A preliminary plan for emergency which describes the fundamental principles of emergency arrangements in a nuclear facility is one key element in which radiation protection has its key role.

N66. There may be need for special arrangements in dosimetry and protective clothing for workers in accident situations. Planning of special needs for radiation protection is needed.

N67. Vital access routes should be planned for emergency purposes already in design phase. Emergency routes within the facility and outside the facility are important. By all these measures dose can be saved in emergency situations.

N68. For emergency arrangements the requirements for licensee should be clearly stated in legislation and requirements. The licensee should be prepared to carry out the measures required by emergency situations, the analysis of emergency situations and the consequences thereof, assessment of the anticipated development of emergency situations, the mitigatory actions needed to control or limit the accident, the continuous and effective exchange of information with the authorities, and communications to the media and the general public.

N69. A key element for regulatory body is to understand emergency situations and the radiological consequences of accidents. The training of personnel for radiological consequences in different types of accidents is important.

N70. As stated before in a nuclear facility all operational states as well as accident situations must be considered already in the design phase.

3.12 Radioactive Waste Management

Radioactive Waste Management and disposal of all radioactive waste is an essential aspect of nuclear power and should be considered early. There is a need for waste handling, waste storages and final disposal of radioactive material. Radiation protection and radiation measurements are most important aspects when nuclear facility is licensed.

Fig 7. A waste drum measurement device.

Even though Estonia has well established infrastructure in handling with radioactive waste, nuclear facilities bring new aspects for waste management including new kind of radioactive isotopes, need for special measurement devices and handling solutions for new kind of radioactive material.

N71. There should be a clear radioactive waste management strategy and policy which covers the whole use of nuclear power from the design of a nuclear facility to the final disposal of all radioactive material produced.

N72. The documentation in the licensing phase should cover the waste sector in order to have a full picture of the amount of the waste produced, waste treatment systems and the interface with the radiation protection and the radiation measurements.

N73. The fuel cycle in a nuclear facility produces different types of radioactive waste. In the operation of a nuclear facility there is normal to have operational waste from the operational maintenances and repairs. The purification of coolant waters produces normally in the nuclear facilities radioactive resin. Also the spent fuel itself is finally waste, which has to be treated.

N74. Low and intermediate level radioactive waste storages are normally established in connection with the nuclear facilities. Also the possibility to have a spent fuel storage in connection with the nuclear facility has to be taken in consideration.

N75. When planning the locations of different supporting buildings and storages transport routes should be taken in consideration in order to guarantee the safe transport of radioactive waste and components. For transport and handling of radioactive waste special handling machines and robotics may be used.

N76. The typical spent nuclear fuel needs to be cooled for a quite long time in a wet storage before dry storage becomes an option, which have to be considered in planning suitable storage solutions.

N77. The waste treatment systems, waste storages and transport methods should be well designed in order to fully implement the ALARA principle. Experience from other countries and state-of-art technology should be utilized.

N78. The environmental surveillance of radioactivity has to be extended even to the waste storages. Radioactivity measurements shall cover the waste treatment facilities and storages.

N79. Management of radioactive material brings the need for suitable measurement systems and well-kept documentation of all radioactive waste produced in a nuclear facility.

N80. Even the disposal of a nuclear facility should be one item in the waste management strategy.

4 Conclusions and Discussion

The launch of a nuclear energy programme requires the development of national expertise and the training of national expert resources to meet the needs of the new nuclear energy programme. These skills are needed both within the organisation of the licence holder and the nuclear safety authority. In addition, the technical support organisations and the inspection bodies need expert resources.

Radiation protection competence is an essential part of the national capacity that is a prerequisite for the safe use of nuclear power. This report assesses the required radiation protection capacities and related national infrastructure required by the nuclear energy programme. It should be noted that in Estonia there are already existing capacities in the field of radiation protection, and the new capacities should be developed taking them into account.

STUK has made 80 comments on the possible needs (N) of new elements in radiation protection that need to be addressed in case Estonia makes a decision to initiate a nuclear energy programme. The comments are organized according to thematic topics. They are general and many of them may already have been taken in consideration in Estonia.

Estonia is in a favorable position to make regulations which can use the experience and lessons learned from other countries. Proven technology is used in nuclear sector. Technology in the nuclear field has also developed in recent years making some old approaches to the use of nuclear power obsolete. Estonia has a possibility to create a new modern approach.

EU Member States shall ensure that arrangements are made for the establishment of education, training and retraining to allow the recognition of radiation protection experts and medical physics experts, as well as occupational health services and dosimetry services, in relation to the type of practice. One aspect in training could focus also on the field of nuclear power.

The objective of the analysis was to develop a structured list of the required additional national capacities considering typical needs of a nuclear energy programme and taking into account the existing national capacities of Estonia.

Estonia needs to develop legislation and regulatory requirements for the use of nuclear energy including regulatory requirements for radiation protection. International safety standards and the specific EU directives are used as references, but at the same time one needs to be familiar with the structure of Estonian legislation and legislative principles. Thus, development of legislation requires the involvement of a wide range of experts.

Estonia needs to develop additional capacities on radiation protection to meet the needs of the nuclear energy programme. It should be noted that these will partly depend on the NPP type and the related technologies to be selected by the licensee.

Estonia needs to develop additional expert resources to support the national nuclear energy programme. Cooperation with the states that have an existing nuclear programme is highly recommended, and STUK recommends Estonia to establish national training programmes at its universities to support the nuclear energy programme. Training experts takes time and should therefore start as soon as the decision to launch a nuclear energy programme has been taken. The listed additional capacity needs can be used for development of job descriptions for employees in different organisations and to some extent also to assess the number of employees needed for the nuclear energy programme.This information is needed for development of national training programmes to meet the future staffing needs of the nuclear energy programme. Many of the tasks in the field of radiation protection in the use of nuclear energy are demanding and require at least a master's level basic education. It should also be noted that at advanced level the best way to learn is on-the-job training and employees also need to update their skills on a regular basis. While, the NPP design and the related technologies chosen by the licensee will have a significant impact on the capacity needs, some fundamental principles of radiation protection apply to any design.

The implementation of the training programmes depends on the existing education system in Estonia and among others the currently available degree programmes of the Estonian universities. Establishing specific degree programs related to the nuclear energy programme takes some time and before that the first employees have the opportunity to study at international universities with relevant degrees. There are also possibilities for cooperation between the Estonian and international universities.

Estonia has a good basic education system, modern and stable society and many pre-existing capacities that could be further developed to meet the requirements in radiation protection expertise of a nuclear energy programme. However, it should be noted that the number of experts needed by the programme is significant and it takes considerable time to train new people. International experiences and benchmarks can be of great value in development of the Estonian capacity building roadmap to meet the needs of the nuclear energy programme.

5 List of acronyms and abbreviations

BAT	Best Available Techniques
DIRATA	IAEA Member States' database on discharges of radionuclides to the atmosphere and the aquatic environment.
DAC	Derived Air Concentration
EC	European Commission
EIA	Environmental Impact Assessment
EU	European Union
FOAK	First of a kind (nuclear power plant)
FSAR	Final Safety Analysis Report
IAEA	International Atomic Energy Agency
HELCOM	Baltic Marine Environment Protection Commission
LILW	Low and Intermediate Level Radioactive Waste
NEPIO	Nuclear Energy Programme Initiating Organization
NPP	Nuclear Power Plant
PSAR	Preliminary Safety Analysis Report
RP	Radiation Protection
SAM	Serious Accident Management
SMR	Small Modular Reactor
STUK	Radiation and Nuclear Safety Authority of Finland
STUK I Ltd	STUK International Ltd is a 100% state owned company which enables STUK to provide radiation and nuclear safety expert services globally
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WPONE	Working Party on Nuclear Energy

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ANNEX 1 Knowledge requirements and work experience of radiation safety experts in Finland

Table 1. Knowledge requirements and work experience of radiation safety experts

LEVEL OF KNOWLEDGE	
A radiation safety expert's fields of expertise: • radiation practices in health care and veterinary medicine • radiation practices in industry and research • the use of nuclear energy	
Level of knowledge	• NQF *) 7
KNOWLEDGE REQUIREMENTS	
1 Scientific basis, general knowledge of radiation 1.1 Nuclear physics 1.2 Radiation physics 1.3 Radiochemistry	
• Has a deep understanding of the properties of different types of radiation, the physical mechanisms which give rise to them, interactive phenomena and the other properties of radioactive substances as well as the principles of applications and research methods based on the use of radiation. • Capable of acting as an expert in the adoption of new applications and methods and when initiating a new type of practice.	
2 Measurement technique and calculation methods 2.1 Radiation measuring and methods of measurement 2.2 Radiation dosimetry 2.3 Design of radiation shielding	
• Understands the methods of radiation measurement and determination methods based on the measurement of radiation exposure and calculations. • Knows how to define the characteristics of radiation meters suitable for the practice. • Knows how to design the radiation shields of the facility or place where the radiation is used.	
3 Radiation protection 3.1 Radiobiology 3.2 Quantities and units 3.3 Basic principles 3.4 Protection of members of the public, including contamination and the environment as an exposure pathway 3.5 Legislation and international recommendations 3.6 Radiation safety and security arrangements at the facilities and places where radiation practices are carried out 3.7 Risk identification and preparing for radiation safety deviations 3.8 Action in radiation safety deviations 3.9 Management system as well as the tasks and cooperation of a radiation safety expert, radiation safety officer and medical physics expert 3.10 Safety culture, supplementary radiation protection training and quality assurance	
• Understands the key principles of radiation protection and legislation as well as the radiation protection and security arrangements needed at the facilities and places where radiation practices are carried out. • Capable of acting as an expert in their own field of expertise, communicating radiation protection matters and guiding the undertaking in complying with statutory requirements. • Capable of guiding the undertaking in assessing the exposure arising from the practice, optimizing protection and in preventive planning and risk mapping. • Capable of advising the undertaking in organizing training and guidance on safe working for personnel engaged in radiation practices as well as planning the necessary supplementary radiation protection training.	

<table>
<tr><td colspan="3">4 Radiation practices
4.1 Practice, ways in which radiation is used, the properties and handling of radiation sources
4.2 The procurement process, installation, maintenance, and remediation of radiation sources
4.3 Trade in as well as importation, exportation, transfers, and transport of radiation sources
4.4 Keeping records, storage and decommissioning of radiation sources
4.5 The management, discharges, and decontamination of radioactive waste</td></tr>
<tr><td>Health care and veterinary medicine
(radiology, dentistry, veterinary medicine, radiotherapy, nuclear medicine)
• Knows practices related to use of radiation in health care and veterinary medicine.
• Knows the requirements pertaining to radiation practices.
• Capable of drawing up a safety assessment of the radiation practices as well as statements, reports, recommendations, and instructions on radiation safety.
• Capable of preparing quality assurance programmes in cooperation with the MPE.
• Capable of advising how to organize training on safe working.</td><td>Industry and research
(unsealed sources, sealed sources, NORM sources, radon, X-ray equipment, industrial radiography, accelerators)
• Knows the radiation sources used in industry and research and the related practices, the sources causing exposure to natural radiation and their behaviour.
• Knows the requirements pertaining to radiation practices.
• Capable of drawing up a safety assessment of the radiation practices as well as statements, reports, recommendations, and instructions on radiation safety.
• Capable of preparing quality assurance programmes concerning the practices.
• Capable of advising how to organize training on safe working.</td><td>Use of nuclear energy, in addition to the research and industry field of expertise
• Knows the operating principles, special characteristics, and principal radiation sources of nuclear facilities.
• Knows the radiation safety requirements and provisions applicable to nuclear facilities.
• Knows the radioactive discharges, nuclear fuel handling, waste management, and decontamination procedures of nuclear facilities.</td></tr>
<tr><td colspan="3">WORK EXPERIENCE</td></tr>
<tr><td colspan="3">A minimum of two years of work experience in the field of expertise or in equivalent tasks.</td></tr>
<tr><td colspan="3">*) NQF = The framework for degrees and other skillsets referred to in section 2, subsection 1 of the Act on the Framework for Degrees and other Skillsets (93/2017), which is divided into eight difficulty levels.</td></tr>
</table>

In the use of particle accelerators in the production of radionuclides for the purpose of manufacturing radiopharmaceuticals and in the use of blood irradiators, the fields of expertise "radiation practices in health care and veterinary medicine" and "radiation practices in industry and research" are suitable for the radiation safety expert's field of expertise.